



DDR 2014

**4th INTERNATIONAL CONFERENCE ON DESIGN,
DEVELOPMENT & RESEARCH**

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& DESIGN**

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Declaration

All papers in this publication have been peer-reviewed, involving initial screening of abstracts, review by referees, modifications of papers by authors, and re-evaluation of re-submitted papers to ensure quality of content.

WELCOMING MESSAGE FROM THE DEAN, FACULTY OF INFORMATICS AND DESIGN, CAPE PENINSULA UNIVERSITY OF TECHNOLOGY,

Prof Johannes Cronje

The Faculty of Informatics and design is proud to host its 4th Design, Development and Research conference. With this conference we wish to further contribute to the growth of design and development as research disciplines. Too often design and developments are regarded as means to an end, and too seldom do we concentrate on the theories that underpin what we do.

As was the case previously, this year we once again have a conference which is of an interdisciplinary nature, with topics ranging from engineering, planning, through to fine arts. It is indeed pleasing to note how cross-disciplinary papers use input from various disciplines to develop unique solutions. Then of course the "Dilemma" track which encourages "out-of-the-box" thinking.

In line with our vision, to be "at the heart of design, technology, education and innovation in Africa," this conference has given us the opportunity to bring together some of the most important experts in the field of design for development, and design education in the world, and we welcome each one of you to the fairest Cape.

I would like to thank each and everyone involved in the arrangements of the conference, and to express the hope that we continue to grow from strength to strength with the future DDR conferences.

We also would like to express special thanks to one of our stalwart in research, the late Professor Pieter van Brakel. His work has paved the culture of research which we continue to cultivate in our knowledge generation. He started the World Wide Web (W3C) conference fifteen years ago, at the time when the web was relatively new and unknown. One of the strength of the conference was its ability to attract key figures in the development and growth of the World Wide Web.

The loss of Professor van Brakel last year has had a devastating effect on the W3C conference, and the DDR is proud to have been given an opportunity to run a slot in honour of Peter at the conference.

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The Scientific committee of the Conference on Design, Development and Research (DDR 2014), upheld the following principles and editorial procedures:

- ❖ Scientific committee consists of invited senior subject specialists from a broad spectrum of local and international universities and research institutions
- ❖ In order to ensure a high standard, all manuscripts of the conference papers were sent for evaluation to those members of the Scientific Committee, who are specialists in a particular area of the conference theme
- ❖ The Evaluation Form is completed by the evaluators and forwarded to the Central Committee of the Scientific Committee, reflecting the rating on a 10-point scale of the quality and contents of the intended paper; how well it fit into the theme and subject of the conference.
- ❖ Upon receipts of the reviews the evaluations are considered, and where more than one evaluation was returned they were compared. If the evaluations of the reviewers differed substantially, the paper was sent for review to additional evaluators. In some cases papers were accepted as practical presentations to encourage participation and exposure to novice researchers.
- ❖ After considering the evaluation of all reviewers, the paper is either accepted, rejected or sent back to the author for improvements in line with the recommendations made by the reviewers. The Central Committee later checks for the approval according to the reviewers recommendations after resubmission.
- ❖ The final peer-evaluated and refereed papers are collated in this proceedings document.

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The following types of papers were received of which only the research papers are included in the proceedings:

(R) – Research papers

(PK) – Pecha Kucha presentations

(P) or (S) - Practical or short papers

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THE ROLE OF DESIGN COURSES IN ENGINEERING PROGRAMMES: THE CASE OF THE UNIVERSITY OF BOTSWANA.

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ABSTRACT

The University of Botswana offers five-year degree programmes in engineering and built environment, which cover among others: Architecture and Planning, Civil Engineering, Electrical Engineering, Mechanical Engineering and Industrial Design and Technology. In the first year, all students from the faculty do science based courses at the Faculty of Science. During the second year, all students do a common year in engineering and technology except the Architecture and Planning students. From year three up to five, students are allowed to venture into their areas of interest. It is worth noting, that during the second year of training all engineering and technology students have to take Workshop Technology course in semester 1 and 2. The course is offered by the Department of Industrial Design and Technology. In order to update the course to keep it aligned to international trends, an action research was conducted with the second year Faculty of engineering and Technology students. This paper seeks to highlight the role of design courses in engineering programmes. It also highlights the importance of design courses and suggests possible improvements that can be done based on how other Universities around the world have designed their engineering curriculum.

Keywords: Industrial Design and Technology, Engineering Design, Design process, University of Botswana

INTRODUCTION

Engineering courses have evolved over the years from being a single discipline to multidisciplinary programmes. The University of Botswana engineering courses are no exception to this international trend. Engineering students find themselves having to do courses that are not only offered in their departments, but from other departments as well. For example, students from Industrial Design Department are offered some courses from departments such as: Electrical, Mechanical, Management to mention but a few. All engineering students are compelled to take

one course (Workshop Technology) in Industrial Design and Technology Department during their second year. Over the years, lecturers who are taking Workshop Technology have observed that students from other departments seem not to take the course seriously as compared to courses taken in their departments. This paper seeks to investigate the importance of design courses for the engineering programmes and try to address why students interest in the course is declining.

DESIGN COURSES IN ENGINEERING PROGRAMMES

The Faculty of Engineering and Technology decided to offer a broad curriculum at second year level to expose students to different disciplines which will impact on their lives, during their study period or in their professional careers. Interdisciplinary is important to curriculum due to the following reasons: There are two main schools of thoughts with regard to interdisciplinary of programmes. Some scholars argue that interdisciplinary curriculum creates 'generic' designers and engineers who lack deep skills and knowledge in their field (ICSID News, 2008). However, some argue that such a curriculum would produce designers and engineers who are able to synthesise different kinds of knowledge and skills and work well in collaborative teams. Pure disciplinarity can result in professional and creative isolation, preventing students from realising the creativity and innovation that comes from borrowing and translating from other disciplines (ICSID News, 2008).

The whole concept of having come with an interdisciplinary programme at the University of Botswana was to produce dynamic designers and engineers with an enhanced experience from other disciplines (Science and Engineering). In design and engineering, there is an increasing use of team-based approach to product development and this has led to broadening of roles. Press and Cooper (2003) argue that individuals are no longer seen as specialists with narrowly defined responsibilities, but as generalists with a particular area of expertise. In addition, Fleming (2004) asserts that teams with very different disciplines produce fewer innovations, but of greater value. It follows that to design a team made up of highly differentiated disciplines incurs greater risk but also potentially greater reward: they are more likely to fail, but their success will be more dramatic. The programmes are premised to offer interdisciplinary curriculum which excites and reward students,

offering new ways of thinking and the potential to produce innovative outcomes (Moalosi and Molokwane, 2008).

For the Faculty to achieve interdisciplinarity of its second year curriculum, all the four departments contributed relevant courses which acted as foundations for other future courses. Therefore, the common engineering and technology year is composed of the following first semester courses: Workshop Technology I, Engineering Drawing, Engineering Materials, Statics, Electrical Principles, Computer-Aided Drafting and Strength of Materials. The second semester courses include the following: Workshop Technology II, Manual and Computer Aided Drafting, Dynamics, Strength of Materials, A.C. Circuit Principles II and Engineering Mathematics II.

Students who enrol in other engineering programmes have to take Workshop Technology I and II. The aim of the Workshop Technology course is to enable students to employ different workshop processes to standard materials such as wood, plastics and metals. This course concentrates on general principles and processes used in manufacturing by developing capability to:

- identify skills and practices for different materials;
- use equipment and tools in a safe and effective manner;
- make products with due regard to drawings, designs, quality and standards.

In semester I students cover the following topics: Structures of materials, Plastics: thermoplastics and thermosetting, Wood: natural and man-made, Metals: pure and alloys, Testing, Measuring and Marking out, Common hand tools and their uses for wasting processes and Wood and plastic finishing processes. In semester II students are cover the following topics: Joining processes: Welding, soldering and brazing, Plastic welding, Fasteners, Casting processes, Forming processes, Forge working, Extrusion, Drawing and Rolling, Vacuum forming, Bending, Injection moulding and Blow moulding, Machining, Heat treatment processes and Metal finishing.

Students are taught both theory and related practical work. This is the only design related course that Industrial Design Department offers to engineering students.

However, the two courses provide students with theoretical and practical competences but does not emphasise on the act of designing. Perhaps, a component of the design process should be introduced in the first semester and the second semester can cover the manufacturing processes which students can use to realise their designs.

INTEGRATION OF DESIGN COURSES IN ENGINEERING PROGRAMMES BY OTHER UNIVERSITIES

The integration of the design courses in engineering programmes is not peculiar to the University of Botswana only. Universities around the world have long started building their engineering programmes around the design principle. Most universities have redefined their engineering courses in line with the New Science Standards which put more emphasis on Engineering Design Process. For example, Norwegian University of Science and Technology, Chambers University of Technology (Sweden), Carnegie Mellon University (United States of America) to mention but a few. Even those universities which do not refer to the courses as engineering design, they have some design aspects covered in the majority of their courses.

The same cannot be said about the University of Botswana engineering courses as evidenced by the way the courses are named and packaged. Instead of apportioning the design process in the engineering programmes, it is being given less time in some departments while in some it is not even mentioned. This fails to give the engineering students an appreciation of how best to tackle engineering problems facing the society.

RESEARCH METHOD

An action research case study was conducted at the University of Botswana. At the end of the second semester, students were given a questionnaire to complete. The questionnaire sought to find out students views on the Workshop Technology courses they are doing and whether they realise its value in their studies now and in the future. Action research is problem centred, participant centred and action oriented. It involves participants in the diagnostic, active learning, problem-finding

and problem-solving (Reason and Bradbury, 2006). This approach enables researchers and participants to collaborate in the diagnosis of a problem and in the development of a solution based on the diagnosis (Bryman, 2001). Creswell (2002) identified three main components of action research: ownership, change capacity and leadership. By using action research, both lecturers and students develop a sense of ownership of the ideas and the process of change. Creating a productive and efficient course design is not easy and requires a lot of self-analysis and reflection from both students and lecturers.

THE MISSING LINK: DESIGN PROCESS

Though workshop technology provides students with basic manufacturing skills, it lacks the basic starting point of designing products – thus the design process. One designs first, before manufacturing the product. It is very important for designers and engineers to understand different design process models, as they are vital tools in the production of new products. Products are designed for the market and it is important for designers and engineers to recognise the voice of the customers when designing new products. Integration of the design process will introduce students to the principles of design and enable them to:

- understand the essence of the design process in product design;
- describe the limitations of the different design process models;
- analyse and design products;
- apply design research methods in designing products.

The design process which can enrich the programmes could follow the one proposed by IDEO: (a) Discover (define the problem, research, specify requirements); (b) Ideate (brainstorm solutions, develop the best solution); (c) Prototype (make prototype, test, evaluate, and redesign). The purpose is not to train professional designers and engineers but expose students to the world of design. All students will be solving societal problems in the future and the basic exposure to the design process can unlock creativity and innovativeness.

STUDENTS COURSE EVALUATION

Towards the end of second semester, 60 students out of 208 students who were doing workshop technology were given some questionnaires to complete to get their views in order to guide the course revision. Only 18 students returned the questionnaire. Admittedly, the number of respondents is too small for the findings or the survey to be reliable. But it must be noted that the researcher has had a number of informal discussion about the course with a lot of students whose responses showed that they felt design courses were not relevant to them since they were doing engineering not design. The 18 students who responded to the questionnaire brought varying responses to different questions.

Overall, 33% of the respondents strongly agreed that there is need for engineering students to do design courses, 22% agreed, 28% were not sure if there is need for design courses to be taught to engineering students, 11% disagreed while only 6% were undecided.

At the end of the questionnaire, students were asked to provide any other information regarding the course and 17% responded that they do not see the importance of Materials Technology in their engineering courses. These were the students who had earlier on in the questionnaire indicated that there is need for design courses to be taught to engineering students. It must be said that the 17% were a representative of a much larger group considering the informal discussion that were held over the years with some students.

DISCUSSION

Despite a small percentage of respondents, it must be said that most students do not see the relevance of design courses in their engineering programmes. This is supported by the conflicting responses that the researcher got from students where the students praised the course at first and later on said they did not see the importance of Materials Technology in their engineering courses.

The paper has also highlighted the fact that most engineering offering universities offer design course in different engineering disciplines and this is now becoming a

universal trend, something that the University of Botswana engineering programmes seems to be very slow in implementing.

Students might not realise the value of a design course at the moment, but in the future design will become a backbone of most engineering activities. The way the Workshop Technology course has been structured does not clearly deal with the design process which makes it a great omission. The current structure equates the course to a Material Technology course with very little design work in terms of creativity and innovation.

CONCLUSION

The importance of the inclusion of design courses into other engineering courses cannot be over emphasised. It is important that students doing other engineering courses should be given a chance to appreciate how products, systems and services they use in everyday life were conceived and also how design has and is continuing to influence people's existence around the world. Therefore, University of Botswana has to review its course offering on Workshop Technology and make it design-orientated so as to be relevant to engineering disciplines.

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A PHENOMENOLOGICAL APPROACH TO SUSTAINING ECO-AWARENESS: ADOPTING A DEEP APPROACH TO LEARNING THROUGH FOUND OBJECTS.

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ABSTRACT

This paper is based on a study that aims at exploring the process of design thinking in the transformation of a found object of decay into an artwork, with a narrative of sustainability and life. The reason is to create awareness of the role and function of decayed objects by reusing these to give them new life. It draws on a qualitative design paradigm that includes embodied experience and phenomenological research. It also employs qualitative methodologies of reflective journaling and lived experience. The paper investigates the initial attraction to found objects, in addition to the decision-making process involved in how they are used in their 'regeneration'. The process of identification and appropriation of the discarded found object is explored through reflection on practicable psychological mechanisms such as motivation, cognitive arousal, and emotion. A sub-text of this paper is the dilemma encountered in attempting to establish clear delineations between art and design in both pedagogic and professional practice domains. Three issues are interrogated: the creation of awareness by using discarded banal found objects and giving these objects new life through design thinking; secondly, the creation of awareness around the critical concerns of sustainability and social responsibility; and, lastly, engaging curricula development in robust dialogue that advances the sustainability agenda in a multi-/cross-/trans-disciplinary context in the Faculty of Informatics and Design at the Cape Peninsula University of Technology in Cape Town, South Africa. In order to start off the robust dialogue, this study will in theory argue and propose that student learning can be enhanced through using a found object as catalyst to ignite creative expression and as a result positively contribute to the sustainability agenda. This study will also propose

through means of arguments in literature that creative practical activities structured around found objects will allow students to adopt a deep approach to learning.

Key words: *cognitive arousal, decay, design education, design thinking, documenting, found object, lived experience, phenomenology, sustainability.*

PREAMBLE

Lived experience introduces a qualitative research methodology in education and related fields that is distinct from traditional approaches derived from behavioural or natural sciences. This approach is rooted in the “everyday lived experience” of human beings in educational situations. Rather than relying on theoretical generalisations and theories, the reference offers an alternative method that investigates and explores the unique nature of each human situation.

The lived experience approach will investigate and explore the first author’s unique situation when choosing a discarded found object and how elaborates on how she interacts with and makes sense of these found objects.

LITERATURE DISCUSSIONS

The earliest intaglio prints can be traced back to the work of 15th Century European metal craftsmen (as seen in Figure 1). Goldsmiths and armorers practiced engraving on metal long before the first engravings were printed on paper. The highly refined art of engraving was done on precious metal using specialised sharp tools (Ross, Romano & Ross, 1990:65).

Many Masters, including Albrecht Durer, Francisco Goya and Pablo Picasso used this. The technique evolved over the centuries into an ever more sophisticated process.



**Fig 1: Master LCz (Lorenz Katzheimer)
The Temptation of Christ, c.
1492**

The term *intaglio* (from the Italian *intagliare* meaning to “carve or to cut into”) covers a multitude of processes using metal plates for traditional techniques, such as *engraving*, *etching*, *dry-point*, *aquatint*, *soft ground*, *lift ground* and *mezzotint* (Ross *et al.*, 1990). There are two broad categories of intaglio processes namely *nonacid* and *acid* techniques (Ross *et al.*, 1990:75).

Diane Victor, the 20th century artist has experimented with unusual materials and continues making works with more conventional materials that push the boundaries of her printmaking in other ways as seen in Figures 2 and 3 (Rankin & von Veh, 2008:32).



Figure 2: Diane Victor (2004) Music to Raise the Dead. Drypoint (Rankin & von Veh, 2008:32)



**Figure 3: Diane Victor (1995); Practice Box for Martyrs
Engraved cleavers, velvet – lined presentation case and etching (Rankin & von Veh, 2008:32)**

Figure 4 shows the first author's experimentation with unusual materials by engraving or etching on glass. The glass replaces the etching plate that one can either choose to ink or to leave un-inked. From previous experience, it becomes apparent that the bulk of the artworks are engraved on glass.



Figure 4:
Hanging gardens Exhibition
'Hanging Tessellation' (source: Penny
George, 2012)

Art object as artistic tools

The art object is a work of art that may or may not fit into the category of artifacts. It is distinguished by the degree of creativity and aesthetic value it has over a pure utilitarian object, usually one-of-a-kind designed and handmade by the artist. Throughout history distinctive designs or artifacts have become art objects (Theisson, 2012). Whereas an artifact has a definite place in history, it tells a story about its use and is not necessarily handmade or one-of-a-kind.

Duchamp is believed to have made the first readymade artwork called the *Bicycle Wheel* in 1913 (Rosenthal, 2004:5). The object became a work of art because the artist made a deliberate decision to designate it thus. Other examples include African art and sculptures that have always been perceived or seen in natural history and ethnographic museums as artifacts. This continued until the breakthrough moment (considered to be in 1935), when the Museum of Modern Art mounted a survey of work from West Central Africa entitled "African Negro Art" Kino (2012). Kino (ibid) quotes Biro, curator of the Armory Show in describing this as "the moment when African sculptures became seen as works of art in the United States". Previous exhibitions of the period confirm that African art influenced a number of key Modernist artists (Kino, 2012).

Modern designers and artists are increasingly adopting Duchamp's attitude to the creative process. Boontje (cited in Margetts, 2006:132) marvels at the resourcefulness of the artists in stating that, they use "clever ideas done from

nothing” to create interesting artworks. French artist Arman did similar artworks with his welded refuse “accumulations” in the 1960s. Additionally, young artists continue to use the process of assemblage, recycling stuff no one else wants into objects of desire but also remake older art with 21st Century economy – something dealers and curators call “referencing” (Yablousky, 2010).

Boontje (cited in Margetts, 2006:124) refers to his found objects as *Rough-and-Ready*, or ‘the idea of beauty in everything’. Similar to Boontje, Hesh also chooses old material: cheap throwaways that have been consigned to society's junk heap, but uses throwaways which people also remember fondly from their childhood (Macclough, 1997). Many of Bullin’s creations have been guided by chance inspiration (McNulty, 2008:13). He does not necessarily start out with a specific design in mind. He usually finds an item that sparks his imagination and then builds on this inspiration. The first author follows a similar process in which chance encounters with discarded objects inspire her.

Found objects as catalysts for creativity

Sarneel's, a Dutch jewelry artist, who's working process relates from her thoughts. Den Besten (2010) quotes her as saying “I never make sketches, I only take down notes: a word, a little scrawl. Most of the creative process happens at the workbench. Things blurb up in my head, like found objects in my mind”. Similar to Sarneel (ibid), the first author starts with found objects and creates artworks and sometimes the work of art can already be a complete image in her head once she has found the object.

On the other hand, Buthelezi does not use randomly collected rubbish, but specifically found materials (Seipel, 2009:13). He uses second-hand materials as well as recycling discarded everyday materials. One may well consider him part of the modern recycling process as he transforms rubbish into art. Seipel (ibid) points out that he reached a crucial stage in his development as a artist when he conceiving of the experimental idea of melting plastic foils together by means of a customary heat gun. This creative process cannot be compared to ‘objet trouve’, the ‘assemblages’ or the ‘ready-made’. The wrapping is not just combined but melted together in a process the result of which resembles painting.

Bourlanges cited in (Malarcher, 2012:22), is an artist who engages with aesthetic effects of chemical changes. Her 'Decay' project explores how the use of time can be mapped out and embedded in textiles. One of her recent works is to wear a carbon fiber suit over a white blouse. By wearing the outfit, Bourlanges secures gestures of the body whilst bending, stretching, scratching, and rubbing, documenting these gestures as imprints on the blouse. The imprints are translated on a fabric into a lace-like pattern of lines that flow (Malarcher, Ibid).

Fine artist Marcus Kenney from Isle of Hope collects objects that cover up all his space in his home. Paskevich (2013) quotes Kenney as saying "I work intuitively. Very rarely do I start out with a specific idea in mind. I let things evolve and I never try to stay in one place too long." He further adds that "I'll find something without really thinking about how I'm going to use it ... then one day it hits me" (Paskevich, 2013).

This is a phenomenon that many artists can relate to. To this end, the Ohio-born artist, Carol Williams still finds uses for the remnants, boards that been washed up by the sea that she prefers to call "assembly" instead of the French-accented assemblage. She prefers to keep things simple without tampering with the natural elements of reclaimed items. "I just see things that are old and weathered as beautiful, and I used to have to find everything by myself," she says (Paskevich, 2013).

Karin Olah became an emerging Charleston artist as she refined a process she calls "fabric-collage-paintings," often employing "retired" fabrics to highlight her paintings (Paskevich, 2013). These processes aid the artist in recalling a childhood devotion to quilting and everything else fabric in a distinctly phenomenological manner.

Garner uses found objects to make compelling and provocative statements about a grab bag of social and political issues: production and consumption, education, unemployment, and post-colonialism enlivening a discourse. Unlike Duchamp's perennially stimulating *Fountain*, Garner's found objects are placed in an autonomous junkyard of a performance. *Future Tense*, a configuration of ready-

mades whose presence is so much circumscribed by the artist's foregone conclusions that they have little chance of a future in our imaginings (Heuser, 2012).

Engaging with the imperative of sustainability

The most agreed-upon or used definition of *sustainability* (Button, 2011:1) comes from the Brundtland Commission and dates back to 1987 in which it is described as “*development that meets the needs of the present without compromising the ability of the future generations to meet their own needs*”. The Oxford dictionary associates sustainability with the quest to conserve an ecological balance by avoiding the depletion of natural resources (Soanes, Catherine & Stevenson, 2009:1452). The word ‘sustain’ comes from the Latin word ‘sustinere’ (Borjesson, 2006:6), which means ‘to hold up’ and, as part of the concept of sustainability, the dictionary meanings of ‘nourish’, ‘keep up’, ‘prolong’ appear to be the most appropriate. According to Borjesson (2006:6), Fry (2003) defines sustainability as actions to secure not only the future of the world but also our well-being, as well as that of future generations. This definition concurs with the most agreed-upon definition.

Marcuse (1998:105) challenges the widely accepted Brundtlands definition of sustainability. He strongly suggests that the purpose is “meeting the needs” and what remains is, “making it sustainable”, which is a clear constraint on what it signifies. Others define sustainable development through passing on to the future the same resources as we have today, which in his view seem to reduce the broad goal entirely (Marcuse, Ibid). He argues “no one who is interested in justice wants to sustain things as they are now. Sustainability plays very differently in the environmental sphere, where the whole point is simply that conditions as they are cannot be sustained and the only question is how rapidly to improve them. If the environmental status quo were sustainable, environmentalists would be without a cause” (Marcuse, Ibid).

Shedroff (2009:xxi) further argues that sustainability is not a well-defined discourse. Arguably, many commentators believe it is identical to the idea of *green* or *eco* considerations that take the environment into account. Adam Werbach, a highly controversial environmentalist, believes that the term ‘green’ has become so problematic that he suggests using ‘blue’ instead (Arnold, 2009:1) – notwithstanding

the popular association of green with the ecological concerns, whilst blue is often associated with clean air and efforts at reduction of carbon emissions. Some groups of environmentalists are primarily concerned with plants and animals (other than with people), and ever so often the 'green' movement is portrayed as a way to promote old, flawed economics in order to ensure 'business as usual'. This could be a threat to our present way of life and could possibly result in society having less of everything. Balancing both large and small ecosystems in the environment in a way to serve human needs on all levels, as well as systems, is the key (Shedroff, 2009:xxi).

Consensus on the issue of sustainability is difficult to attain because it means different things to different individuals and groups. In this regard, Shedroff (2009:2) believes the only way to approach sustainability effectively is from a systems perspective. However, due to the interconnectedness of most other things to one another, to design anything effectively is to consider what it connects to – in other words, an integrated, systemic and holistic ethos is desired. Cross (2011:75) also concurs with this view in challenging innovative designers adopt the 'systems approach'. Additionally, from his studies of innovators, Maccoby (1991) also suggests that innovators have "a systems mind, one that sees things in terms of how they relate to each other in producing a result, a new gestalt that to some degree changes the world".

From discourse to responsible action

Design is equally part of the problem and the solution to sustainability agendas (Shedroff, 2009:284). Design can bring many benefits but it is very difficult to measure, especially developments that are projected into the future. Already design thinking processes are currently being utilised in some South African educational fields, businesses, government policies and initiatives, and individuals. Even so, designers are deemed powerless convincing these groups the value that specific design process solutions itself can enhance (Shedroff, 2009:22).

Borjesson (2006:12) considers affective sustainability and the real world to be generally ever-present where design is involved and points out that both designers and manufacturing companies should implement responsible design if we want to

strengthen the impact of sustainability as Arnold and Button are advocating. There are grounds to believe that many designers are honest and the emphasis on the importance of responsible sustainable design might only be done because it is suitable. Borjesson (2006:12) also refers to Victor Papanek's book, 'Design for the Real World', which according to Borjesson was a revelation for many when it was published in 1971.

Papanek believed that responsible design is a significant way to come to terms with a wasteful society. There are a few designers contradicting their professional social responsibility. Borjesson (2006:13) states the design of everyday objects is guided largely by fashion and style. These objects are therefore considered to be 'occasional' dissimilarly to buildings, which Lavelid (2003 cited in Borjesson, 2006:13) argues should last for centuries.

Wood (1997:5 cited in Borjesson, 2006:13) suggest that priority be placed on a strategy "to quantify materiality rather than celebrating a temporal experience of Being", which Borjesson considers to be a discourse on sustainability. Our current existing economic system discourages the longevity in designed objects. Undeniably if products were designed to last longer our wasteful consumer society would be at risk because our nation has become so dependent on consumer goods with a short life span.

Hill (2003:44 cited in Borjesson, 2006:13) is quoted as saying that "it is not because we are committed to a particular economic ideology that we desire *the new* even if it is upon *the new* our market economy depends". One can therefore deduce that the nation is bound to desire the new. It is human tendency and behaviour to state individuality through possessions and taking the increasing production of ranges of objects and there diversity for granted. Designers constantly desire to express their talents by designing new user-friendly objects and in so doing entice people to desire the new.

If we want to contribute to affective sustainability by possibly reducing the desire for new by designing more timeless products, it might slow down the wheels in the economic system thus preventing a wasteful society. On the other hand it is very

important to stress that affective sustainability should not hinder innovation (Borjesson, 2006:14).

Arguably, to strengthen the impact of responsible sustainable design, designers, manufacturers and the individual need to implement responsible design without limiting innovation. This imperative informs the authors' endeavours to constitute a growing awareness around the role and function of discarded found objects by innovatively giving them a new life whilst concomitantly contributing to sustainability awareness. As articulated by Borjessen we believe that the first author's process will not only contribute to sustainability but also effectively advance awareness of sustainability in a demonstrable way subsequently increasing the desire for the rekindled discarded object into a new and sustainable life.

Effective sustainability is approached in different ways in other disciplinary areas proposes that storytelling can be a useful method to advance change. Grace and Kaufman (2013) examine the role of storytelling in effecting positive change in worldview and attitudes toward sustainable agriculture. The assumption of the study is that a story-based approach will be more valuable than an information-based approach to promote positive change. Stories are rich in meaning, and are powerful tools for communicating desired behaviour.

Similar to Digby (2006) and Camic (2010:85), the first author's found objects will create meanings through narratives and storytelling. The inherent narratives, stories and journeys inform her research rather than present it in a case to be argued and proven (Jacobs & Don, 2008:95).

The economy of recycling glass

The Roman Empire nation used more glass than any other ancient civilization. After the discovery of glassblowing the slower processes of casting and polishing phased out and glass vessels became commonplace throughout the empire by the first century A.D. (Whitehouse, 1997). Glass has become cheap and has several practical advantages over other materials. Unlike other materials in our waste stream, glass is infinitely recyclable. As the Consol corporate advert states "Glass is 100% recyclable, it adds nothing, and leaves nothing".

Glass can be recycled many times, additionally it saves water, refills our natural resources and decrease waste landfill. Utilising the cullet (recycled glass) represents that one-ton of cullet will produce the capacity to manufacture one ton of bottles. Consol, the glass recycling company has contributed a vast amount of money for the revival and recycling of used glass. Consol is devoted as part of their social responsibility and community development programmes to guarantee that recycling of glass remains beneficial to aid both the environment and entrepreneurs throughout Southern Africa (Consol, n.d.).

There are several factors why glass recycling is beneficial: firstly it conserves our irreplaceable natural resources; secondly it saves energy through lower melting temperatures; thirdly it conserves landfill space; fourthly it reduces litter; sixthly it has educational value; seventhly it is associated creating employment and profitable; and last but not least it generates financial support to aid various organisations in need. Statistics shows that the Glass Packaging Industry, Consol Glass and Nampak Glass manufactures glass an estimated one million tons per annum of glass. Only 40.1% of the glass containers manufactured in South Africa is recuperated and recycled (Consol, n.d.).

This study will attempt to place renewed emphasis on sustainability and social responsibility. In contrast to Nash who uses garbage to create objects with a utilitarian purpose Nash (2012) I will be using waste material to produce artworks. The fact that Cape Town, South Africa, has been selected to be the World Design Capital in 2014 also makes this study urgent. Cape Town, as World Design Capital 2014, will be accountable for delivering on the local population's needs, guaranteeing this city's successful position with the World Design Capital 2014 vision.

Certainly one of the most pressing design challenges is the crisis of collecting and removing refuse in the townships. The intension is to co-design a workable solution with the community, for the community, and by the community taking all the challenges around refuse into account. In this study a conscious effect will be made to encourage communities to become conscious of consumption and refuse collection.

The city committed itself to transforming lives by design, restore community cohesion, reconcile communities through infrastructural development, and repositioning the city for the knowledge economy around sustainability. This study will endeavour to encourage communities to become conscious of consumption and refuse collection. Already Consol has established 40 formal glass-collecting agents in Gauteng townships collecting no less than 500 tons per month.

Through further investment and links with government department Consol intends on providing more entrepreneurial opportunities in growing this market to even greater heights. Expansion into the Western Cape and Greater Durban areas are to be initiated. The result will be that all artworks created for this study will incorporate found objects, like the glass jar figure 7, which places emphasis on sustainability and social responsibility.

DESIGN METHODOLOGY

Phenomenology provides a excellent methodology for studying the lived experience of human beings (Halldorsdottir, 2000: 48). The main task of phenomenological methodology is to investigate the phenomena and the purpose of phenomenology is to describe my lived experience and the documentation of the experience must be documented in such a way that it truly reflects the description.

To gain access to these experiences I explored and also questioned the themes that emerged from my descriptions. Finding what is common and unique in these themes allows the essential structure of the phenomenon to shape and as a result a description of the essential structure of the phenomenon studied, could later be explored (Halldorsdottir, 2000: 50).

The research method is going to adopt a convenience or accidental sample which is not representative of a population as the objects are presented to the researcher by accident (Leedy, 1993:200). Artworks created will incorporate found objects that are selected randomly. The possibility of a thematic approach could be later investigated not just with the choice of the found object, but the inclusion and the incorporation of engraved glass

To find commonalities between the found-objects I have been using to create artworks, I constructed a spider diagram to find possible themes to describe the fundamental structure of the phenomenon. Figure 5 is an overview of all objects used dated back from 2004 until 2014.

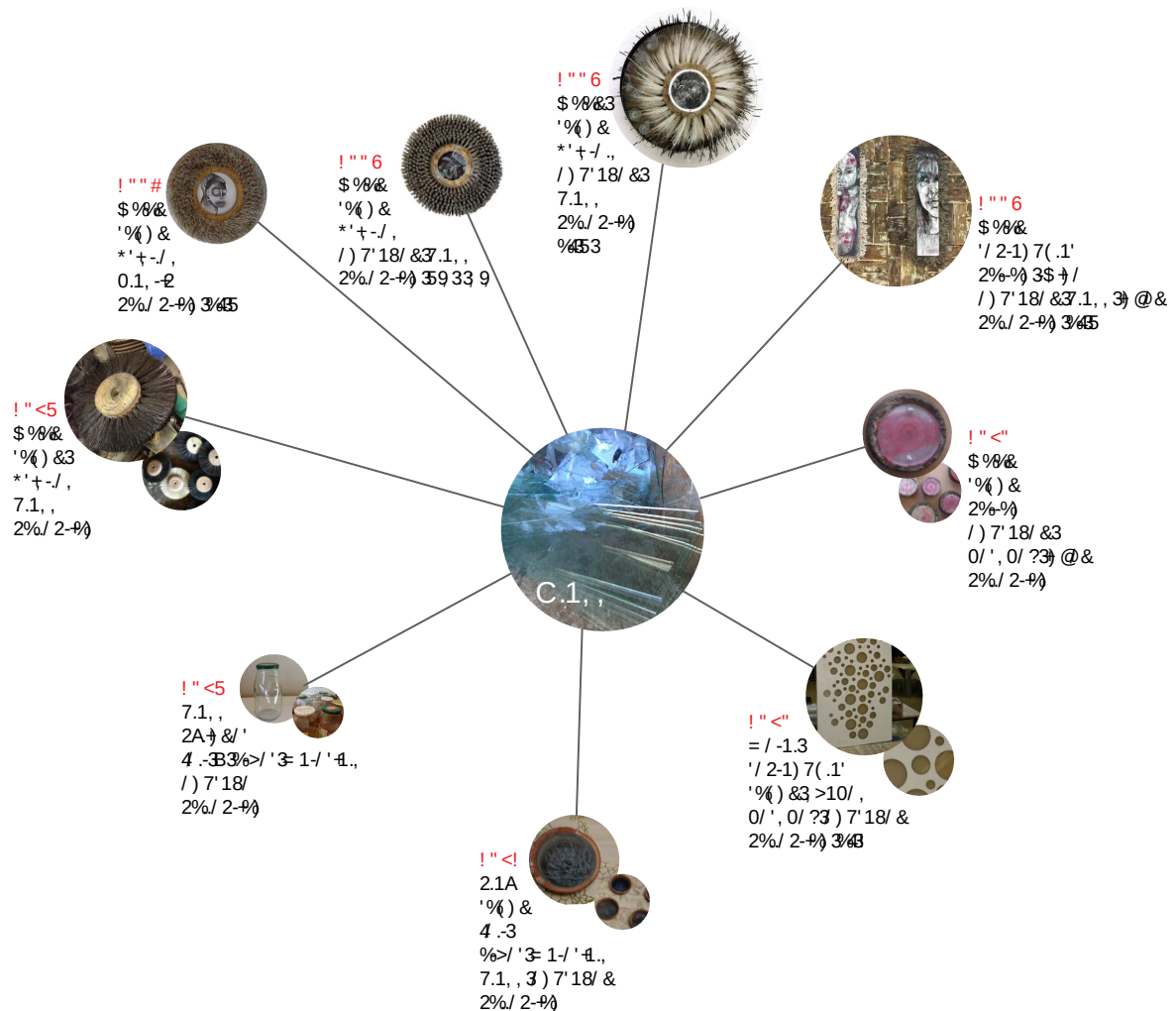


Figure 5. Penny George's diagram of found-objects and materials (2014)

No.	Medium	Number of similar materials used
1	Wood	6
2	Bristles	4
3	Clay	1
4	Glass / engraved glass	7
5	Cotton twine	1
6	Cotton & leather	1

7	Plastic	1
8	Metal	1
9	Felt and other material	2
10	Perspex	2
11	Round	6
12	Cylinder	1
13	Rectangle	1

Figure 6. Penny George's material indicator use for Figure 5. (2014)

In Figure 6 one can assess that from thirteen materials used thus far, I used found-objects of which six are made up of wood, and four of the six found-objects have bristles. Essentially I am drawn to round shapes rather than cylindrical or rectangular shapes. The combination of discarded glass I have used 7 times with the found-objects. Other materials like clay, cotton twine, cotton and leather, plastic and metal I used once and perspex and felt I used twice. Below the use of similar material can be seen in Figures 7 and 8.



Figure 7: De Kay Police Report - detail
Found object with inked glass
engraving
(source: Penny George, 2009)



Figure 8: WOODEN BRUSH SERIES - detail
'Challenge Machine versus Diatoms'
Found object with un-inked glass
engraving
(source: Penny George, 2006)

To further explore and capture in depth descriptions I have selected a single-case study. The interaction of aesthetic, cognitive, emotive and creative factors in the seeking, discover and the utilization of found-objects could be captured.

DISCUSSION

For the purpose of this paper the findings of a single-case study (mayonnaise glass jar) as seen in Figure 7 will be discussed. A case study is situated between the descriptive survey method and the experimental method (Leedy, 1993:186). This concept starts with the observation that all research takes place in the form of single studies (Yin, 2011:100).

The study of this sample would seek to develop and discuss how the findings might have implications to enhance understanding of this particular concept in this case (Yin, 2011:100), the found object a mayonnaise glass jar.



Figure 7: Mayonnaise glass jar
Found object
(source: Penny George, 2013)

The following is an entry from the first author's reflective journal:

On Saturday, 02 February 2013 while diligently washing the dishes amongst them were mayonnaise and gherkin jars. These you have to soak to remove the labels. I find myself storing so many of these in my kitchen cupboards and was about to discard them when at that very moment they presented themselves to me. In my experience working with found objects it is not necessarily the hunt for the object but the instantaneous surprise and the delightful sensory feeling when I stumble across an object, which frequently is at an unexpected place or time. Like an elemental surprise revealing itself to me. I presume the experimentation with unusual materials by engraving or etching on glass triggered me. As previously mentioned the glass replaces the etching plate that one can either choose to ink or to leave un-inked. From previous experience as seen in Figures 5 and 6, it becomes apparent that the bulk of the artworks are engraved on glass.

Results has been identified that the found object process involves the interaction of aesthetic, cognitive, emotive, mnemonic, ecological, and creative factors in the seeking, discovery, and utilization of found objects, but (Camic, 2010:81) Camic (2010:90) also reveals in his data analysis that the instantaneous surprise was one of his unanticipated findings. A corresponding statement is made in a review report on Practice - Led Research in Art, Design and Architecture (Rust, Mottram & Till, 2007:4); Katy Macleod is quoted saying: "The logic comes after the event. After the rendezvous, as Duchamp would have it, the co-efficient of the gesture (object?) and its interpretation."

The mayonnaise glass jar triggered me possibly involving the identification of the found object processes as mentioned by Camic above to engrave on the glass substituting the etching plate. Using this jar reminds me of preservation jars of a series of using several of these jars will be called 'Preservation Jars' as seen in transformed glass jar in Figure 8 (*with the arrow indicating the engraving*). Inside every jar a plant a cacti or succulent will be created from different found materials like, felt, wool, sewed paper, folded paper, croched plants and air plants etc. just to name a few. Each jar will be enclosed with crochet hemp.



Figure 8: Mayonnaise glass jar transformed: (source: Penny George, 2013)

Different glass engravings will be done on each jar complimenting to what is inside the glass jar. Incorporating all of these elements suggests the preservation life and decay.

By constituting a growing awareness around the role and function of discarded found objects by innovatively giving them a new life whilst contributing to sustainability following in Consol beliefs and systems.

From this example it is clear that a process of discovery and self directed learning took place. A re-evaluation of the meaning and purpose of the found object led to a new understanding and creative concept. Before this study can further explore the

approaches to learning and how each approach can be or are implemented in learning facilitation, some clarification about the definition of the word art is needed.

Creative process defined: Art object.

Art, for the purpose of this study will be defined as the vehicle or medium of expression, which is created to communicate values containing truth, reality and or beauty for the purpose of aesthetic appreciation (Chessic, 1999: 405; Wollheim, 1987: 44). In other words, the artist expresses personal views, opinions or feelings by using for example, an engraving, a drawing or sculptural object, which in turn is interpreted and appreciated by the art viewer. Art and design education in this study is defined as learning by observing and creating works of art (Favre, 1981: 3).

The following pages will give proffer reasons as to why it is important to know how students learn in art, as well as consider some important aspects regarding the art and design related learning relevant to this study.

Learning in art

Learning in art, remains learning and does not change in definition just because the study field partly concentrates on practical ability. Learning, according to Biggs (2003: 13) and Biggs (2004: 3), is the manner in which the learner engages in, or absorbs knowledge from, the world around him/her. The author explains that education is about conceptual change and that learning only takes place when the learner's understanding of concepts change (as is evident in the example of the mayonnaise jar discussed previously). This, not only results in a better and clearer understanding of the world, but also influences how the learner views the world and behaves in it (Biggs, 2003; Biggs, 2004). It is this much wanted change in behaviour or improved art creating ability that holds important value, not only for this study, but also as an aspect of learning in art and design education (Taylor, 1993: Introduction).

In an attempt to further define and understand the different learning approaches an art learner can adopt when confronted with the production of an artwork made from a found object, as a learning activity, the following paragraphs describe why current art facilitation practices in the formal design class enhances learning through a deep learning approach. Even though practical art activities are structured to encourage

students to learn through a deep approach, it could be expected that some students might because of variables such as personality traits still adopt a surface learning approach.

Although this study is not focussing on the different learning approaches that students adopt, it is still deemed necessary to shortly refer to the findings of researchers who considered the relationship of personality, art learning and the deep, surface and strategic learning approaches to learning. By defining the different learning approaches, the reader will understand why this study argues that creative activities structured around found objects will not only enhance what and how the student learns but also why these activities will contribute positively to sustainability. In a practical art and design class students have to actively take part in the learning process. The deep, surface and strategic approaches to learning can be described as follows:

- The deep approach to learning is described as:
 - (a) The learner's intention and intrinsic motivation to understand the learning material and subject matter in a meaningful way (Diseth, 2003: 146),
 - (b) The learner's ability to relate previous knowledge or experiences to new experiences,
 - (c) An active participation in and discovery of patterns and fundamental principles,
 - (d) Focussing on a high conceptual level in order to relate evidence to conclusions,
 - (e) The ability to critically evaluate information (Biggs, 2003:16; Burton and Nelson, 2005:1433).
- Students adopt a surface learning approach when:
 - (a) The intention is to engage in the task merely to get it out of the way while appearing to meet the course requirements,
 - (b) Studying by memorising facts just to obtain a minimal pass (rote learning),
 - (c) Information is treated as unrelated parts of knowledge, thus ideas are not linked,
 - (d) They are cynical about learning and the need to gain knowledge and experience undue pressure and worry about work load (Biggs, 2003:16; Diseth, 2003:145; Zhang, 2003:1433).

- Finally, achievement is linked to the strategic approach or also called the achieving learning approach (Diseth, 2003:146). This approach reflects the following:
 - (a) Emphasis on organisation,
 - (b) The use of study methods and skills, and
 - (c) An innate need to achieve high grades (Duff, Boyle, Dunleavy & Ferguson, 2004:1908).

Biggs (2003:16) and Zimmerman (1992:16) describes the deep learning approaches as a felt need to actively and meaningfully participate in activities, through which the student will have to use the most appropriate cognitive activities in dealing with it. The lecturer has to encourage the need to know, make students curious and as mentioned previously, build on students' prior knowledge. In Art, this means that students are expected to get actively involved in selecting and choosing their own concept and reference material within a given theme and individually complete the activity during class time and under the supervision of the facilitator.

As each of the approaches to learning is also linked to academic achievement it is worth mentioning Burton and Nelson's (2005: 1437) findings which indicate that the deep approach is positively related to academic success, while the surface approach was negatively related to achieving good results at an institution of higher learning (Zhang, 2003: 1432).

CONCLUSIONS

The goal of phenomenological research is to describe on 'live experience' of a phenomenon (Groenewald, 2004). Merleau-Ponty (1945; 1962) in (Poulsen & Thøgersen, 2011:32) believes that phenomenology reflects on our lived experiences to how we as humans are engaging in the world through different forms of intentionality, how we direct ourselves towards the world, for instance through spontaneous pre-reflective or thoughtful actions.

Phenomenology reflects on one's lived experiences, which enables one to investigate, interrogate and explore the unique situation when choosing a discarded found object and how to engage with found objects in the world through transforming the found objects and giving them new life by means of practicing effective

sustainability. As mentioned earlier the possibility of a thematic approach could be later investigated with the choice of found objects.

The 20th Century graphic artist Diane Victor has experimented with unusual materials in the 1995. From the first author's previous experience it becomes apparent that the bulk of her artworks are engraved on unusual material like glass therefore the possibility of a thematic approach could be later investigated.

Modern designers like Tord Boonjie and artists like Marcus Kenney are increasingly adopting Duchamp's attitude to the creative process and continue to use the process of assemblage, recycling stuff no one else wants into objects of desire. This is a phenomenon that so many artists can relate to.

Consensus on the issue of sustainability is difficult to attain because it means different things to different individuals and groups. Shedroff (2009:2) believes the only way to approach sustainability effectively is from a systems perspective. Maccoby (1991) also suggests that innovators have "a systems mind, one that sees things in terms of how they relate to each other in producing a result, a new gestalt that to some degree changes the world".

Arguably, to strengthen the impact of responsible sustainable design, designers, manufacturers and the individual need to implement responsible design. By constituting a growing awareness around the role and function of discarded found objects by innovatively giving them a new life whilst contributing to sustainability similarly like Consol, the first author demonstrates a strong commitment to ensuring that recycling of glass continues to benefit both the environment, entrepreneurs, designers and artists. The resultant explorations with found objects elaborated in this paper demonstrate that cognitive arousal can be triggered even by the most banal or mundane of artifacts thereby offering powerful demonstrators of eco-awareness in advancing discourse on the important issue of sustainability.

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INTO THE GREY: TOWARDS SUCCESSFUL IMPLEMENTATION AND EFFECTIVE EVALUATION OF “DESIGN FOR DEVELOPMENT” PROJECTS

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ABSTRACT

The present study originates from the consideration that the final phases of implementation and evaluation of “Design for Development” projects have not yet been systematically addressed by design literature. Consequently, the objective is to investigate which factors impact successful implementation and effective evaluation of “Design for Development” projects. The study has been performed with a qualitative approach. Six designers with relevant experience in the field of “Design for Development” were interviewed at the Industrial Design Engineering faculty of Delft University of Technology. The focus of the interviews was the implementation and evaluation phases of one of the “Design for Development” projects in which they have been directly involved. The main contributions of this research are: pinpointing several factors that underlie the successful implementation and effective evaluation of “Design for Development” projects; indicating a possible path to help design practitioners in these two final and critical phases of “Design for Development” projects; aiming to increase the impact of future “Design for Development” projects.

Keywords: *Design for Development, implementation, evaluation, success, failure.*

INTRODUCTION

The debate around the performance and results of development projects has been characterized by criticism since 1950 (Ika, Diallo and Thuillier, 2012: 105). Prahalad (2006: 10) has argued that many projects targeting developing countries from the “outside” fail. In a similar way, Gui Bonsiepe (in Fathers, 2003: 48) has pointed out that the problem exists also in the field of design; during an interview about design for local empowerment in developing countries, he stated: *“Design problems will only be resolved in the local context, and not by outsiders coming in for a stopover visit”*.

Donaldson uses the expression “Design for Development” to define all those design projects that *“sustainably improve the livelihoods of people who do not have their basic needs met”* (Donaldson, 2009: 97-98). “Design for Development” can therefore be considered a subdomain of the broader domain “Development Projects”, comprehending projects in which the discipline of design plays a preponderant role. Donaldson (2009: 98) maintains that projects carried out by western designers in developing countries too often *“focus on the early stages of product design, with insufficient consideration of the production, distribution and repair of the product”*. This approach causes consistent problems in implementation that ultimately lead to a failure in terms of achieving a concrete improvement in the target users’ lives. In several cases, Donaldson continues, the final outcome of unsuccessful design projects is not properly assessed and the evaluation phase is skipped or performed with a biased and unconstructive approach. *“Too rarely is there transparency in mistakes”* (Donaldson 2009: 100), whereas the outcomes of such projects, both positive and negative, must be reported in order to learn from them and build upon them (Donaldson, 2002).

An internationally renowned example, that generated strong criticism in the “Design for Development” arena, is provided by the PlayPump® case, a design project for water supply in rural Africa in which several million dollars was invested. In 2007 Unicef reported: *“The water system is an innovative and robust technology, which can be improved with some minor modifications. On the other hand, the implementation strategy adopted by PlayPumps International and its partners requires serious and urgent revision. The current PlayPumps International implementation strategy clearly contravenes several Government policy directives and water sector development principles common to the countries under consideration”* (Unicef, 2007:14). The flaws in the project were so significant that PlayPump® had to deeply revise its operational strategies and implementation plans (Unicef, 2007: 17). *“In May 2009, the board of PlayPumps International-U.S. brought in a new CEO to identify a new path forward. Under his leadership the organization announced a grant of funds and technology to Water For People, which now offers PlayPumps as part of a larger portfolio of solutions from which rural African*

communities can choose” (Case, 2010). Nevertheless, the project was nominated for the prestigious National Design Award in the United States in 2007.

As a consequence of the growing criticism towards the real impact of development projects, more attention is now being devoted to their implementation and evaluation. Over the past fifteen years, an increasing number of guidelines and frameworks for the implementation and especially evaluation of development projects has been published by several international organizations such as *The World Bank*, *The United Nations* and the *Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP)*, to cite a few. The purpose of these documents is to make project developers more aware of the challenges that arise upon project completion, to provide more focus on the final phases, and to foster more consistent and reliable evaluation processes (e.g. Baker, 2000; Beck, 2006; Benoît, 2009; Catley, 2007; Diallo and Thuillier, 2004; Gradl, Herrndorf and Kramer, 2009; Ika, Diallo and Thuillier, 2012;). These documents denote a major step forward in the “Development Projects” domain and represent a valuable source of knowledge for practitioners, including designers, operating in development contexts. However, as noted by Easton and Schelling in *Divided Knowledge: Across Disciplines, Across Cultures* (1991), due to the increasing professional specialization in society, the understanding of a particular issue is parcelled across disciplines and valuable knowledge gets lost in the cracks of discipline boundaries. This is also valid in the domain of “Development Projects” where several disciplines collaborate towards the same goal. Possibly as a consequence of what is stated above, the content of the mentioned documents do not encounter a capillary diffusion amongst designers yet. There are other sources in the subdomain of “Design for Development” which have been created by designers, specifically to aid design practitioners working in development contexts. Examples are provided by the renowned *Human Centered Design (HCD)* method and toolkit by *IDEO*, the *Collective Action Toolkit* by *Frog Design* and the manual *Design for Sustainability (D4S): A practical approach for developing economies* developed within the *Design for Sustainability Programme* at the Industrial Design Engineering faculty of Delft University of Technology. An overview of these design toolkits and methods reveals that, specifically in “Design for Development”, the crucial importance of both project implementation and evaluation is still overlooked. Indeed, they can be very useful to facilitate the design process in

unfamiliar contexts, mostly by using participatory design techniques to integrate local knowledge in the field research and concept development phases. However it can be noticed that these toolkits and methods do not specifically address the implementation and evaluation phases in a thorough and systematic way as it is done by the sources previously mentioned.

In the light of the consideration that valuable information for designers may get lost across discipline boundaries, this research aims to contribute to the existing efforts of improving the implementation and evaluation phases of development projects, specifically within the discipline of design.

RESEARCH OBJECTIVE

This research investigates the factors that lead to successful implementation and effective evaluation of “Design for Development” projects from the perspective of designers who have worked in development contexts. The objective is to gather from designers existing knowledge concerning specifically project implementation and evaluation; ultimately the aim is to provide a direction that can improve the performance of all design practitioners in these two final and critical phases of a development project.

As mentioned, within the research, the expression “Design for Development” (DfD) refers to design projects that *“sustainably improve the livelihoods of people who do not have their basic needs met”* (Donaldson, 2009: 97-98). The notion of basic needs is hereby put in correlation with the goals set by the Millennium Project of the United Nations: eradicate extreme poverty and hunger, achieve universal primary education, promote gender equality and empowering women, reduce child mortality rate, improve maternal health, combat HIV/AIDS, malaria, and other diseases, ensure environmental sustainability, develop a global partnership for development (Sachs and McArthur, 2005: 347).

The expression “successful implementation” is derived from the Project Management Handbook. A project is considered to be successful if it is completed on time, on budget, if it achieves all the goals that were originally set for it and if it is accepted and used by the clients or targeted users (Pinto and Slevin, 1988: 169-170). The definition of “successful implementation” specifically for international development

projects is relatively recent (Diallo and Thuillier, 2004: 19). Diallo and Thuillier (Diallo and Thuillier, 2004: 21) refer to Pinto and Slevin's definition as the traditional constraints for project success and, building upon it, they propose five criteria specifically for international development projects: relevance, efficiency, effectiveness, impact, and sustainability (Ika, Diallo and Thuillier, 2012: 107). Within this research, the general definition given in the Project Management Handbook will be used as primary reference.

The expression “effective evaluation” is derived from the Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP): *“Evaluations should have a positive effect on improving learning, accountability and performance”* (Beck, 2006: 3).

METHOD

Given the scarcity of extensive previous academic research within the domain “Design for Development”, the present study is exploratory. As Stebbins explains (2001), exploratory research should not be seen as something that leads to definitive results but rather as an interest-driven and cumulative process into an area where discovery is possible and broad. The study has been conducted with a qualitative approach making use of semi structured open-ended interviews in order to investigate and uncover which factors impact successful implementation and effective evaluation of DfD projects. Six designers working in the field of DfD were recruited at the Industrial Design Engineering faculty of Delft University of Technology and interviewed individually. The criterion used to select the respondents was their extensive experience in the field of DfD. The sample includes MSc graduates, PhDs, professors and design professionals working both in the academic and commercial environment as well as in the non-profit sector (Table 1). The interviewees were first introduced to the topic of the research through a brief description and provided with the definition of “Design for Development”. In this context, the definition was put in correlation with the goals set by the Millennium Project of the United Nations in order to achieve a better focus on the investigated topic. The interviewees were subsequently asked to select one DfD project in which they were directly involved in the implementation and evaluation phases and to provide valuable information about such phases.

Table 1: Research sample

	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5	Respondent 6
Background	Product and graphic design.	Environmental science and sustainable design. 20 years of experience with design for development projects in developing regions of Latin America, Africa and Asia.	Industrial Design Engineering.	Industrial Design Engineering.	Industrial Design Engineering. 20 years of experience with design for development projects all over the world.	Industrial Design Engineering.
Current position	PhD candidate within the Design for Sustainability program at the Industrial Design Engineering faculty of Delft University of Technology. Research Topic: Sustainable Product Service Systems in Emerging Markets.	Coordinator of the Design for Sustainability Program at the Industrial Design Engineering faculty of Delft University of Technology. Product design and cleaner production projects in developing regions. Consultant for the United Nations.	Assistant Professor within the Design for Sustainability program at the Industrial Design Engineering faculty of Delft University of Technology. Project coordinator of design for development student projects. Industrial design engineer working in design practice. Eco-design consultant.	Project coordinator of design for development student projects at the Industrial Design Engineering faculty of Delft University of Technology.	Project coordinator of design for development student projects at the Industrial Design Engineering faculty of Delft University of Technology. Expert in design methods for contextual research.	Product design engineer working in design practice and for the Industrial Design Engineering faculty of Delft University of Technology on design for development projects.
Project	Design a Product Service System for rainwater harvesting in low-income households in Brazil.	Introduce and test a Product Service System for gas clean cooking in rural areas of Vietnam.	Design a solar powered light developed in Cambodia with tree goals: (1) give people access to light; (2) make light sustainably; (3) foster local development through local production.	(Student project) Design a playground for children in Ghana. Goals: (1) to find a social use for a field that was not utilized; (2) train design students to work in developing markets.	Design a locally produced lightweight hand operated wheelchair in Vietnam.	Disseminate design practices among small and medium enterprises in Vietnam, Laos and Cambodia.
Duration	1 year.	1 year.	5 years (still on-going).	6 months.	3,5 years.	2 years.
Implementation	Implemented up to prototyping.	Implemented with short delays and minor technical shortcomings.	Implemented. Goal (1) and (2) were achieved. Goal (3) not yet achieved.	Not implemented.	Implemented up to prototyping.	Implemented with local involvement but lack of local active participation.
Evaluation	Evaluation performed through user testing with the prototype.	Evaluation performed at the end of implementation testing.	No formal evaluation was performed.	Evaluation performed from an academic perspective, on the students learning process.	Evaluation of the prototype.	Evaluation performed roughly as the collaboration progressed.

The interviews were performed making use of interview guides to ensure consistency in the findings, hence increasing the reliability of the study (Appendix B). All questions were intensively probed, and when necessary repeated, in order to obtain deeper insights regarding the investigated topics. All interviews lasted approximately one hour, they were digitally recorded and most insightful sentences and passages have been transcribed in order facilitate the analysis process and increase the reliability of the findings (Appendix A). The partial transcripts were analysed and coded according to Grounded Coding Theory. Grounded Coding is a data analysis technique that allows *“to study fragments of qualitative data - words, lines, segments, and incidents - closely for their analytic import”* and to categorize and cluster them comparing *“data with data and then data with codes”* (Charmaz, 2006: 42). The coding process led to the definition of a list of factors impacting successful implementation (Table 2) and effective evaluation (Table 3) of DfD projects. The factors were subsequently clustered in macro-categories, or topics.

The next section factually reports all the information that emerged from the interviews with the six respondents. The analysis was carried out integrating and comparing the answers of the six respondents against each other. The results are structured in two sub-sections. The first sub-section reports a list of topics related to successful implementation. The second sub-section reports a list of topics related to effective evaluation. Each topic corresponds to the title of a paragraph in the next two sub-sections. The various factors impacting successful implementation and effective evaluation of DfD projects are reported within each topic and summarized within two tables.

RESULTS

Successful implementation

Type of organization

The type of organization working on the project has significant implications on how the solution will be implemented. Many small local companies have three characteristics that are fundamental for successful project implementation. First of all, they are well integrated in the local socio-economic dynamics and consequently have a deep understanding of the context and its needs. Secondly, they are small

and hence relatively unstructured organizations: they are very flexible and can quickly change direction depending on temporary contingencies. *Flexibility* is indeed helpful in a developing country setting where a *trial and error approach* to implementation is often required due to the complexity of the context. Finally, small local companies can have a strong motivation to implement successfully because their “life or death” frequently depends on that. On the other hand, not being overly concerned with financial growth, small local companies are often not very ambitious. “Sometimes for them it’s not about making big money. Sometimes it’s just about making enough money to support their families” (Respondent 6). Moreover, small local companies might be reluctant to innovate because of cultural reasons as in some cases they have shown to be scared of being different from the competitors. Lack of *corporate assets* is another problem. Not having sufficient financial resources, they may sacrifice quality to lower costs. Notions on strategy, design mind set and technical competences are often missing: they may know how to identify unaddressed needs but then they are not capable of translating them in a design brief and eventually into a fitting product. Finally, they hardly know how to target the customers and make promotion. Multinational companies are radically different: they have less *contextual knowledge*, which makes it more difficult for them to find and implement solutions that fit local conditions, but they have more assets and capacity, resulting in a drastic advantage when it comes to market launch and *scalability*. Another great difference between multinational and local companies lies in their mentality. The *pursuit of profit* that encourages multinational corporations to enter low-income markets is, at the same time, the main driver and a barrier for successful implementation. The mentality of multinational companies, which can be summarized in “easy profit now”, represents the core of the problem. Low-income markets have unaddressed needs and less competition, hence they are potentially profitable, but entering them successfully is not an easy endeavour. Doing so requires an intense effort in terms of time and acquisition of new competences. Most of the issues arise during implementation, where *long-term field support* is required from the company. Lack of perseverance and *long-term orientation*, hinder successful implementation and may ultimately lead to a distortion of intents. A typical example is when a multinational company seeks profit through a return on brand equity rather than in successfully selling solutions. In fact, it has to be considered that most of these companies do not depend on the profit made in low-income

markets and may use DfD as a mean to connect their brand image to the trend of social sustainability and consequently increase their brand equity in western markets. A last category of a company undertaking DfD projects is represented by non-profit organizations. The main advantage non-profit organizations have over the two previously mentioned company types, is that their main focus is on solving socio-economic problems. On the other hand, it often lacks the necessary energy to implement successfully because it is not driven by profit. All the three categories of companies that have been identified have their own strengths and weaknesses. *Mutual learning* can significantly improve performance in implementation.

Local factors

Local capacity refers to the ability of a population to create value starting from the resources it has. Capacity is highly affected by *local education*. DfD has the role to increase *local capacity* by creating awareness around issues and opportunities while bringing the necessary knowledge to develop and implement new solutions. “We shouldn’t give them fish. It is better to give them a rod and teach them how to get it themselves” (Respondent 6). It is now clear that successful implementation is strongly dependent on a shared effort in which *local participation* is the first requisite. *Local participation* refers both to involvement and support. Local involvement is needed to understand “how to make things work” and to create trust. Trust is very important for successful implementation because it affects how people react to something new and ultimately the *local acceptance* of a solution. Acceptance requires time and contextual research based on participatory co-design techniques can speed up this process. Local intermediaries play an irreplaceable role but so far are not yet considered a crucial design asset. Moreover, trust also influences the willingness of local people, organizations and institutions to provide active support. In the long run, the success of a good DfD project mostly depends on how much the people directly interested are willing to improve their conditions: active participation in implementation is the first step of this path.

Time

Successful implementation has a lot to do with time. *Iterative processes* and *long-term orientation* are strictly connected and both fundamental for successful implementation of DfD projects. *Iterative processes* are suitable when dealing with

complex problems that are difficult to define in all their variables. A *trial and error approach* allows to constantly progress towards improvement through step-by-step incremental changes. *Iterative processes* require *long-term orientation*, which in this case is practically concerned with *long-term field support* from the project executor. It has to be acknowledged from the very beginning that the project will most likely require longer than desired and its success strongly depends on the perseverance of the executor. Often “*you cannot do it in one year, you cannot do it in two years. You need at least three-four years to build everything and make it work down there*” (Respondent 3). A design team cannot remain abroad for several years due to time constraints and lack of financial resources. This is why long-term thinking implies pushing the locals to actively take over during implementation while scheduling follow-ups and ex-post interventions after the project is completed. Unfortunately, many project developers consider projects to be linear, forgetting that without *iterative processes* and *long-term orientation* most DfD projects are bound to fail.

Operational dynamics

A balance between *planning* and *flexibility* is crucial for successful implementation of complex problems such as those tackled by DfD projects. Developing countries are highly complex and unstructured contexts where project development has to deal with more problems and unexpected issues than usual. Lack of *contextual knowledge* and *adequate material supply* or *adequate production technologies*, local misuse and delays of various nature, are all intrinsic limitations of DfD. Project specifications should consider *local capacity* in order to exclude on beforehand unfeasible solutions and contemplate alternative options. Carefully *planning* the implementation up-front allows the design team to identify and tackle the challenges in advance, ultimately increasing the chances of success and improving the quality of the final outcome. International commissioners of development projects, such as the United Nations and World Bank, are experienced with this kind of issues and always require an implementation plan in the project proposal. On the contrary, western multinational companies and design firms in general don't have this kind of experience and regularly underestimate the importance of *planning* the implementation. For this reason, they often find themselves dealing with critical problems that could have been easily foreseen and avoided. Indeed it has to be considered that implementation is highly context dependent and therefore also

requires *flexibility*, especially in the cases where too complex methodologies and detailed *planning* slow down the project instead of helping it. Sometimes the original solution does not fit the context as expected and needs to be changed and *"sometimes the best solution comes from picking partial solutions and combining them in new and unexpected ways"* (Respondent 6). However *flexibility* is not yet accepted in the context that is being discussed, especially in subsidized projects where the commissioner habitually sets strict requirements. *"Big organizations and NGOs are scared of flexibility because they seldom employ designers and they are not used to deal with uncertainty"* (Respondent 2). On top of this, a recurrent problem is that *"some designers forget their objectives while others are too rigid with their initial objectives."*

Realistic expectations

Realistic expectations are hereby concerned with *realism*, *focus* and *selectivity*. *Realism* is fundamental for successful implementation. Very often design projects in development contexts *"are not realistic enough because expectations are too high and the objectives too ambitious"* (Respondent 4). Trying to solve problems with visionary solutions, which require significant financial effort and changes in the status quo, is one of the main causes of failure of DfD projects. On the other hand, lower expectations, combined with a step-by-step, down-to-earth approach, lead to more successful results in most cases. *Realism* is also concerned with scheduling since sufficient time is recurrently not allocated to implementation in project *planning*, forgetting that in a developing country setting unexpected issues are more likely to arise. Finally, *realism* is essential to avoid escalation of commitment and to recognize when a failing project has to be abandoned, especially when failure largely depends on lack of acceptance and/or support from the local population. *Focus* is needed in order to be selective. Making too many projects at the same time is not beneficial, as organizations have limited capabilities, and might even be counterproductive because excess of help hinders local development by creating a passive attitude among the population. *Selectivity* is also required at the level of the objectives. Compromises are always necessary, especially in developing countries, and projects with multiple goals require prioritizing such goals in order to be able to make well-informed trade-offs.

Business and system design

On the one hand, undertaking a project with a *business oriented approach* and entrepreneurial mind set is a powerful driver for successful implementation. “*Having a business mind set since the beginning is crucial to increase the chances of a successful implementation*” (Respondent 5). Defining a business model up-front, in parallel with concept development, allows the design team to anticipate unexpected issues that usually arise only in the rush of later stages. Finding key *partnerships* and proper *distribution channels* should be considered critical activities from the beginning of the project. Having strict *budget constraints* on beforehand is also very important in order not to lose the feasibility boundaries necessary for successful implementation. It is crucial to involve and motivate local parties to actively participate by showing them concrete opportunities of growth and *pursuit of profit*. Long-term success is highly dependent on business sustainability and many projects fail due to a lack of economical interest by all the parties involved. Nevertheless, it also has to be kept in mind that a profit driven approach should not make compromises on quality at the expenses of the locals, remembering that improving the life conditions of people is a goal just as much as making profit. On the other hand, solving effectively complex social problems requires a systemic approach. Product-Service-Systems (PSS) can bring significant improvement to a superior extent than what a product-based approach would do. Moreover PSS can be very successful in implementation because they foster the *integration of stakeholders’ interests* and make solutions affordable for users through the *creation of new business models*. Unfortunately, both multinational and local companies do not have much *familiarity with PSS* and it is quite difficult to change their mentality, which sees profit to be mainly concerned with selling products. Finally it has to be considered that systemic approaches are sometimes too ambitious, requiring major infrastructural changes that are not likely to be achieved in a short or mid-term time frame. There are cases in which simpler, product-based, projects can be more effective in targeting and quickly solving a problem.

Design strategies

The adoption of design strategies can significantly increase the chance of success in implementation. *Upgrading* and *leapfrogging* provide relevant examples. Upgradeable products evolve with changing needs and can stimulate the local

population to adopt them for a longer period of time in order to save money. Leapfrogging can foster successful implementation because technologically more advanced solutions often require less infrastructural support.

Competences and skills

Successful implementation requires various sets of competences in the design team. *Adaptation skills* are mainly concerned with the ability to deal with project development in an environment that is radically different from a cultural and socio-economical perspective. These skills are fundamental for effective intercultural interaction throughout the whole project, therefore also during the implementation phase. *Organizational skills* are also needed throughout the whole project in order to successfully manage all the activities and operations in a complex environment. *Technical skills* are essential for implementation and they are repeatedly overlooked: designers are able to conceptualize brilliant solutions but very often “*their approach is too fuzzy and they are not technically prepared enough to deal with implementation*” (Respondent 6).

Table 2: Factors impacting successful implementation of DfD projects.

Topic	Factor	N° of respondents that mentioned the factor
Business and system design	Business oriented approach	3
	Partnerships	2
	Budget constraints	1
	Creation of new business models	1
	Distribution channels	1
	Familiarity with PSS	1
	Integration of stakeholders' interests	1
	Pursuit of profit	1
Competences and skills	Adaptation skills	1
	Organizational skills	1
	Technical skills	1
Design strategies	Leapfrogging	1
	Upgrading	1
Local factors	Local participation	5
	Local acceptance	3
	Local capacity	3
	Local education	2
Realistic expectations	Focus	4
	Realism	4
	Selectivity	1
Operational dynamics	Contextual knowledge	5
	Flexibility	4
	Adequate material supply	3
	Adequate production technologies	3

	Local capacity	3
	Planning	3
Time	Long-term field support	4
	Long-term orientation	4
	Iterative processes	3
	Trial and error approach	1
Type of organization	Contextual knowledge	5
	Corporate assets	4
	Flexibility	4
	Long-term orientation	4
	Scalability	2
	Mutual learning	1
	Pursuit of profit	1
	Trial and error approach	1

Effective evaluation

Interest

Evaluation is usually considered a phase which is somehow disconnected from the rest of the project. This misconception is strongly detrimental to the quality of the evaluation itself. To increase its validity, the *integration of evaluation* is fundamental. Evaluation should be continuously performed as the project progresses in an iterative and checkpoint-based process. Spreading evaluation across implementation is also useful to gather local feedback at an earlier stage and integrate diverse considerations into the final solution. Moreover, a *critical long-term evaluation*, performed after a few years the project has been completed, is fundamental in order to properly assess the results and overall impact of the project on the local population. In spite of this “*nobody goes back there to assess long-term success five years later*” (Respondent 2). *Critical long-term evaluation* is so far non-existent in DfD due to lack of money, time and, even worse, interest in it. Time, money and interest for evaluation are essential and should not come only from one side: evaluation, especially over the long-term, should derive from a *joint effort* coming from both project developers and local parties, including population, organizations and local institutions, which should collaborate and invest on this phase.

Evaluation criteria definition

Project evaluation requires the definition of clear criteria in order to see if, and to what extent, the initial objectives were reached. A complete and thorough evaluation, such as those performed for international cooperation projects, takes into account the following objectives: objectives towards the funding, objectives towards the

locals, and learning objectives. Within this framework, a multidimensional evaluation with different sets of *pre-defined criteria* can greatly enhance the quality of the output. Design research has a primary role in the definition of the right evaluative criteria, bridging between foreign and local perspective. However, defining the evaluative criteria beforehand is never easy, especially in a developing country setting where standards and regulations are almost non-existent. Another problem is related to *data gathering* and *measurements*, which can be rather problematic due to a lack of structure in the context and tools for project developers. Indeed “*setting the right criteria and gathering the right data are the biggest challenges in the evaluation*” (Respondent 2). Sometimes the only way to define the criteria is to start working on the project and sometimes the initial criteria turn out not to be suitable for evaluation in the end. Projects evolve and a good evaluator should be able to see criteria as modifiable and dynamic as well; therefore a certain degree of *flexibility* in evaluation is also required. Project commissioners require a structured evaluation and do not welcome this kind of *flexibility*. Nevertheless, an excessively rigid evaluative framework with predetermined criteria is strongly restricting because qualitative aspects are hard to measure but they are often the most important ones. *Quantitative and qualitative evaluation* should be performed in parallel in order to provide both objective and insightful information about the project.

Evaluators

During project evaluation there is a natural and recurrent tendency to emphasize positive results and hiding the flaws. *External monitor* ensures objectivity and it is particularly crucial when dealing with DfD since many organizations are reluctant to recognize their failures and local people are hardly considered for feedback. The United Nations have been adopting this strategy for several years but in the field of design such a solution is barely contemplated. The problem is even more acute because designers are creative professionals, often lacking objective criticism towards their own work. *External monitor* has the shortcoming of being often affected by the field of competence of the evaluator, who might not know much about the project or might emphasize aspects that are not too relevant; there are many points of view from which a project can be evaluated. A *multidisciplinary approach* enhances the quality and the completeness of the output of the evaluative process. A joint evaluation effort, with multiple experts from different fields of competence,

ensures a holistic overview over the project outcome. Partial evaluations can be later analysed and summarized altogether. This approach also allows identifying specific areas in need of improvement while pinpointing responsibilities for the future.

Table 3: Factors impacting effective evaluation of DfD projects.

Topic	Factor	N° of respondents that mentioned the factor
Evaluation criteria definition	Flexibility	4
	Pre-defined criteria	3
	Data gathering	2
	Measurements	2
	Quantitative and qualitative evaluation	1
Evaluators	External monitor	2
	Multidisciplinary approach	2
Interest	Integration of evaluation	2
	Joint effort	2
	Critical long-term evaluation	1

DISCUSSION

The goal of the research was to gather from designers existing knowledge concerning specifically project implementation and evaluation in development contexts. Through qualitative interviews, several factors impacting successful implementation and effective evaluation of DfD projects have been identified. A total number of 41 factors have been clustered in 8 topics related to successful implementation and 3 topics related effective evaluation. The mentioned factors and topics have been defined with a prominent focus on tracing patterns of similarity and contrast among the answers of the respondents. For this reason some factors are mentioned multiple times within more than one topic, ultimately providing a more exhaustive and insightful perspective.

The first consideration that emerges from the research is concerned with successful implementation. All the projects discussed, in different measures, did not meet all the four criteria of successful implementation defined by the Project Management Handbook (Pinto and Slevin, 1988: 169-170) at the beginning of the research. None of the projects was in fact completed on time and on budget while meeting all the objectives that were set for it and being accepted by the targeted users (Table 1). Several respondents, in different ways, mentioned phrases such as the following: *“The impact was limited but the outlook still very promising and we were happy with*

that” (Respondent 2); “You cannot always be there because you don’t have time and money” (Respondent 3).

The second consideration that emerges from the research is concerned with effective evaluation. All the projects discussed were evaluated in different ways, at different stages of advancement and with different criteria (see Table 1). Five out of the six respondents have a design background. All of them reported a flexible view on how and when a project can be evaluated, differently from the structured approach to effective evaluation indicated by ALNAP (Beck, 2006: 3). One of them stated: *“It depends because the results can be measured in different ways”* (Respondent 3). Another one reported strong criticism on the capability of designers, as creative professionals, to evaluate their own work: *“Designers evaluating their own work would say that their work is great”* (Respondent 4). On the other hand, the respondent with a science background and who works as a consultant for the United Nations, reported a more clear cut and structured approach towards evaluation: *“An evaluation is successful if it is done in terms of objectives reached towards the founding and towards the locals. The third objective is learning from it”* (Respondent 2).

Of course, this does not imply that the interviewees’ work, which was carried out with motivation and skills, is worthless. The intent is to move onto a third, consideration and finally point out a possible direction to improve the implementation and evaluation phases in DfD practice. The research findings seem to indicate that, specifically in the subdomain of “Design for Development”, the implementation and evaluation phases are not yet rigorously regulated as they are in the domain of “Development Projects”, where, over the past fifteen years, significant steps forward have been made towards a more aware and standardized approach in these two critical phases (e.g. Baker, 2000; Beck, 2006; Benoît, 2009; Catley, 2007; Diallo and Thuillier, 2004; Gradl, Herrndorf and Kramer, 2009; Ika, Diallo and Thuillier, 2012;). The findings are consistent with the assumption presented at the beginning of the paper, pointing out that in the broad domain of “Development Projects” valuable knowledge can get lost across discipline boundaries. As already reported in the introduction, there are design methods and toolkits that aim to help specifically designers working in developing context, however, possibly for the above mentioned

reason, they do not thoroughly and systematically focus on implementation and evaluation. Some of the respondents reported to make use of these methods and toolkits and consider them beneficial for the quality of the design process in general while others seemed to be more sceptical about the use of a methodological approach in DfD. In spite of this, all respondents agreed that in DfD there is a gap of theoretical knowledge concerning implementation and evaluation. This knowledge gap has to be addressed in order to make design practitioners more aware of the challenges that arise upon project completion and support them in these two final and critical phases of a development project. The field experience of designers who have worked in DfD practice represents a rich and valuable source of knowledge to fill this gap. Accordingly, this research represents an initial attempt to do so, showing that such knowledge can (and should) be gathered more systematically, in order to be passed on to other DfD practitioners.

We envision the creation of a case study based framework for DfD practice, in which several factors for successful implementation and effective evaluation are categorized and aggregated over time by geographical areas, industrial sector and project category. Such solution would allow designers who work in developing context to learn from previous experiences, eventually foreseeing and working around challenges that often arise too late, ultimately increasing the impact of future DfD projects.

LIMITATIONS

The present study is exploratory. In the light of this consideration, the results should be seen critically as they might be incomplete or not provide a full perspective on the investigated topics. The reported factors are significantly context dependent and this affects their relative importance. The projects discussed did not meet all the criteria of successful implementation and effective evaluation defined in the research objective. For merely practical reasons, this issue was overcome by probing the respondents not only on the drivers that fostered successful implementation and effective evaluation, but also on the barriers and challenges they encountered in order to inversely extract factors from their answers. All the information in the results section is reported factually. Factually means that all the information derived from the interviews is reported in a statement form. Nonetheless, it should be considered that

such information does not represent the opinion of the researchers on the investigated topics and does not pretend to have general validity. It has to be acknowledged that even though the findings were drawn not just from the academia but also from a commercial environment and the domain of non-profit, all the respondents were indeed recruited within the academic environment of Delft University of Technology. This consideration, as well as the small sample size, affects the external validity, hence generalizability of the findings to all DfD projects.

CONCLUSIONS AND FURTHER DIRECTIONS

The present research has shown that the experience of designers who have worked in developing contexts represents a rich and valuable resource that can be used to fill in the existing gap of theoretical knowledge concerning the implementation and evaluation of DfD projects. Consequently it proposes the creation of a case study based framework as a mean to systematically gather and report the factors that underlie the successful implementation and effective evaluation of DfD projects over different geographical areas, industrial sector and project category. Further research will focus on mitigating the limitations of the present study and enrich the findings by interviewing more respondents from diverse contexts including countries, field of specialization, academia and commercial practice. A questionnaire based, quantitative follow up, will eventually provide more structure and generalizability to the results allowing to create the above mentioned case study base framework and finally test its efficacy in DfD practice.

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TOWARDS THE COMPARISON OF THE FUNCTIONAL CREATIVITY EXPECTATIONS OF VARIOUS SECTORS IN THE IT INDUSTRY WITH THE FUNCTIONAL CREATIVITY OF FINAL YEAR PROJECTS OF INFORMATION SYSTEMS STUDENTS.

Kruger, M. Matthee and M.Turpin

ABSTRACT

Many organisations today invest in creativity workshops to enhance the creative abilities of their employees in order to produce innovative ideas, products and processes. This is also true of the IT industry where there is an increasing demand to recruit creative personnel to develop innovative systems. However, the question as to the importance of creativity in the design and development of information system remains. For example, do IT managers not consider usefulness as more important, or is this considered part of creativity? Also, how do these perceptions differ between the different IT sectors? In addition, what are the implications of these perceptions of the IT sectors for the teaching of Information Systems (IS)? These are the questions this research aims to address. This paper uses the Creative Product Analysis Model (CPAM) as an interview guide to elicit the importance and expectations of creativity in IS products by various IT sectors. It is found that the different sectors do not vary much in their opinion in what a creative IS product is. They consider the value, usefulness and understandability of the systems more than other aspects of creativity. In further research, the model will be used as a point of reference to look at final year IS students' software projects to better understand how creative the projects are and how these projects relate to the IS industry's expectations of creativity.

Keywords: *CPAM, creativity, information systems, creative products*

INTRODUCTION

In the late nineties there were many senior engineers at the NASA's Jet Propulsion Laboratory (JPL) that were retiring. JPL experienced a sudden shortage in good quality engineers and went through a difficult process of recruiting and replacing the retired engineers. JPL only recruited engineers from the top academic schools like MIT and Stanford. They soon realised that many of these newly hired graduates were missing something that is crucial to their job: creative problem solving skills.

They were good at theoretical and mathematical problems, but they struggled to take a complex problem to a practical level and build a solution (Brown, 2009).

Research seems to show that this same need is prevalent in IS: to ensure a competitive advantage, the IS industry needs people with creative problem solving skills to come up with creative solutions and systems (Couger et al., 1993; Robertson, 2005). Therefore, the different sectors in the IS industry are asking for IS personnel, but more specific, for systems analysts with creative problem solving skills (Robertson, 2005). This does not tell us if the various sectors in the IS industry value creative systems more than other qualities in a system. It also doesn't tell us about their perception and expectation about creative IS products as an output of a person's practical creative abilities and skills. In addition, if creativity as a skill, expressed in a product, is important to various sectors of the IS industry, then educational institutions should be able to know if their IS students are prepared for industry, that is, they are students with both theoretical knowledge and practical creative problem solving skills that can take it to a practical level and implement a solution. These are issues that this paper aims to investigate. The current research on the role played by creativity in the design and development of innovative technological products is relatively scarce and does not provide answers to these questions (Couger, 1993; Seidel et al, 2010).

It is well known in the creativity research community that creativity is something that is within a person, a process, a product, and a press (environment) (Rhodes, 1961). In the field of psychology, the major research focus is on the person. A psychometric test can reveal a person's general creative abilities. However, the evaluation of a person's performance in a specific setting focuses more on domain-specific creativity skills. (Plucker, 1998; Lubart & Guignard, 2004; Dow & Mayer, 2004). Therefore we argue that the most visible and effective way to determine the practical creative abilities of a person, and in this study specifically the IS students, should be in the evaluation of their performance or output in the IS domain where they have the knowledge and experience to express themselves creatively in a product. Consequently, the main focus of this research study will be on the creative product as an output of a person's creative abilities.

The research presented in this article aims to explore the perspectives on functional creativity in Information Systems by various sectors and to compare it with the functional creativity observed in the IS products of Information Systems students. It is assumed that since the different sectors use systems for different purposes, their expectations for creative systems will differ. Since this is research in progress, only the first part of the study is presented. Representatives of three sectors were interviewed and the findings are presented. The sectors included for this research are Banking, Insurance and Software Development sectors. A fourth sector, Telecoms, is in the process of being interviewed. The comparison with the functional creativity of the projects of final year IS students remains to be done within the next six months. The Informatics student from the University of Pretoria will be involved in the study.

LITERATURE REVIEW

The Systems Analyst and Information Systems development

A systems analyst, according to the Oxford dictionary, is “a person who analyses a complex process or operation in order to improve its efficiency, especially by applying a computer system.” (ODE, 2011). A systems analyst is also perceived as the inventor of a computer system to help solve a real-world problem for a client (Robertson, 2005). The development of a new information system is an opportunity to improve the practice, processes or products of an organisation in an innovative way to boost value (Nguyen & Cybulski, 2008). The success of an information system depends largely on how well the systems analyst understood the defined problem as a starting point, if the requirements are correctly documented, and if an appropriate solution have been chosen and designed based on the requirements. Requirements are all about the wants and the needs of a client. The challenge for the systems analyst is to come up with the right solution for the specific problem when the problem is vague and when the client is not sure what exactly the wants or the needs are. Thus, to come up with a good solution requires creative thinking skills to invent a solution to a problem with the time and resources available (Robertson, 2005). The next challenge will be to implement the creative solution to make it practical and useful for problem solving. Creativity skills (specifically novelty) is not always about coming up with a new product to solve a problem. Creativity skills can

also include the re-engineering of outdated systems or business processes, improvement of old systems' quality and robustness, and applying existing systems in new ways. (Lobert & Dologite, 1994).

Creativity

Creativity, as a research topic, has a long history that has its origins in psychology and arts. (Guilford, 1950; Amabile, 1982, Torrance, 1987). The word 'creativity' was not a well-known word until the 1950s. The word did not appear at all in the 1933 edition of The Oxford English Dictionary. (Pope, 2005). It was only after Guilford's influential speech about creativity in 1950 that research on the subject of creativity started growing in psychology and soon expanded to other disciplines as well. (Guilford, 1950). It was only during the 1980's that creativity gained recognition in the Information Systems field as something that should be researched. In 1988, there were barely any research papers available on IS and creativity. Due to this lack of research papers, the Center for Research on Creativity and Innovation (CRCI) has been established in 1990 by Daniel J. Couger in the USA. According to Couger, the research papers produced between 1990 and 1996 were labelled as the first generation of creativity/innovation research in IS. The IS industry started to realise the need for formal training on creativity. By 1995, content about creativity has been included in the curriculum for undergraduate degree programs in Information Systems in America. (Couger, 1996). Couger was one of the first researchers in the Information Systems discipline who looked at creativity as a necessary skill that people and organisations should have to be competitive. (Couger, 1993).

Functional Creativity

There are many definitions about what exactly creativity is. These definitions vary from defining the ingenuity of a person to the uniqueness and beauty of an idea or product. Many researchers have agreed that when we investigate a creative product, the following properties describe it: flexibility, correctness, integrity, understandability, economy, interoperability, reusability, validity, modifiability, generality, modularity, testability, clarity, usability, resilience, portability, maintainability, efficiency, utility, novelty (Couger, 1992; Buckley & Poston, 1984). When looking at definitions of creativity and the properties of a creative product, the most common property that a person should be able to observe is the concept of

novelty (i.e. something new or original). Although the concept of novelty is a necessary element in the domain of arts and aesthetic products, it seems not to play the same role when looking at creativity in a technological or engineering product (Besemer, 2006; Cropley et al., 2011).

Guilford argued that the purpose of creativity is to have something that is also useful (Guilford, 1950). Mumford and Gustafson define creativity as the ability to produce both novel and useful ideas; or ideas that can be put into practise to solve a meaningful and unique problem (Mumford & Gustafson, 1988). In organisations a creative idea or product must also be useful. (Amabile,1996; Couger, 1993; Cropley et al., 2011). Products, such as information systems, that perform tasks or solve problems relates to a type of useful creativity, or creativity with a goal (Burghardt, 1995; Horenstein, 2002). David Cropley and Arthur Cropley combined these terms of novel and useful creativity and called it '*functional creativity*'. (Cropley & Cropley, 2008). Functional creativity can be observed and evaluated in a product if the observer or user of the product understands what the problem was as a starting point to appreciate the product as a functional creative solution. The design and development of information systems requires an understanding of the problem as a starting point and end as an information system that is a functional and creative product or solution to the problem.

For the purpose of our research we shall refer to this definition by Plucker, Bugethi and Dow who state that creativity is "the interaction among aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context" (Plucker et al., 2004).

Functional Creativity in IS products

Creative ideas usually become purposeful by expressing it in some kind of product. Based on the definitions discussed on functional creativity, we argue that an information system is a functional creative product which originates with a creative idea to solve a problem. The idea goes through a process of design and development in a specific social context, which is then expressed in a product that is both original and useful to the industry. When looking at functional creativity we can say that the concepts of novelty and usefulness should form the foundation of any

functional creative product. Boden observed creativity as novel, valuable, and surprising (Boden, 1994). Some researchers includes 'elegance' of a product as part of being creative (Madni, 2012; Cropley & Cropley, 2008). An elegant system design is about the emotional connection that it generates within the user through its use, appearance and feel (Madni, 2012). Although elegance is not the main creativity property in a functional product, it does contribute towards the degree that a user connects and enjoys using a functional product.

If an IS product can meet a customer's need then it is not important if the system is a completely new solution to a problem or an existing system applied in a new way (Couger, 1992). Thus, a functional creative product should have the ability to meet a customer's need in order to gain the desired admiration and respect. Couger believes that novelty is about the imaginative recombination of known elements (Couger et al., 1993). The design and development of a functional creative product relies on the application of existing knowledge and skills in new ways in order to accomplish a goal (Seltzer & Bentley, 1999). Savransky (2000) elaborates on this view of novelty and states that novelty can either be a completely new solution to a problem or a change to existing methods or systems.

Functional creativity, as observed in a product, cannot tell us all there is to know about a person's creative abilities due to the influence of the process and the environment on the outcome of a product. However, it can tell us something of how a person understood a problem, came up with ideas to solve it, and then on a practical level made it happen.

There are researchers in the field of psychology who are of the opinion that the evaluation of creative products should be the starting point for any research on creativity (MacKinnon, 1987; Besemer, 2006). Many researchers agree that there is a level or a degree of creativity in any product. Creativity in a product is not an all-or-nothing property (Beghetto, et al., 2001). Previous research studies that relate to the assessment of creativity in IS products looked at the impact of creativity support systems or decision support systems on individual creativity (Massetti, 1996; Elam & Mead, 1990); or the assessment of creative IS ideas (Lobert & Dologite, 1994). Researchers like Couger and Dengate were among the first to introduce a framework to measure creativity in IS products. (Couger & Dengate, 1993). Their

framework looked at measuring the 'utility' and 'novelty' criteria of a software product on a scale of low, medium, and high. This framework was used by a panel of judges to assess six innovative software products in the industry to see how they have contributed towards novelty (e.g. new technology, algorithms, etc.) or economy (such as to increase on Return On Investment (ROI), customer retention, retaining market niche, etc.) (Couger & Dengate, 1993). Although this is a good starting point to look for creativity components in a software product, it only looked at specific software projects, specific novelty, and economic components. Also, there was no distinction between the opinions and expectations about creativity in software from different IS sectors.

Literature on the assessment of creativity in an Information System as a creative, physical, and practical product, is scarce. Cropley confirmed this by stating that there is limited research that looks at the assessment of the creativity in practical and technological products. (Cropley et al, 2011). These studies usually focus on one aspect of creativity in a product, such as 'Elegance' (Madni, 2012; Salado & Nilchiani, 2013), or 'Usability' (Han et al., 2000).

Domain-specific Creativity and IS product development

Cropley says that products that are novel and useful originate from an existing knowledge base and that these products are accomplished through systematic hard work. (Kaufman & Sternberg, 2010). Can a person with a general high score on creative abilities perform creatively in many different domains such as writing, arts, music, engineering, etc.? Many researchers agree that creativity is both general and domain-specific, depending on the evidence that you look at. Psychometrical tests focus more on the creative abilities that a person have in general (Guilford, 1967; Torrance, 1974), whereas the assessment of a person's performance in a specific setting focus more on domain-specific creativity skills. (Plucker, 1998; Lubart & Guignard, 2004; Dow & Mayer 2004). We know that all people are creative to some extent. (Taylor & Sacks, 1981; Torrance, 2000; Gordon, 1961; Maslow, 1959; Rogers, 1970). However, a person can only express himself in a creative way within a specific domain if he or she has the knowledge and experience to do so. (Ericsson, 1999; Weisberg, 1999; Dow & Mayer, 2009). When a person has the knowledge and learn the skills of a specific domain, then it increases a person's creative abilities in

that specific setting. For example, a child is very aware of the crayon in his hand when drawing for the first time. This hinders creative ability. It is only after lots of drawings over a period of time that the child becomes unaware of the crayon in his hand and focus more on being creative in drawing a picture.

In conclusion, research on the functional creativity in IS products is scarce. This paper attempts to address the gap in literature by investigating the opinion on functional creativity of information systems as understood by various sectors in the IS industry. It will also aim to understand how functionally creative final year IS students' projects are and how it relates to the expectations from these various industries. The next section explains how this research is being done.

RESEARCH DESIGN

This paper aims to determine the perspectives of different sectors in the IS industry on the importance of functional creativity in their information system design and development and compare this to the functional creativity of third year projects of IS students. The final year Informatics students of the University of Pretoria will be involved in the research.

Research Paradigm

The Information Systems field is complex in nature because it deals with both technology and people aspects. Interpretive research helps us to understand the social context of an information system (Oats, 2006). Information systems are designed for people by people and the idea of creativity and its importance has subjective meaning for each person. Thus, this study will make use of an interpretive approach to explore the perceptions and expectations of functional creativity in IS products by various sectors in the IT industry. It will also look at the creative ability of IS students as potential system analysts for industry (Cresswell, 2013). An existing creativity heuristics will be used as theoretical framework to guide the investigation. This model is discussed in the next section.

The Creative Product Analytical Model

The theoretical framework that will be used in this study is the Creative Product Analytical Model (CPAM) of Besemer (2006) which defines and evaluates creativity

(including functional creativity) using nine components. These nine components, divided into three groups are novelty (surprising, original), resolution (logical, useful, valuable, understandable), and style (organic, well-crafted, elegant) (Besemer, 2006). Each of these components is visible and measurable elements in a product which can be evaluated. The model is based on thirty years of research in the field of psychology and has been thoroughly tested on many different products for functional creativity. It has also been successfully used in an IS study to assess creative ideas (Lobert, 1994).

This framework will serve as a starting point to explore the different perceptions about functional creativity by various sectors in the IS industry. The reason for this is that creativity is such a wide concept and needs some framework or structure to guide an observer of a product systematically to recognise the creative properties of a product. If a person is asked about his/her perspective on the importance of creativity in information systems, the person might jump to conclusions on how 'weird and wonderful' a product should be in order to be creative. However, if a framework is provided of what functional creativity is all about and asks that person to first evaluate the framework and then explain what his/her perspective is on functional creativity in an IS product, the answer might be of better quality. Table 1 provides an explanation of the different components of the model.

NOVELTY	RESOLUTION	STYLE
The degree of newness in the product in terms of the number and extent of new materials, new processes, and/or concepts included	The degree to which the product fits or meets the needs of the problematic situation	The degree to which the product combines unlike elements into a refined, developed, coherent whole, statement or unit. (How well the solution is presented to the world).
Surprising	Logical	Organic
<i>The product presents unexpected or unanticipated information to the user, listener, or viewer.</i>	<i>The product or solution follows the acceptable and understood rules for the discipline.</i>	<i>The product has a harmonious sense of wholeness or completeness about it. All the parts "work well" together.</i>
Original	Useful	Well-crafted
<i>The product is unusual or infrequently seen in a universe of products made by people with similar experience and training.</i>	<i>The product has clear, practical applications.</i>	<i>The product has been worked and reworked with care to develop it to its highest possible level for this point in time. Quality</i>
	Valuable	Elegant
	<i>The product is judged worthy because it fills a financial, physical, social, or psychological need.</i>	<i>The product shows a solution that is expressed in a refined, understated way. Simplicity</i>
	Understandable	
	<i>The product is presented in a communicative, self-disclosing way, which is "user-friendly."</i>	

Table 1. The creativity framework designed by Besemer (2006).

This approach and theoretical underpinning do not aim to make any predictions due to the subjective nature of the interview data of the participants. This study will use

and analyse the interview data gathered from various sectors in the IS industry and discussions of student projects to compare, describe and explain perceptions and expectations of functional creativity of Information Systems. Figure 1 below depicts how the CPAM framework will be used for exploring and evaluation purposes:

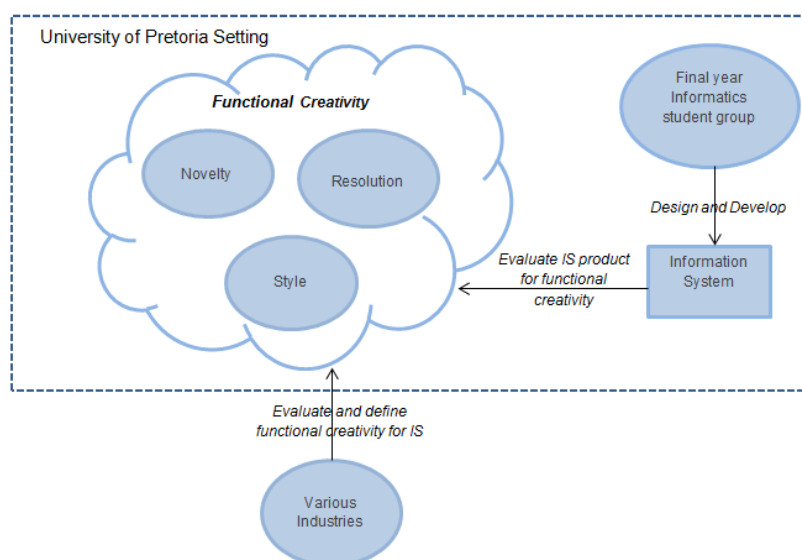


Figure 1. Theoretical framework for how CPAM will be used.

Research Methodology

Data gathering

IT Managers and IT directors in various sectors in the IS industry have been identified who are directly involved with systems design and development. These managers and directors are in the process of being interviewed. Managers and directors in general have more expert knowledge in their field of systems design and development for their specific industry sector as well as the knowledge about the company's philosophy and strategy of software development. Four IT managers or directors from each sector have been invited for an interview via email. These managers and directors were randomly selected from the top performing companies in their industry sector. The four main sectors where IS students start their careers are Banking, Insurance, Telecoms, and Software Development firms. It is assumed that each of these sectors has a different approach and focus on software development and what they perceive innovation to be. Open-ended face-to-face interviews were used to gain a deeper understanding of their experience and perception of functional creativity in software systems development. More structured

questions were used to understand their opinion of the CPAM, whether they agree with the model, want to change it, or perhaps want to remove something that they don't agree with when it comes to software design and development. All interviews were recorded and transcribed and notes were taken.

The following questions were asked during the interviews with each IT manager or director to help fill the gaps in literature that this study aims to answer.

The interviewer started the conversation on a discussion of what functional creativity is and presented the CPAM as a starting point for the conversation. The following questions were asked by the interviewer:

- a. In your opinion, is functional creativity (CPAM) important when it comes to the design and development of an information system or software product in your industry sector?
- b. If you have to weigh and rate each component in this model in order to reflect its importance in systems development in this specific sector, how much weight will you put next to each component in this model?
- c. Is there anything in this model that you would like to add or take away that you don't agree with in what you experience daily with systems design and development in your industry sector?
- d. Are there any other things that are more important in an information system product than just being creative for this sector?

These managers will be invited to come and experience and observe the final year projects of the Informatics students from the University of Pretoria later this year for creativity according to CPAM. Each manager or director will have access to all documentation with regards to the student project to understand what the problem was and what the solution is. They will also have access to the information systems developed by the students to use it as an end-user would to appreciate the creative elements of the system.

These students are doing the BCom(Informatics) degree at the University of Pretoria. This comprehensive degree includes both business and IT modules. The aim of the

Informatics degree is to cultivate systems analysts that are involved in the complete systems development life cycle (SDLC) – from understanding the problem statement, gathering the necessary requirements, designing and modelling the best system solution, developing, testing, and implementing the system for an industry user. Final year Informatics students have to put all their skills and knowledge into practice to build an information system for a client in the industry. This is done in groups of not more than five students. There is an underlying assumption that a final year Informatics student is a creative problem solver due to the domain knowledge, skills, and practical experience they have.

Data Analysis

The aim of the research is to stay as true as possible to the meaning of the original words during analysis. A theme analysis was done on the interview data of the IT managers to identify the main themes that emerged from the data. A summary of each interview will be created emphasising the main themes. These interview summaries will be sent to each interviewee to verify if they agree with the content and that it is a truthful reflection of what was discussed.

FINDINGS

Below is the data available of the various sectors interviewed so far and the data collected. The three main components of functional creativity were rated, weighed and discussed during the interview. The 'Novelty' component rated the lowest across all sectors with a weight between 5% and 20%. The 'Resolution' component rated the highest in importance across all sectors with a weight between 50% and 80%. The 'Style' component rated as second important factor when it comes to software development with a weight of 15% to 40% across all sectors. The numbers in the diagram below is an indication of how much each sector values the components of CPAM. A rating of '1' means that the component is more valuable or important to that sector than a rating of '2' or '3'. For example, the Banking sector adds more importance to the 'Logical' aspect of functional creativity with a rating of '1' than the Insurance sector with a rating of '2'. The Banking sector values 'Well-crafted' and 'Elegant' as equally important with a rating of '1' for both components. The 'Useful' component for the Software Development sector vary much from one software development company to the next and there was no specific pattern.

Towards the comparison of the functional creativity expectations of various sectors in the IT industry with the functional creativity of final year projects of information systems students.

			VARIOUS INDUSTRIES							
			Banking	Importance	Insurance	Importance	Software Development	Importance	Telecoms	Importance
F u n c t i o n a l C r e a t i v i t y	Novelty	Surprising	2	Low - Less than 5% important	2	Low - Less than 5% to 10% important	1 or 2	Low - between 5% to 20%	No data	No data available get
		Original	1		1		1 or 2		No data	
	Resolution	Logical	1	High - around 80%	2	High - around 80%	1 or 2	High - between 50% and 80%	No data	No data available get
		Useful	3		3		Varies		No data	
		Valuable	2		1		1 or 2		No data	
		Understandable	1		4		1 or 2		No data	
	Style	Organic	2	Low - around 15%	1	Low - around 15%	2	Medium - between 20% to 40%	No data	No data available get
		Well-Crafted	1		varies		1 or 2		No data	
		Elegant	1		varies		3		No data	

Table 2. The perspectives on functional creativity (CPAM framework) of various sectors in IS industry.

DISCUSSION

From the data collected so far it seems as if there is no clear distinction between various sectors on how they value and perceive creativity in IS according to CPAM. All these sectors share more or less the same sentiment with regards to creativity in IS products.

With question (a), almost all managers and directors in all sectors agreed that functional creativity is important in information systems development. There was only one manager in the Insurance sector who mentioned that sometimes creativity in a product can be a bad thing. Although it can be great for innovation, it can also be a scary thing. Once you have success with a good creative information system, then it becomes the standard in the organisation and managers are expecting that level of creativity in all information systems development. It becomes impossible to live up to that standard because creativity is special and rare. With question (c), there was no manager or director who wanted to add or remove any component from CPAM to improve this model or change it in any way. Some of them were actually surprised and found this model very interesting because they haven't thought about creativity

in this way before. The main discussions came in with question (d) where managers and directors all indicated that functional creativity is great but that it is not everything. These other aspects speak more about the things around the information system as a creative product rather than the physical creative properties. As previous research has already shown (Couger et al, 1993; Besemer, 2006; Cropley and Cropley, 2008; Amabile, 1996) the '*Resolution*' component of functional creativity is valued the highest and '*Novelty*' the lowest when it comes to IS related functional products. All sectors agreed that most systems are already in place and it is basically like following a recipe to create the next software solution. It is only in rare occasions that there is the opportunity to really be creative and invent an innovative product. Most companies agreed that whenever they have the opportunity to bring novelty into the product, their first priority will be to be original rather than surprising. The highest level of '*Novelty*' was found in the Systems Development sector – especially where companies have more freedom to use technical skills, technologies, and expert knowledge on how to approach a specific industry problem. Sectors like Banking or Insurance are much more constrained by legislation and organisational product rules that it really is all about '*Resolution*'. Most companies also prefer the '*Style*' aspect above '*Novelty*', but there is no clear preference per sector. It really depends on the IT manager's personal philosophy about Style in a product rather than it be a critical factor for the sector as a whole. All managers in all sectors agreed that '*Style*' is very important in a creative IS product. From the interviews it became clear that managers consider other aspects more important than only having a creative product. These will be discussed below for each sector. These aspects speak more about the process or the person rather than the product.

Other Aspects

Banking

In general the banking industry is governed by legislative requirements which make it a bit more difficult to be creative in IS product development. The most important factor that the banking sector value more than just having a creative system seems to be the IS employees that needs to develop the system. They need to value quality. If a person values quality within everything they do, then it will pull through to everything else.

Insurance

Similar to the banking sector, the insurance sector has also legislative requirements and value creativity in information systems in a similar way. From the interviews it became clear that their online systems should be highly creative because they don't see their customers face-to-face most of the time and rely on the information system to fulfil that role. However, they do value the following aspects as more important than a creative information system:

- Change management process: This is the process that needs to be in place to prepare the system users of what changes the new system will bring about. This helps especially to prepare the system users for the 'Novelty' aspect of the system. If this process is not in place, then system users easily rejects the information system.
- The development process: The choice in process, SDLC versus Agile, of system development plays such a big role in being successful or not. An iterative design process or agile methodology contributes towards a successful creative system that serves the needs and expectations of the end-user(s).
- Requirements gathering: The problem statement for the product development should be more and regularly questioned rather than only accepted and just do what needs to be done. Without critical questions there cannot be a good quality creative product. IS personnel quickly develop a tunnel vision about product development because they don't ask enough questions.
- Attitude: An IS personnel's lack of positive attitude towards any challenge or project can stand in the way of developing a creative system.
- Maintenance: If a creative information system is not maintained well after implementation then it becomes useless.

Software Development Sector

The Software Development sector contributed the following factors as being more important than a creative information system:

- Expert skills and knowledge (both business and technical): The challenge is not the development of a good creative information system but rather to recruitment of good quality IS experts. If you can recruit the right experts, then they will design the creative system that you need.
- Development process: It was again mentioned just as with the Insurance sector that a company cannot develop creative systems by still using the SDLC process.
- Affordability and probability: The information system as a creative product can be highly creative in all aspects of CPAM, but if it is not affordable for the client and profitable for the organisation then being creative has no value.
- Problem meditation: Think about the problem and meditate on it before embarking on the process of creating a product. Have time to get bored with it so that you can start being creative with developing a product or solution. It is difficult to invent a creative product or solution if there is no time to really think about it.
- Integrating systems: An information system can be very creative by itself, but if it cannot co-exist or be integrated with other IS products then it becomes useless. Thus, the art of integration between various products is very important.
- User experience: What the end-user experience from the information system really determines the success of any creative IS product. User experience is on a deeper level than just admiring a product for being creative.
- Environment: If a manager cannot manage his/her IS employees well and give them the trust and freedom that they need then people will not perform as expected and trust is broken.

Expected Contribution

This research study is hoping to make a contribution in the following ways: From the findings of this study, faculty teaching IS on tertiary level might adjust their teaching or evaluation process to take into account what is expected from industry

regarding creativity. The IT Industry might rethink the way in which they advertise for and think about creative staff. Also, they are given the opportunity to give feedback to higher institutions who are educating their future employees. It will be the first time that functional creativity will be evaluated in an information system that was designed and developed by IS students as a creative product.

Limitations to Research

This research study is limited to the investigation of the functional creativity of IS products of final year Information Systems students and how it compare to the expectations of the IS industry. It will on a high level recognise the creative process that leads to the creative product, such as group dynamics, but it will not attempt to analyse the process at all levels. It will also not attempt to investigate the role of the creative environment in which product design and development occur. Possible limitations in data might be the small sample size of students' projects, the three industry sectors, and also the sixteen managers and directors who represent the different sectors in the IS industry.

CONCLUSION

It is clear that all sectors in the IS industry value a creative or innovative information system. The reality is that that with a tight budget and timeframes the 'Resolution' (logical, useful, valuable, understandable) aspect the most important component in the functional creativity framework is. Style and Novelty become a nice-to-have. This correlates with the findings from research done by Couger et al (1993) and Cropley and Cropley (2008) of the importance of 'Resolution' in any functional product. Novelty seems like a scare commodity and if it is available to an organisation that it will be used sparingly. The Software Developing sector seems to value Style much more than other industries. All sectors agreed that there is something else that they value more than just developing a creative product. These factors relate more to the creative person or the creative process that feeds into the creative product.

The next phase of this study will happen later this year where invites will be sent to industry managers of these various sectors to have a look at, use, and discuss the students' information system projects. The aim of this will be to see if these systems are creative according to CPAM and what components of functional creativity the

students focussed on. It will also be interesting to see how industry values the student projects according to what they perceive as important in systems design and development.

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YOUTH EMPOWERING THE YOUTH THROUGH PARTICIPATORY SERVICE DESIGN

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ABSTRACT:

Immediate and sustainable interventions are required as a result of an extremely high unemployment rate among youth in Southern Africa that is leading to many socio-economic ills. We postulate that the inclusion of youth into participatory service design activities can unleash their dormant potential of creativity, technological inclinations, as well as their energy to resolve youth related issues by themselves. We have conducted a series of participatory sessions, deploying a variety of techniques, with a selected group of unemployed youth in Windhoek. Having jointly explored and identified the socio-economic context, youth skills and preferences, the group has determined “self-actualization of youth” as the theme to be tackled over the next months through different actions. The actions include self-development, youth helping more vulnerable youth and the creation of a technical platform for communication, fund raising, project planning, and mobilization of other youth. The approach has demonstrated that given the opportunity and a conducive environment a group of unemployed youth have been engaged beyond our expectations in self-actualization activities to fight current societal troubles, such as abuse, crime, illness, etc. We have identified a substantial lack of youth services in Namibia. Thus the openness of participatory service design applied to the vast field of youth unemployment services, allowed the youth participants to identify and self-determine services to be developed and thereby take ownership of the action.

Keywords: *Underserved youth, Namibia, participatory design, service design, self-actualization, unemployed youth*

INTRODUCTION

In Southern-Africa, many less qualified youth are being excluded from economic life by a combination of joblessness and barriers to the creation of start-ups. Frye and Kirsten (2012) stated that, failure to address the development priorities of youth potentially undermines social cohesion and social reproduction. Unleashing the energy, entrepreneurial spirit, and technological genius of the young people is not

just a moral imperative, but an economic necessity. These unemployed youth can be transformed into useful human resources by unlocking their creative and innovative minds. Some of them possess special gifts or talents with which they could become very productive citizens, without necessarily undergoing formal educational processes of attaining academic qualifications as per current job market requirements. However there is a general lack of opportunities and services targeting these groups in Namibia.

An increasing rate of youth unemployment sets demands on innovating new services for unemployed youth. In order to succeed, a deep understanding of the unemployed youth, their consumption, need of services is required (Cooper and Schindler, 2006). Additional learning prospects, such as technical and vocational forms of training, post-school and extra-curricular career initiatives, as well as special skill development, and talent discovery and management services, besides many other youth services are nearly non-existent in Namibia.

In this paper we present our current initiative where we are engaging a group of unemployed youth in participatory service design, thereby unleashing their potential and positive attitude towards resolving youth issues in Namibia. Presented with an opportunity to become active agents, the youth demonstrated their deeper understanding of the socio-economic settings as well as the desire to contribute to a major change by empowering themselves and fellow youth. The focus is on the design method as tool for empowerment rather than the resulting product developed.

A PARTICIPATORY APPROACH TO SERVICE DESIGN

Service Design (SD) can be defined as the activity of planning and organizing people, infrastructure, communication, and material components of a service in order to improve its quality and the interaction between service provider and customers (retrieved from <http://www.service-design-network.org>). The purpose of service design methodologies is to design according to the needs of customers or participants, so that the service is user-friendly, competitive, and relevant to the customers. According to Stickdorn and Schneider (2011), “*service design is all about making the service you deliver successful, usable, efficient, effective, and desirable.*”

Service design (SD) as an approach takes the user as the centre of the design process and considers all the factors surrounding the user. In the SD landscape, users or rather people who will benefit from the design are invited into the design process as partners. During the SD process, methods that enable and give the user power to have influence on the service design process are used. SD ensures the inclusion of citizens by using co-design tools. The use of different design methods, design research, design thinking and various visualisation techniques link different stakeholders' views during the service design process.

Participatory SD draws from a long tradition of participatory design, which was born out of worker movements in Scandinavia in the eighties, empowering workers to co-create their working space. Since then, participatory design methods have been refined and adapted to ICT development among other disciplines, recognizing the end users as content experts and valuable participants in the design process itself. While user-centred design attempts to model potential users, participatory design involves the users from the onset into the development process. Discussions and developments have centred on the politics of design, the nature of participation and techniques to facilitate participatory design projects (Kennsing and Blomberg, 1998).

Within participatory service design the user or client's context, resources available, and needs are jointly explored and mapped. User participants uncover many opportunities and produce viable ideas that solve problems and create solutions that can be implemented. Often an iterative process, where ideas are tested, improved, and missed opportunities and refinements done within the development process are applied (Davies and Wilson, 2013). Davies and Wilson further added that PD uses prototyping to test results, plans, and process maps to implement the solutions. In this context, tools and techniques used in participatory SD ensure that the user experience created is consistent and guarantees a positive user experience. Participatory SD therefore seems to be a most promising approach in empowering unemployed youth to deal with their own socio-economic setting and derive viable solutions.

PROJECT CONTEXT

The potential of unemployed youth in Namibia

Considering the high number of unemployed youth, we are investigating the prospective of participatory SD as an approach to unleash the youths' potential to contribute towards viable solutions and services for unemployed youth in Namibia. Namibia has a population of approximately 2.1 million people based on the census figures from 2011 (National Planning Commission, 2011). Approximately 60 percent of the population consists of the youth, aged between 15 and 24 years. According to the Labour Resource and Research Institute (LaRRI, findings based on Shindondola-Mote, 2011), 75 percent or more of Namibian youth are unemployed. The percentage of unemployed youth per age group decreases with the age. For the youth between the ages of 15 to 19 years was 86%; youth between 20 to 24 years was 67.4%; youth between 25 to 29 years was 53.3%; and youth between 30 to 34 was 46% (Mwinga, 2012). Without a clear intervention or 'an external shock' it is unlikely that the level of unemployment in South Africa or Namibia will decrease (Banerjee, Galiani, Levinsohn, McLaren and Woolard, 2006). At the micro level, the employability of the youth is tied to education, experience and skills, hampering youth transition from marginalised environments (Mlatsheni and Rospabe, 2002). The prioritisation of special skills and talents among the youth in South Africa and Namibia will pave the way for newly defined career paths, increased number of self-employment as well as employment opportunities, besides a general level of national growth in innovation. As well as engaging the youth in service design, we seek to study techniques and support tools needed to promote these untapped talents. The investigators will explore the use of innovative participatory service design to survey above-average abilities and interests, high levels of task commitments and creativity. This approach will lead to the design of technology and interventions for youth development, which will open avenues for new career paths and promote grassroots innovation.

Project Participants

The participating youth were recruited from the last cohort of youth trained by RLabs Namibia. Reconstruction Living labs (RLabs) was established in 2008 by a Marlon Parker in South Africa as a community driven research collaboration project between

the Cape Peninsular University and a community Non-governmental organisation Impact Direct Ministries (Parker, Wills, and Wills, 2012). Parker et al added that RLabs' aim is for community members to be developed, empowered, and encouraged through the use of innovative Information Communication Technologies (ICTs) solutions. RLabs has expanded its innovative community driven social venture to over 21 countries including an RLabs Namibia. RLabs Namibia is situated at the Namibia Business Innovation Centre (NBIC), a unit within the Polytechnic of Namibia which aims at "providing an implementation medium to influence innovation and technology to address the challenges and apprehension in communities in Namibia, creating an environment where people are empowered to make a difference in the lives of others" (<http://nbic.polytechnic.edu.na/innovators/rlabs-namibia/>). RLabs Namibia provides ICT related training courses to unemployed youth aimed at empowering them to use social media platforms so that they could become social media trainers, social media marketers, and self-employed entrepreneurs.

Out of a cohort trained in 2013, we invited all the youth that were not permanently employed at the date of our first contact session. Thirteen youth attended and committed to a continuation of the joint initiative. The group consisted of seven female and six male participants. Nine of them are in the range of sixteen to twenty-four, three of them in the range of twenty-five to twenty-nine and only one above thirty. All of the participants were literate in English reading and writing as well as computer literacy.

Project approach

A first initial half day workshop was held with the youth to explore their context as well as skills and preferences. In the second workshop, distributed over two days, a common theme of action was decided and subsequent joint sessions contributed towards the implementation of a solution. The workshops involved game playing and exploration of different technologies such as collages, role plays, Legos, context mapping, think aloud, sticky papers and evaluations of a series of open discussions and brainstorming. Beyond these variations in content, we aimed for consistency in as many aspects of the workshops as possible. All the workshops took place in a large lab that was part of the RLabs at the Namibia business innovation centre

(NBIC). The room was set up so that several tables were pushed together for the round-the-table activity in one area. In another area, a computer was set up with a connection to projector for youth presentations. All workshop sessions were video recorded. In the following sections we shall present the methods deployed in the sessions and workshops as well as the results.



Figure 1: Game Construction (left) and open discussion and brainstorming activities (right)

EXPLORING CONTEXT AND SKILLS OF UNEMPLOYED YOUTH

The purpose of the initial workshop was to identify youth preferences through exposing them to a number of activities throughout the afternoon. The workshop started with a short project aim description followed by a self-introductory round, where the members were tasked to identify something unique about themselves. Making new friends, DNA and singing were common answers among the participating youth.

Firstly we engaged into contextual mapping to identify the youths' spaces of activities and existing services and infrastructures. During the context mapping activity, the participants were tasked to identify things that are associated with the youth, during this process, a step by step mapping was done, which included; identifying most important places both formal and informal, organizations/people, Youth Services, Youth Social Activities, Education and Training, Health, Information and communication, Local economy and business, and other Opportunities. The results were summarised as shown below;

Table 1: Youth context

Important places	Organisation and people that are important	Youth services	EDUCATION AND TRAINING
✓ Kapana ✓ Warehouse ✓ Home ✓ Mall ✓ CBD ✓ FNCC ✓ NBIC ✓ The lodge ✓ Museum ✓ UNAM ✓ Polytechnic ✓ Cinema ✓ Church ✓ Stadium ✓ Gym	✓ Rlabs ✓ NBC ✓ NYC ✓ FNB ✓ MTC ✓ Old mutual ✓ MVA fund ✓ Traditional chief ✓ Telecom ✓ Avon ✓ Young achievers ✓ Afriyan ✓ UN ✓ Parents	✓ Youth empowerment ✓ Youth training ✓ MTC sports ✓ FNB student's account ✓ UNFPA international networking ✓ Career fairs	✓ Rlabs ✓ Church ✓ VTC ✓ NBIC ✓ WAD ✓ NTA ✓ IDCL ✓ Afriyan ✓ Poly ✓ NYC ✓ UNAM ✓ NAMCOL ✓ Libraries
How they make money?	Social activities	Information and communication	
✓ Reselling clothing ✓ Avon representatives ✓ Working ✓ Family : pocket money ✓ Graphic designs ✓ Compensations ✓ Facebook managing	✓ Facebooking ✓ Cocktails ✓ Social networking ✓ Potjie ✓ Pizza ✓ Super aweh ✓ Live performances ✓ Dancing ✓ Sports ✓ Gym	✓ Social Media ✓ Print media ✓ TV/RADIO/VERBAL media ✓ Workshops ✓ Library ✓ Forums ✓ Cellular phones ✓ Billboards	

During activity two, sticky papers were used to engage youth to identify problems, challenges, strength, youth's spirit and general community spirit in brainstorming manner. Each topic was written in different coloured sticky paper. Figure 2: shows the outcome of the sticky paper activity.



Figure 2: Brainstorming (left) and outcome of sticky paper activity (right)

Problems and challenges faced by youth identified in this activity were; passion killing, human capital, teenage pregnancies, collateral, unemployment, environment pollution, lack of resources, financial problems, substance abuse, school dumping, lack of education, alcoholism, drug abuse, ignorance, sexual abuse, rape, and educational fund. While their strength was in: washing cars, taking advice, dancing, fast, patient, multi-tasking, talkative, entertaining, good friendliness, entrepreneurship ability to mention but few. They also pointed out that; feeling like a million dollars, safe, you can never achieve anything, jealous, happy, envious, free, sense of belonging, useless, neglected, sad and rejected was mixed general community spirit and finally hard work, being inspired, empowered, educated, experienced, caring, happiness, unity, creativity and energetic are youth spirit.

In the third activity, collages were used to evoke and identify individual dreams and aspirations of the youth. They were first tasked to pull pictures from newspapers, magazines, articles that had some emotional attachment to them, and thereafter they were requested to assemble them into a personal collage. All the collages were hung up around the room. Figure 3 shows the activity of the collage pulling and a sample collage. Figure 4 shows a frequency count of the images glued on the individual collages.



Figure 3: Collage picture pulling (left) and sample collage (right)

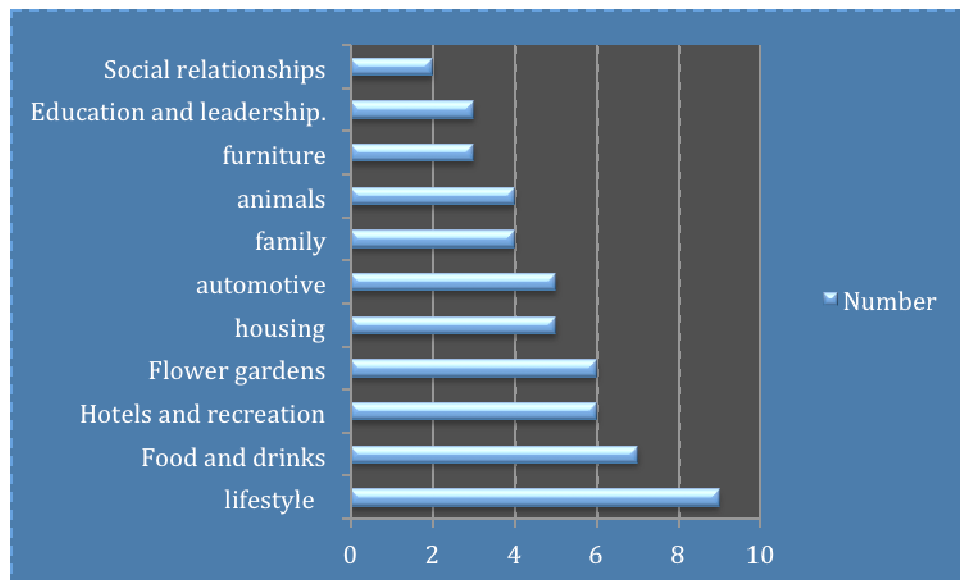


Figure 4: Frequency count of items on youth collages

In order to explore real case scenarios around the concepts mentioned by the youth during the sticky paper activity, we adapted the well-known role-play also known as acting to the conditions, as a fourth activity. In this setup we chose a list of words extracted from previously recorded challenges, strength, problems and youth spirit during stick paper activity. Each group of 3-4 youth received a handful of randomly mixed terms and was requested to develop a play integrating those terms. They were given as little as 15 minutes to draft a script and then to act it out. During the acting process we noticed that youth was very creative in their expressions. One group composed an original song using (Confident, passion killing, Speak-out) words given to them, using passion killing as chorus. Another group depicted skills such as

guidance and counselling, HIV prevention and awareness campaign and medical enthusiasm.

The team emphasised that even people living with HIV and AIDS can be innovative to start-up businesses and live happy life instead of living with frustration or committing suicide. A third group used poverty, happiness, and alcohol abuse as a least words given to them to exhibited marketing and entrepreneurial innovations in their act. It was very surprising to see them juxtapose activities around poverty, prostitution, and alcohol and road accident in business ideation. For example they staged a car washing next to a bar and were able to convince some taxi drivers, who according to them were potential causers of road accidents to wash their cars while they are sobering up after drinking. The fifth group were given; education, encouraged ,excited and responsible least of words, they used these words to staged role-play depict the role of parents most especially a father in streamlining the behaviour of their children, their play showed that some school children drink a lot of alcohol during evening hours, sleep while in class without their parents noticing. These same children are lured into sex in exchange for alcohol or drinking money, while some of them are raped when drunk in drinking places. This was a very educative skit to parent the youth on HIV prevention and parents were advised to be vigilant on location of their children when not at home, and what they do or if at school whether they are attending classes.

Construction was the last activity for the workshop. Different material were distributed on the tables ,e.g. legos on one table, wooden blocks, wooden building parts, plastic connection toys on the other tables. The individual participants could chose the material they would like to work with thereby a natural grouping occurred. The first group used wood to construct the home stead, with Kraal, fence, houses, and shading. They chose wood because they liked building and working with wood. The second group used lego building blocks. At first they started by building a house, but as they kept on adding blocks it turned out to be a defensive tower with big and small guns attached to every corner of the tower. A second house turned to be car; according to them if there were any cases of insurgences, the tower could be used to defend people and car for retreating in whenever a need arose. The third group constructed cross and wind direction; according to them it's very important that with

this they would always remember the death and resurrection of Jesus Christ through the cross. They choose those tools because there are colourful. The forth group also used marble building blocks to come up with a flow channel representing their life. And finally the last group constructed a tractor and a bridge; according to them, since it was the rainy season, the tractor could be used for ploughing and the bridge to connect farmers to the market.

At the end of the day all youth agreed that it was a worthwhile workshop and that they would like to attend the next one as soon as possible. We transcribed all data recorded as well as thematically coded the data to comprehend the context and the aspirations of the youth.

SELF-ACTUALIZATION OF YOUTH

The second workshop extended over two days with the purpose of identifying a common goal for action with the youth. The workshop was divided into three major parts, the first inspecting reality, the second fantasizing about a better future and the last looking at a path to realize a better future for the youth. Firstly the youth were asked to take the role of a journalist and report on a critical topic of concern in their community. They were given 24 hours to report back on the following day, having used internet research, own investigations and searched for public opinions. In groups of three they designed a newspaper featuring their stories, while one youth who was very skilled in video recording produced a documentary on gender based violence. The video featured a number of youth in his community who gave their opinions on the topic. It shed light on a number of issues around gender based violence.

Three newspapers were then written, each with various journalist articles and one documentary "1000 questions on passion killing" were presented based on their investigations. The first article by a group of youth was said to be a newspaper "Ohera Namibia"; it had three inspiring articles which include: community library, "I don't know" syndrome and citizen being worried about the increasing number of shacks in the country. The second newspaper "Namibian yesterday" focused on the increasing number of homeless children that ended up as street kids, the rampant road accidents and men at road sides. And lastly the third newspaper named "Erero"

had articles such as; meat sold in most stores as nothing but the rip-off, whether Namibian vision 2030 was a reality, youth identity “Be yourself. Who you are”.

In the second part, the youth were encouraged to immerse into a fantasy where they could create a perfect world for youth. They were given colour pens and modelling clay to use at their free disposal. The drawing process and discussion during the drawing and clay modelling sessions provided valuable insights into different perspectives. It deduced discussions on aspects of great importance to their lives. They were randomly chosen to discuss what message they tried to pass using the creations. The first discussants believed that perfect youth was an entrepreneur always busy doing something like managing the big restaurants, creating jobs for others. The second discussant believes that the perfect youth were successful person, team of two discussants used fruitful tree and flower basket to represent perfect youth according to them in form of flowers and fruits showing that perfect youth were those who were beneficial to others around them, another discussant believes that the perfect youth were happy youth and used smiling models to depict this. The last discussant used a boat to represent perfect youth sailing towards greener pasture such as nice cars, huge houses. Figure 5: depicts the design-through-drawing and modelling sessions.

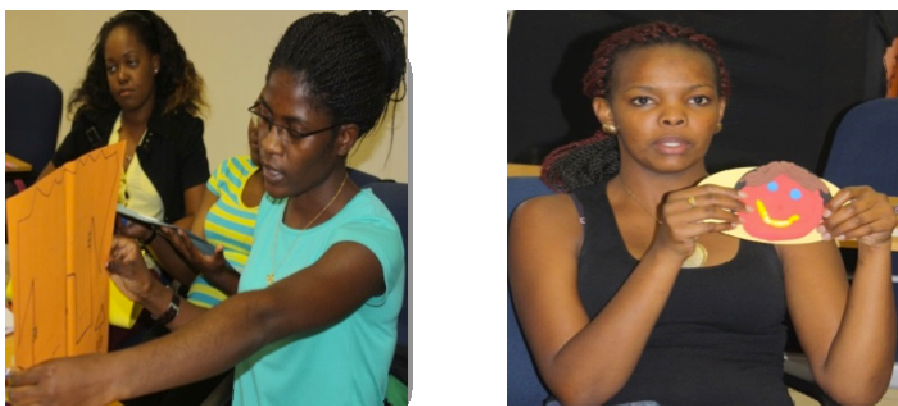


Figure 5: Design-drawing and modelling sessions

The third part of the workshop engaged youth in extensive brainstorming and discussions in order to agree on a joint theme to tackle over the months to come. While the previously mentioned problems of society such as abuse, crime, and unemployment were worthwhile fighting, the youth recognized that they were just

symptoms of deeper causes created by society. Using a tree symbolizing societal ills as branches, questions arose around the root causes. Pictured in the tree diagram in figure 6: below, youth attitude towards life associated with lack of responsibility, colonised minds and lack of vision were identified as the cause of problems faced by underserved youth, such as road accidents, insecurity, unemployment and domestics violence which in turn emanated to other sub categories of problems such as pregnancy, poverty. To solve these, the root cause identified namely the youth's attitude must be addressed first. Creation of youth platforms, workshops with youth, career campaigns, youth forum conference, mobile applications were some of the suggested solutions that could be used to change youth attitude. According to the youth if these approaches were used, it would enable the youth to realise their potential therefore changing their attitude and mind set towards life. This led to the immergence of "self-actualisation for youth (SAY)" as the agreed project theme.

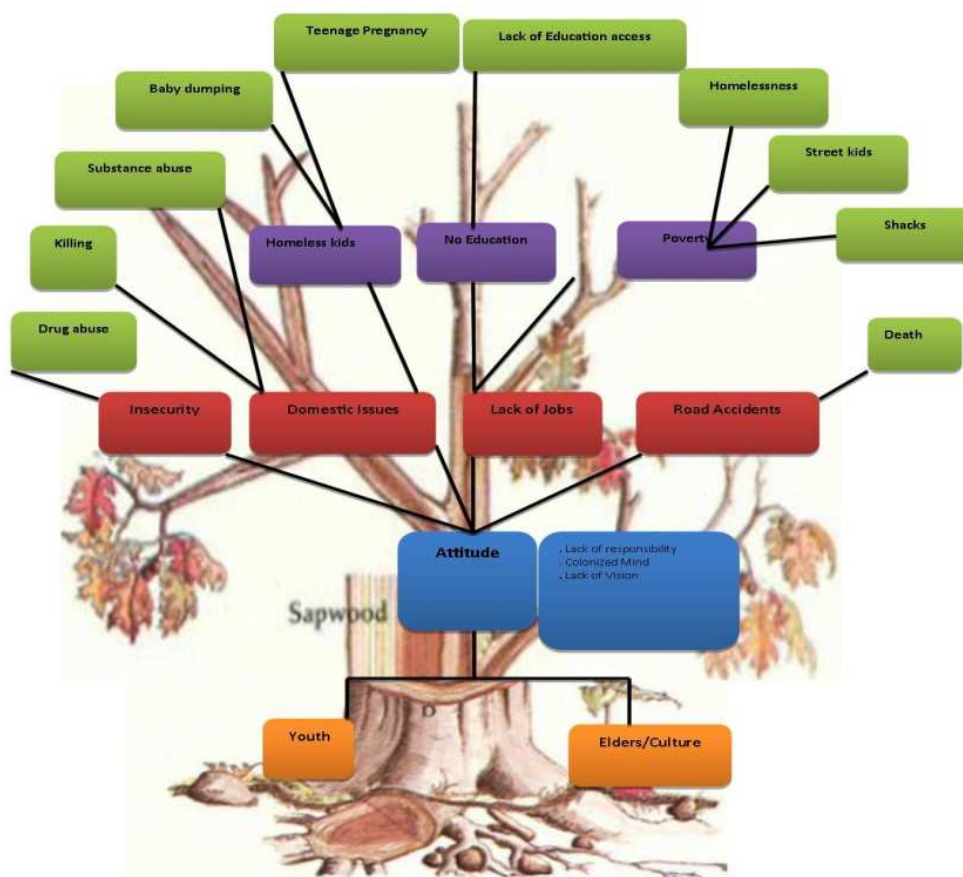


Figure 6: Tree-structure of theme formulation

Self-actualisation is a psychological term describing a person reaching one's full potential (Maslow, 1965). Maslow also recognised some of the key characteristics of self-actualised individuals, which corresponds one to one with the desired output as expressed by the youth: Self-actualised people have a realistic vision of themselves, others, and the world around them. Self-actualised people are those concerned with helping others and finding solutions to problems in the external world. These people are often motivated by a sense of personal responsibility and ethics. Self-actualised people are spontaneous in their internal thoughts and outward behaviour. While they can conform to rules and social expectations, they also tend to be open and unconventional. Another characteristic of self-actualized people is the need for independence and privacy. While they enjoy the company of others, these individuals need time to focus on developing their own individual potential.

At the end of a long day workshop the youth was so enthusiastic that they decided to meet the next day again to start taking actions towards self-actualization.

ACTION FOR EMPOWERMENT

Our ongoing efforts of supporting the youth in their realization of their self-defined goals have started with a couple of sessions addressing specific objectives. After inspecting suggested actions and the definition of self-actualization, we divided the activities in three groups focusing on different segments of self-actualization. Firstly we identified self-actualisation for the individuals themselves, that would involve helping the youth identify themselves, in other words self-help strategy would be used here; Secondly a problem-centric view with youth taking action to help more vulnerable youth. The most urgent action identified was to support out-of school kids living at the dumpsites in Windhoek. Suggested actions were to in the future organise community outreach programs, community campaigns, career development outreach, educational support, and fund raising. And the third activity was to create a technology supported platform to have a wider outreach and to have a shared platform for unemployed youth to support each other. The platform will also support the other two activities.

6.1 Self-actualization support for individuals

This includes many activities that would help the youth identify themselves by realising their potentials, capabilities, and abilities. It helps the youth have a vision in life that they work towards to and have a purpose in life. Once they have self-actualised, they would then identify another community from a very different community in Windhoek where the youth need to be exposed to activities and hence helping others self-actualise. The objective of these activities, is to give youth hope and purpose in life, that living is so much more and it not only about being idle and involved in things that are not positively contributing to their growth.

Youth helping youth: Action - Dump site

This action practice is about helping others that are more unfortunate than themselves. The participants suggested engaging dumpsite kids in Windhoek, as reported in the local Namibian Newspaper (A 'dumpsite' for people with nowhere to go, 2007). Besides campaigns, regular visits were proposed to make the kids feel loved and assured of help, and to ensure a sustainable change. Further workshops would be scheduled where these dumpsite kids could be counselled and career guided in their own languages. This exercise will help them realise their potential. During dumpsite campaign workshop, the youth also suggested that dumpsite kids should be subdivided in small groups with people they are comfortable with. The experience attained from these campaigns could then be used in other regions as well while using the transformed former dumpsite kids as example to others.

Youth technology platform

The youth created their own facebook group page as a platform to exchange encouraging quotes as well as plan activities. In the second instance a design session was held to identify all features of the system to be implemented. To encompass the dumpsite campaigns and youth self-actualisation, the participants identified tasks to design a platform and suggested the following requirements to be implemented in the tool; online counselling and career guidance functionality, streaming option to keep records of tv and radio shows or campaign sessions held by youth, implementation video, audio, and flash multimedia, download and upload photos, videos and articles system, online forum, crowd-funding campaign and sms gateway systems, links to other social sites such Facebook, twitter, advertising page.

REFLECTIONS ON YOUTH AND PARTICIPATORY SERVICE DESIGN

At the sentiment of participatory service design activities applied in this research, it is essential for the youth who will be affected by the new technology to have full participation. These approaches were originally employed in work-settings, however it has been noticed that the field has diversified not only to include non-work settings in the design of technologies that are increasingly becoming embedded within peoples' everyday lives, but also to accommodate a variety of approaches and views (Bodker and Pekkpla, 2010). One issue about which there is still some debate concerns the extent of the users' role (Winters and Mor, 2008) and the importance of mutual learning between designers and end-users (Béguin, 2003). Our approach has taken the perspective that the unemployed youth can be empowered to develop technology that could help improve their career paths hence improving the livelihood of impoverished, less qualified youth as they are being neglected from job markets.

Many of the workshop activities were grounded in tangible, hands-on activities and brainstorming. We made use of observations, video recording and camera photos. The observations and video recordings of all workshop activities used held so far were reviewed and reflected upon, and were a mechanism for the researchers to contribute to the design activities, in part replacing the oral and written contributions that other PD techniques elicit from participants. We allowed lots of time, holding two workshops and a number of supporting sessions over a period of 2 months.

As researchers, it was interesting to observe that the commitment of participants to attend the workshops. They remained relatively the same number with the exception of one youth who had prior obligations. We observed that the youth were committed and motivated to make a change in their lives through participatory co-design methodologies.

During the participatory design workshops held with the unemployed youth, the researchers discovered the act of co-designing with the participants empowered them to reflect on the positive contributions that they could make towards societal needs. We also discovered how the youth were driven and motivated to empower themselves and others in their communities.

The exposure of the participants to the different game playing activities such as the construction, role plays, brain storming and discussion session amongst others lead to them discovering various creativity and hidden talents in themselves.

Conclusion

We documented the initiative in which we empowered unemployed youth in the design of technology and solutions while they did not have any strong academic background. The technology to be developed will be used as an alternative path way to empower further underserved youth. Careful consideration of methods chosen was observed in order to facilitate effective participation of unemployed youth.

As regards to participatory service design workshops with youth, there was significant value attained when the researchers engaged the unemployed youth using various design methods and tools such as hands-on activities, game playing and acting and brainstorming. At the end of research process, the youth were able to identify their strength and values. This was evident when they proposed the adoption self-actualization for youth, dumpsite campaigns and technology platform as the remedy to youth's negative attitude toward life. We noticed that none of the researchers had any idea on solutions raised during design process. In terms of the process, we found considerable benefits in carrying out the participatory service design workshops over an extended period of time thus enabling strong bonding amongst the youth and the researchers and continual reflection of the processes and allowing it to evolve; in taking time in the participatory workshops, and in ensuring as much consistency in as many of the different aspects of the process as possible.

With the perspective of an increasing scope of innovative technologies, with wide range of possibilities of using participatory service design practices to empower local community, we argue that other design projects must embrace the message that, with the use of relevant methods and tools, they can empower affected communities in designing appropriate yet viable solutions.

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AN EMPIRICAL ANALYSIS FOR THE MOBILE LEARNING INFORMATION SYSTEMS USER EVALUATION

A. Bere

ABSTRACT

Extant literature on task technology fit has often emphasised task characteristics and technology characteristics as the prime determinants of effective task technology fit. Since any process of task technology fit cannot be conceived without considering user characteristics. The author argue that any pre-occupation with task technology fit from the perspective of task characteristics and technology characteristics that does not embrace the individual (User) characteristics is unrealistic and unauthentic. Contributing to contemporary debates on task technology fit, this study provides perceived ease of use, perceived usefulness and social influence as antecedents providing enabling conditions for the sustainable uptake of emerging technologies. Drawing on these antecedents this study develops a factor model and empirically tests it on South African tertiary students to explore their task technology fit and including the performance enhancement of a mobile instant messaging system. The study, which involved 175 national diploma students at a South African University of Technology employed partial least squares for statistical analysis. Overall, the proposed model displayed a good fit with the data and rendered satisfactory explanatory power for mobile task technology fit. Findings of the study suggested that perceived ease of use, perceived usefulness and social influence are the drivers for task technology fit within the m-learning environment. The study also confirmed the statistical significance of the original task technology fit constructs.

INTRODUCTION

The Unicef (2012) report findings indicate a 30% per annum growth for mobile phone adoptions in Africa within the 2002 to 2012 period. Sanou (2014) the director of the International Telecommunications Union (ITU) claim that the number of mobile-broadband subscriptions will reach 2.3 billion by the end of 2014, with 55% of them in developing countries. The report went on to state that Africa recorded the highest in mobile-broadband growth globally. Its diffusion stretches close to 20% in 2014, up from 2% in 2010. In 2012 Africa was estimated to possess around 750 million mobile connections. Availability of low cost handsets and cheap SIM cards contributed to the 20% increase in the embracement of mobile phones in South Africa from 2005 to

2010, particularly among the youth (Unicef, 2012). The world's emerging economies are speculated to foster economic and social development through the appropriation of Information Communication Technologies (ICTs) in form of mobile systems (Hystra, 2012).

The Hystra (2012) report identified education as one of the essential areas that mobile technologies can foster a quantum leap of evolution in servicing development for the resource constrained nations. According to Looi et al. (2010) the current students belong to the digital generation. This generation integrated the exploitation of emerging technologies such as collaborative social networking systems, video, photo exchanging, and podcasting in their lifestyles. Apart from making phone calls, cellphones are also used for accessing the Internet, social networking, and podcasting on the move, particularly by the digital generation. Utilisation of these ubiquitous emerging technologies in education promotes information sharing, and informal peer mentoring. Furthermore, these emerging technologies enable facilitators to work unrestrained by time and place. Students enjoy learning in these 'informal' platforms more than in 'formal' learning environments (Looi et al., 2010).

Despite mobile technologies' potential to transform lives and availability of adequate technology for scaling up, very few mobile learning (m-learning) projects have had success in reaching scale (Hystra, 2012; Roberts and Vänskä, 2011). It is essential to establish factors that influence m-learning adoption and craft strategies that can help bring these innovations to scale in developing countries (Hystra, 2012).

The purpose of this study is to establish factors that promote higher performance impacts within the m-learning environment. These factors will improve m-learning adoption and subsequently enhance effective learning using mobile devices. The WhatsApp mobile instant messaging (MIM) application will be utilised as the learning platform. The Task Technology Fit (TTF) theory will be used as the theoretical lenses for this study.

The contributions made by this study are double folded: Firstly the study contributes to the body of knowledge for the TTF theory through an extended model. Individual characteristics antecedent extended the TTF theory. Utilization factor was omitted in the modified TTF model proposed in this study based on the argument that

performance impacts can be realised after utilisation. However, this study assumes that utilization is embedded within the performance impacts antecedent.

LITERATURE REVIEW

The literature review for this study is structured in the following headings: Mobile learning, Theoretical framework: Task technology fit; and the proposed model.

Mobile Learning

Shih et al. (2012) defined m-learning as “a learning paradigm which takes place in a ubiquitous computing environment”. These m-learning environments enables people to learn at their convenience in terms of place and time, and it is suitable when a high mobility of learning atmosphere is required to situate students in an authentic learning environment. Looi et al. (2010) posist that the portability and flexibility of mobile devices have the possibility of supporting an educational transformation from instructive teacher-centered to active student-centered learning. In the mobile learning environs, the lecturer facilitates the learning process, rather than being viewed as an exclusive proficient of knowledge. Previous research findings on m-learning documented that the mobility and connectivity of mobile emerging technologies enable students to turn into active participants rather than passive receivers in instructional delivery activities. Instead of just learning through listening to the lecturer, students with mobile devices can experiment with new avenues of learning, and share their experiences with others (Roschelle, 2003;Squire and Klopfer, 2007).

The potential for m-learning to facilitate the mobility of the context of interaction could promote effective education from both the instructor's and learner's perspective. According to the Centre_for_Digital_Education (2011) a recent technique in m-learning allows the lecturer the mobility to create learning materials anytime and anywhere, by using mobile technologies with specialised software. As such, Looi et al. (2010) argues that “the new notion of m-learning foregrounds a transitory context in which all learning resources (interacting peers, educators, pedagogical content, the enabling technology) are all “on the move”. Mobile learning therefore breaches the spatial, temporary, time zones by bringing educational resources at the disposal of the roaming learner in real time”. It also lends itself to overcoming the shortfalls of

traditional instructional delivery, especially its reliance on transmission of pre-packaged content, delivered by specific individual academics at specific times and at specific venues. Essentially, it grants the learners considerable power to choose what they desire to study and when they want to study, and from which place they will study (Ally, 2009; Brett, 2011; Schulman et al., 2012). Learning through mobile devices is flexible because it affords learner engagement beyond the prescribed materials, through their interaction with peers, senior students and the extended academic community. The m-learning strategy broadens learners' learning space by extending learning beyond the closed walls of classrooms to informal spaces, augmenting the learning community of information seeking students, and recruiting the participation of thought leaders formerly beyond the reach of learners (Schulman et al., 2012).

'Anywhere and everywhere' learning milieus accommodate learning that takes place both privately and collaboratively (publicly) and across different contexts. Interestingly, mobile digital inclusion overpowers the notions of traditional learning where the location, time and environment for learning are regarded as important factors for effective instructional delivery (Chu et al., 2010). The learning environment is no longer defined by attending class, and rather by the instructional delivery, unimpeded by scheduled class periods. Handheld mobile technologies have enabled students to learn both in formally and informally, during and after school sessions. Learning responsibilities are at times student-initiated, hence promoting students to take control of their learning (Looi et al., 2010).

The following projects report on previous utilisation of student centered m-learning approaches.

Brett (2011)'s study conducted in the United Kingdom documented initiatives to promote collaborative learning using Short Message Service (SMS). In this study students academically interacted with their peers and facilitator in a virtual platform, thereby enjoying flexible mobile learning, since learning could be supported anytime and anywhere. However, students' overall experiences with the exploitation of mobile technologies for pedagogical delivery were positive. Additionally, the SMS usage for creating interactive learning opportunities was reported to be successful. Brett argues that an effective m-learning environment can be achieved through

improved staff development, and more dialogue with mobile learners. The flexible learning notion is in line with Kukulska-Hulme and Traxler (2005), who claim that m-learning is centred on flexible learning, facilitated by hand held electronic gadgets.

In the United States of America m-learning was adopted in the military medicine. The findings of the m-learning military medicine study suggest that mobile learners were motivated, persistent, independent and goal-oriented. As a result, m-learning was reported to be effective and its effectiveness was linked to reduced study time, owing to self-directed learning. The study reported that mobile learners gained the same knowledge in about one-quarter of the time needed to provide it in traditional didactic lectures (Schulman et al., 2012).

In 2008, the South African presidency requested a project exploring the usage of mobile technologies to enhance educational activities. In 2009 Imfundo Yami/Yethu Project was rolled out to 30 secondary schools. The project utilised MixIt, a mobile instant messaging platform, to support mathematics teaching and learning for grade 10 learners. Findings suggest that convenient learning, playful learning, and flexible learning significantly contributed to the successful adoption of this strategy (Roberts and Vänskä, 2011).

The three m-learning projects stated above clearly indicate the m-learning perspectives that contribute to performance impacts. In this paper the TTF theory was applied in an effort to establish factors that have potential to promote m-learning adoption which therefore result in mobile academic performance impacts in the South African tertiary institutions context.

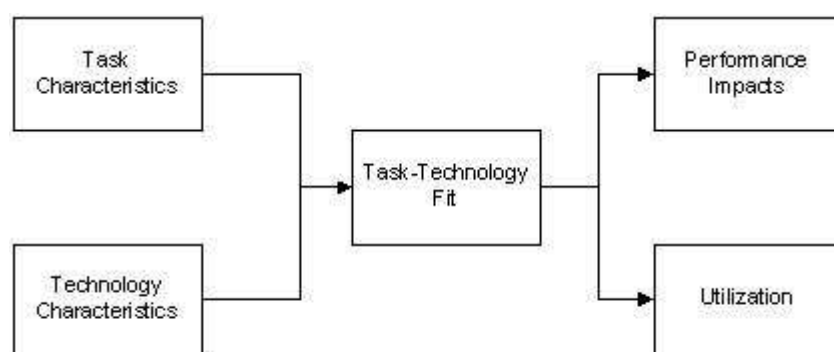
Theoretical Framework: Task Technology Fit (TTF)

The first dimension in the TTF framework is the fit between the technology and the task (Wei and Liang, 2004). According to other researchers, TTF suggests that a high task technology fit will result in better performances. TTF is a construct referring to the ability of an information provider to support task matching technology capabilities to task demands (Klaus et al., 2003).

TTF theory holds that information technology (IT) is more likely to have a positive impact in individual performance and be used if the capabilities of the IT match the

tasks that the user must perform (Goodhue and Thompson, 1995). Goodhue and Thompson (1995) developed a measure of task-technology fit that consists of 8 factors: quality, locatability, ease of use/training, production timelines, system reliability, relationship with users' intake and authorization. TTF has been applied in the context of a diverse range of information systems including but not limited to electronic learning, electronic commerce; and electronic health systems. Figure 1 below presents the original diagram for TTF theory.

Figure 1. Original Task technology fit model

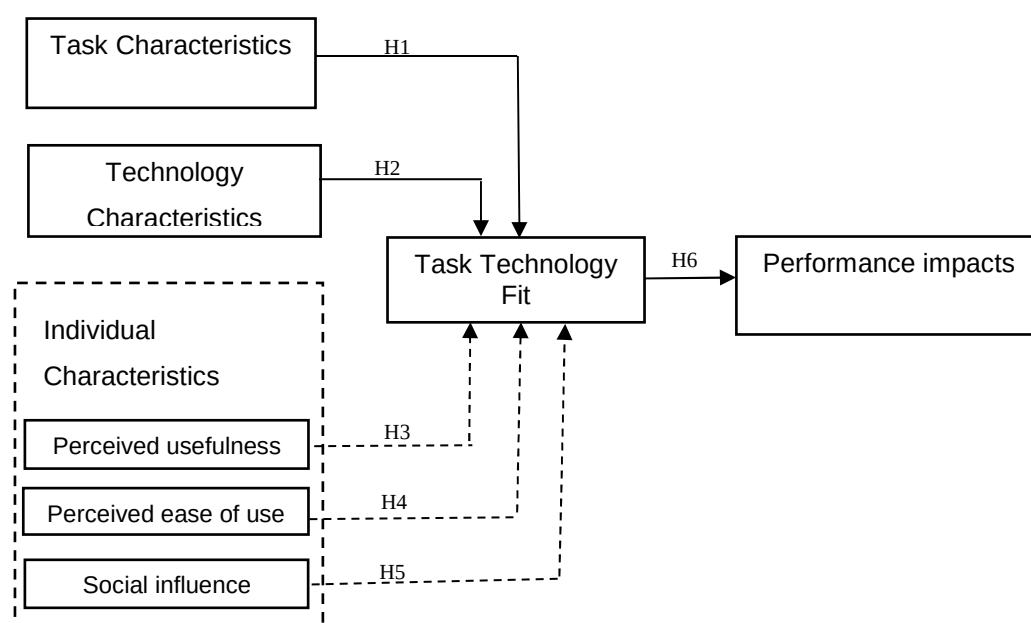


Source: Goodhue and Thompson, (1995)

The Proposed model

The proposed model for this study is presented on Figure 2.

Figure 2. Proposed Task technology fit model



Task characteristics

In the TTF theory, tasks refers to activities performed by people in transforming inputs to outputs for the purpose of satisfying their information needs (Goodhue, 1995). Task characteristics are the attributes for a task that can be executed using information technology communication technologies (ICTs). Tasks can vary in a number of dimensions: task non-routineness, task interdependence, and time criticality (Goodhue, 1995;Goodhue, 1998). The task considered in this study is learning. The aspects of learning that can be achieved using M-learning are the task characteristics focus of this study. These main task characteristics for this study include: Studying using MIM, academic collaboration using MIM, assessment preparation using MIM, peer mentoring and academic support using MIM just to name a few. The following hypothesis was developed based on this background information about task characteristics:

H1: Task characteristics have a positive influence on task technology fit.

Technology characteristics

Goodhue (1995) defined technology is the tool that is either hardware or software used by individuals in carrying out their tasks. The aspects of technology tools may influence technology utilization and users perception (Goodhue, 1995;Goodhue, 1998).The TTF model considers the importance of fitting the functionality and attributes of technology used to the demands imposed by individual needs. In this study technology refers to mobile devices that can be used to support the MIM for academic purposes. The attributes for mobile devices and for the MIM that hinder or support learning constitute technology characteristics.

The following hypothesis for this study was developed against technology characteristics.

H2: Technology characteristics have positive influence on task technology fit.

Individual characteristics

A previous study on TTF have revealed the significant role of the individual characteristics like perceived ease of use and perceived usefulness as the drivers for satisfaction (Brown et al., 2013). Furthermore the technology acceptance model (TAM) also identified perceived ease of use and perceived usefulness as the key

contributors to technology adoption (Davis, 1989). Venkatesh et al. (2003) extended TAM, among other things they identified social influence as another individual attribute that influence adoption of new technology. In this study individual characteristics antecedent is made up of three attributes namely: perceived ease of use, perceived usefulness and social influence. Perceived Usefulness refers to ‘the degree to which a person believes that using a particular system would enhance his/her job performance’(Davis, 1989). Perceived ease of use refers to how mental and physical effortless one should apply on using new technology (Davis, 1989). Social influence occurs when one's emotions, opinions, or behaviors to adopt new technology are influence by others (Venkatesh et al., 2003).

The following hypothesis have been developed against the individual characteristics construct:

H3: Individual characteristics facilitated by perceived usefulness has positive influence towards task technology fit.

H4: Individual characteristics facilitated by perceived ease of use has positive influence towards task technology fit.

H5: Individual characteristics facilitated by social influence has positive influence towards task technology fit.

Task technology fit

Goodhue (1995) reported that “individuals’ interactions with an information system are often intertwined with their task-technology and individual-adoption behaviours”. The TTF may be assessed by considering the individual’s satisfaction level about the extent to which a system’s operational activities meets the individual task needs (Goodhue, 1998). The TTF entails the association between task requirements, individual abilities, and the functionality of the mobile device and the WhatsApp MIM application. Further TTF has been linked to the criterion of personal performance, which can be used in the larger context of considering the impact of information technology on individual performance.

The following hypothesis has been formulated based on the task technology fit construct:

H6: Task technology fit based on academic appropriation of MIM has positive influence on students' productivity (performance enhancement).

Performance impacts

Performance refers to the successful completion of the task activities by an individual. Performance impact means an improvement in the successful completion of tasks. High TTF increases the performance impact of the system (Goodhue, 1995). Tertiary students adopt mobile devices for the academic utilisation of WhatsApp MIM. A high performance implies a high level of task-technology fit, and satisfaction with adoption of mobile technologies for the MIM for academic utilisation (Goodhue, 1998).

METHODOLOGY

The methodology for this study covers the study population, research procedure; and measurement items.

Study population

The study was carried out at a University of Technology in South Africa. The study considered Information Technology students registered for Bachelor of Technology (BTech) Internet programming module and third year diploma students registered for Information systems (IS). The study took place in the first semester for the 2013 academic year. The institution had 35 BTech Internet programming students and 263 Diploma third year IS students. Based on this population all 35 BTech students participated in the study. The study included 244 third year IS students. The total study population was 279. These participants possessed web-enabled mobile devices capable of downloading and installing WhatsApp mobile instant messaging. Participants' age ranges from 20 to 31 years.

Research procedure

The researcher uploaded a manual on ethuto (Institutionally supplied learner management system) which guided students on downloading and installing WhatsApp application on their mobile devices. The manual also contained a section on basic WhatsApp usage in order to support those that had limited knowledge on

the operation of WhatsApp MIM. The lecturer used an open door policy for further training on WhatsApp usage. Mobile devices used by participants included but not limited to Smart phones, PDAs, iPhones, iPads and tablets. The lecturer randomly placed BTech students into virtual discussion forums groups comprising of at most 10 participants per cluster inclusive of the lecturer. Randomly placing students in groups addressed perceived knowledge and power differentials between peers, since students could only view a peer's cell numbers (call ID) and not peer's names hence ensuring the anonymity of interactants in intra-cluster interactions. The study involved two cohorts with different discussions (BTech discussions different from Diploma discussions). Any participant and the lecturer were free to post questions and contributions at anytime from any section of the syllabus. Group members were encouraged to provide feedback as quickly as they could. Those that were unavailable were also allowed to respond as soon as they become online. In an effort to provide effective learning, participants were heartened to research and think critically before responding. The lecturer played a facilitator role by chipping in especially when students are stuck. The lecturer was actively involved during assessment preparation, where he assisted with assessment answering techniques. Students who could not participant in the WhatsApp initiative were encouraged to create similar clusters on ethuto.

Measurement Items

A thirty-eighty measurement items instrument was initially developed. The researcher conducted a pilot study meant to ensure the validity and reliability of the measurement items instrument since it was the bases of the study questionnaire. The pilot study also enabled identification of items that should be revised. Twenty participants were randomly selected from the population of the study. Participants of the pilot study were asked to identify vague and ubiquitous measurement items and they were asked to suggest some recommendations to enhance the measurement items. The thirty-five final measurement items for the study were produced after analysis of the pilot data and subsequent revisions in the wording of a few items resulting in the omission of three measurement items from the original instrument. Table 1 below shows the measurement items employed in this study.

Table 1. The measurement items

Variable	Item	Measurement Items
Task Characteristics	TC1	I use MIM for studying
	TC2	I use MIM for academic collaboration
	TC3	I use MIM for assessment preparation
	TC4	I use MIM for peer mentoring
	TC5	I use MIM for academic support
	TC6	Use of MIM is advantageous for effective learning
Technology Characteristics	TECC1	I use various formats (text, audio, video; and etc) for Academic engagements
	TEEC2	I access previous academic engagements for revision purposes using MIM
	TECC3	Due to mobile phones' size, I carry it around and learn anywhere and at any time.
	TECC4	Mobile smart phones screens are reasonable for supporting MIM academic engagements
	TECC5	Mobile technology are effective learning
Individual Characteristics	ICPU1	Academic use of MIM is useful for studying
	ICPU2	Academic use of MIM is useful for academic collaboration
	ICPU3	Academic use of MIM is useful for assessment preparation
	ICPU4	Academic use of MIM is useful for peer mentoring
	ICPU5	Academic use of MIM is useful for academic support
	ICPU6	Overall, academic use of MIM is useful for effective learning
	ICPEOU1	Academic use of MIM is easy to learn
	ICPEOU2	It is easy to navigate in an MIM platform for learning purposes
	ICPEOU3	It is easy to download peer academic contributions on a MIM environment
	ICPEOU4	It is easy to upload academic contributions on a MIM platform.
	ICPEOU5	Overall, using MIM for academic purposes is very easy
	ICSI1	I use MIM for learning because my lecturer recommended it
	ICSI2	I use MIM for learning because my friends are using it
	ICSI3	I use MIM for learning because it is a fashionable way of learning
	ICSI4	I use MIM for learning because I would like to prove to my friends that I am not technophobia
Task Technology Fit	TTF1	I have a an option of studying privately or publicly using MIM
	TTF2	I could get feedback timely in a MIM learning environment
	TTF3	I could learn anonymously using MIM
	TT4	I could learn at my convenience in a MIM learning environment
	TT5	Academic use of MIM fits my learning needs
Performance Enhancement	PE1	Using MIM for learning improved my academic participation
	PE2	Using MIM for learning improved my question answering techniques
	PE3	Using MIM for learning enhanced my interest for learning
	PE4	Academic usage of MIM has overall improved my academic performance

RESULTS

This section of the study presents the results.

Main Survey

A sample of at least 175 participants would be ideal for achieving 95% confidence (El-Gayar et al., 2011). The questionnaire was administered by online means to 279 participants. Two hundred and thirty one questionnaire were returned but eight were discarded due to incomplete completion. The usable returned questionnaire were 223 which constituted 80% response rate and it surpassed the minimum recommended sample size. Table 2 shows the demographics for the 223 returned questionnaire.

Table 2. Demographics

Variables	Variable Category	Frequency	Percentage
Course	Diploma IT	192	86.10%
	Bachelor's Degree IT	31	13.90%
Gender	Male	98	43.95%
	Female	125	56.05%
Age	< 21	8	3.59%
	21-25	168	75.34%
	26-30	45	20.18%
	>30	2	0.90%

Overall Model assessment

The study used the confirmatory factor analysis (CFA) to establish the reliability, convergent validity and discriminant validity of the proposed model. The Partial Least Square (PLS) was employed for the overall model assessment. Application of Cronbach's alpha and composite reliability are appropriate for testing construct reliability. The values acceptable for both Cronbach's alpha and composite reliability must be at least 0.7 (Fornell and Larker, 1981). The Cronbach's alpha and composite reliability calculations performed for the constructs in this study produced acceptable values. The Cronbach's alpha values ranges from 0.766 to 0.836 and the composite reliability values ranges from 0.798 to 0.892 indication adequate Cronbach's alpha and composite reliability in this study. Average Variance Extracted (AVE) evaluates convergent validity and acceptable values for AVE should be

greater than 0.5. Satisfactory convergent validity was achieved in this study since AVE values ranges from 0.6253 to 0.801 (El-Gayar et al., 2011). The mean values greater than 5 obtained in this study reveals that participants had a positive evaluation of the m-learning projected implemented in this study.

Table 3. Factor Loading and reliability

variable	Item	Mean	Standard Deviation	Factor loading	Cronbach's alpha	Composite reliability	AVE
Task Characteristics	TC1	5.362	1.139	0.862	0.766	0.892	0.623
	TC2			0.926			
	TC3			0.886			
	TC4			0.852			
	TC5			0.866			
	TC6			0.836			
Technology Characteristics	TECC1	5.661	1.033	0.884	0.794	0.798	0.785
	TEEC2			0.8721			
	TECC3			0.792			
	TECC4			0.812			
	TECC5			0.803			
Individual Characteristics	ICPU1	5.212	1.201	0.836	0.817	0.782	0.655
	ICPU2			0.823			
	ICPU3			0.818			
	ICPU4			0.832			
	ICPU5			0.821			
	ICPU6			0.848			
	ICPEOU1			0.892			
	ICPEOU2			0.833			
	ICPEOU3			0.833			
	ICPEOU4			0.842			
	ICPEOU5			0.856			
	ICSI1			0.752			
	ICSI2			0.829			
	ICSI3			0.792			
	ICSI4			0.786			
Task Technology Fit	TTF1	5.462	1.103	0.823	0.836	0.854	0.711
	TTF2			0.874			
	TTF3			0.829			
	TT4			0.844			
	TT5			0.835			
Performance Enhancement	PE1	5.169	0.315	0.779	0.788	0.832	0.801
	PE2			0.842			
	PE3			0.822			
	PE4			0.837			

Discriminant validity was examined by comparing the AVE square root values and factor correlation coefficients. Drawing on previous studies claims that, if the square root of AVE is significantly larger than its correlation coefficients then a scale has good discriminant validity (Fornell and Larker, 1981). It is evident that, in this study the scale had good discriminant validity. For each factor shown in Table 4 the square root of AVE is significantly larger than its correlation coefficients with other factors. The square root of the AVE is shown in bold.

Table 4. Discriminant Validity

	Task Characteristics	Technology Characteristics	Individual Characteristics	Task Technology Fit	Performance Impacts
Task Characteristics	0.789				
Technology Characteristics	0.739	0.886			
Individual Characteristics	0.694	0.725	0.809		
Task Technology Fit	0.721	0.798	0.793	0.843	
Performance Impacts	0.699	0.883	0.778	0.814	0.895

Structural Model testing

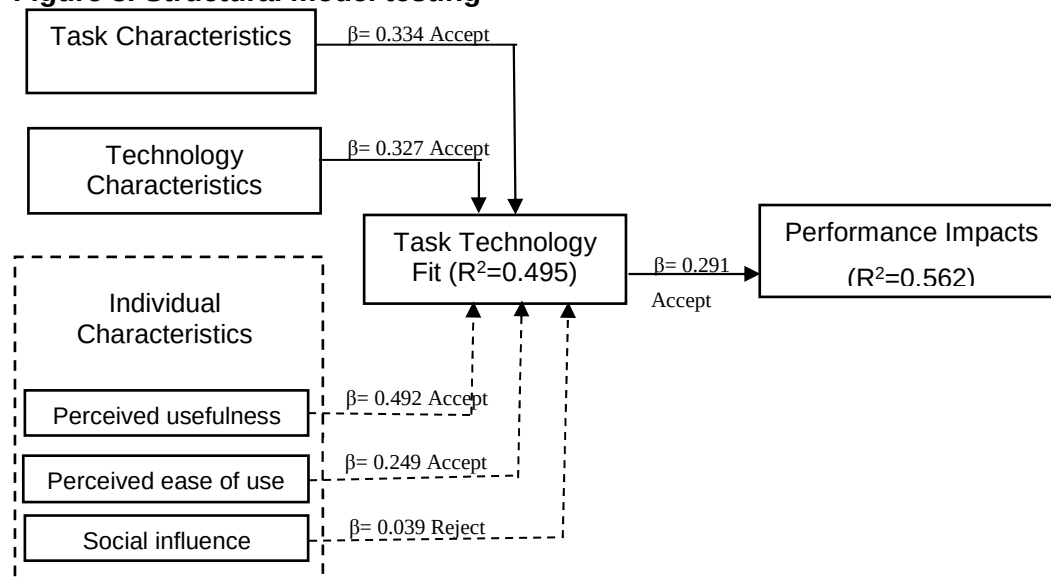
The structural model analysis was utilised to establish the path coefficients (β) and R^2 among antecedents of the research model. Path coefficients and R^2 signify the common ground between the structural model and experimental data (Chang et al., 2012). A statistically acceptable path coefficient should be at least 0.05 is (Suki and Suki, 2011)

Task characteristics, technology characteristics, individual characteristics (facilitated by perceived usefulness and facilitated by perceived ease of use) explained almost 50% total variance in task technology fit. Task technology fit explained almost 56% total variance in performance impacts. These total variances explained for task technology fit and performance impacts are derived from $R^2 = 0.495$ and $R^2 = 0.562$ shown on the structural model shown below.

All the path coefficient were found to be statistically significant except for H5 (Individual characteristics facilitated by social influence has positive influence

towards task technology fit). H5's path coefficient is 0.039 hence the path was rejected. Paths H1 to H4 and H6 had path coefficients that range from 0.249 to 0.492. These R^2 obtained for these paths indicate that the constructs are significant hence the paths were accepted.

Figure 3. Structural model testing



DISCUSSION

The TTF relative hypothesis showed that: a) task characteristics have positive influence on task technology fit. B) Technology characteristics have positive influence on task technology fit. C) The task technology fit has positive influence on performance impacts. These findings are consistent with (Goodhue, 1995; Goodhue, 1998).

For individual characteristics construct, the results reveal that perceived usefulness positively influences task technology fit construct. These findings are close to Davis (1989) who confirmed the hypothesis that perceived usefulness has positive influence on technology adoption. This hypothesis for individual characteristics construct reveals that the usefulness of MIM (for studying, assessment preparation, academic support, and peer mentoring just to name a few) may influence the fit between mobile technologies and learning. Another hypothesis for individual characteristics that was statistically significant is: perceived ease of use has positive influence on task technology fit construct. Once again these findings are comparable to Davis (1989) who reported that perceived ease of use has positive influence on

technology adoption. This finding of this study indicates that ease navigation, ease download and upload of academic engagement within the MIM for academic use influences the fit between mobile technologies and learning.

The hypothesis that individual characteristics facilitated by social influence has positive influence towards task technology fit has been rejected in this study. These findings contradicts Venkatesh et al. (2003). Possible reasons for the contradictions may be due to the fact that most mobile learners in this study realised the usefulness on MIM for learning and the also realised the fit between this technologies and the task hence they did not see the influenced to be influenced by someone to use these technologies.

CONCLUSION

Individual characteristics construct is a determinant for task technology fit. The individual characteristic construct extended the task technology fit in this study. The study reveals that perceived usefulness and perceived ease of use are the facilitators for individual characteristics construct. The social influence factor was proved to a non-driver for individual characteristics construct. Another extension made to the TTF theory is the omission of the utilisation construct from the original model. The TTF theory relative hypothesis tested in this study were all reported to be statistically significant.

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ENGAGING IN ART APPRECIATION: A DIGITAL AUTOBIOGRAPHICAL PERSPECTIVE

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ABSTRACT

Autobiographical learning is defined as “storytelling” the curriculum, where one links specific curriculum content to personal experience. The purpose of this paper is to explore how autobiographical learning, using the vehicle of digital storytelling, can be used as a tool for improving the ability of B Education students to engage with the process of art appreciation. A narrative research design was selected in order to address the research question which had been posed. The data were analysed using content analysis of the digital stories and reflective essays, in order to identify narrative threads. The results indicate that art appreciation using the vehicle of autobiographical digital storytelling, concerns itself with the identification of a symbol within a painting, which morphs into a ‘master metaphor’, so that the retelling of an emotional personal experience becomes a journey in self-exploration, making sense of loss and finding a purpose in life, thus linking the curriculum content with personal experience.

Keywords: Art Education, Narrative research, Autobiographical learning, Digital storytelling

INTRODUCTION

Art enables us to find ourselves and to lose ourselves at the same time

Thomas Merton (1915-1968)

The purpose of this paper is to explore how autobiographical learning, using the vehicle of digital storytelling, can be used as a tool for improving the ability of B Education students to engage with the process of art appreciation, as part of their art education course. In order to prepare pre-service teachers in the B Ed Foundation Phase programme to extend their art appreciation skills, a project was designed in which a visual literacy assignment was incorporated in the theoretical component of the 2nd year Art Education module. During the second semester of 2013, three lecturers, an Art Education lecturer, an English First Additional Language lecturer

and a Reading specialist at a University of Technology in the Western Cape, combined their efforts to explore the application of digital storytelling in the Bachelor of Education degree course. A strong motivation towards the inclusion of this assignment in the second year Art Education module was the fact that students' knowledge regarding art and artists, as well as their ability to read and interpret visual stimulus, proved to be problematic (Westraadt, 2013 and Westraadt, 2014). The reason for the implementation of this project was thus twofold: firstly, to engender engagement with art appreciation and to provide pre-service teachers with the opportunity to write a digital narrative, in a cross-curricular autobiographical learning experience.

As the nature of digital storytelling is that of the narrative and the project was designed in such a manner as to elicit emotional narrative responses through the identification of symbols within art work, after the students had been taught the skills associated with art appreciation. As stories are used to help make meaning of particular experiences (Hart, 2002:155), this project aimed to determine if students could use digital stories as a vehicle for narrative autobiographical learning in Art Education, using the work of contemporary South African artists as inspiration. The research aimed to probe and work towards an in-depth understanding of patterns of meaning-making among a relatively small group of students involved in a university based Art Education programme.

The narrative application of autobiographical learning (Randall, 2010; Rossiter and Garcia, 2010) in this study aimed to link curriculum content (i.e. the skill of art appreciation) with personal narratives, using the vehicle of digital stories. The participants embarked on a 7 week writers' workshop, where they were tutored in the use of strategic goal setting, planning and writing strategies, all geared toward narrative writing and digital story production. The digital stories were 3-5 minutes in length and the pre-service teachers were encouraged to use text, sound, graphics, focus and movement using a simple programme such as Photo Story 3 or Windows Movie Maker. Following the presentation of the digital stories, the pre-service teachers were asked to write a guided reflection describing their experience regarding the creation of the digital stories and the development of their art appreciation skills.

REVIEW OF LITERATURE

Since this research project aimed to investigate students' engagement with the process of art appreciation, using the vehicle of digital storytelling, the review of the literature will therefore, discuss the concepts of art appreciation and autobiographical digital storytelling.

Looking as learning

Art education provides holistic and multi-symbolic learning opportunities through which students can gain enhanced cognitive performance and become visually literate. Learning to read and use symbol systems in a world where the visual is becoming increasingly important is part of this process (Deans & Brown, 2008:342). For art education, the study of visual imagery is concerned with the whole context of images, their production and the lived experience of those who view and interpret them. According to Eisner (2001:7) the term visual culture is open to all forms of visual communication: architecture, product design, graphic design, painting, sculpture, the layout of parks and cities. Furthermore, the study of such phenomena makes it possible for students to become acquainted with the sociological, historical, cultural, and especially the economic factors that have influenced those forms and, even more importantly, their social consequences.

During visual art lessons three levels of knowledge and understanding - knowledge gained by observation, contextual knowledge and knowledge gained in a cultural, social and philosophical context, can be activated (Hickman, 2000:40). Intellectual and interpretive processes take place during the appreciation of the language of the visual elements (Hickman, 2000:146). Art education is the training ground for visual thinking as pupils learn to look at pictures attentively. Visual thinking is the ability of the mind to unite observing and reasoning in every field of learning (Pressman & Dublin, 1995:73).

Art appreciation heightens perceptive awareness. The study of art forms within a specific period of time or within a specific community or culture can provide historical and cultural insight for pupils (Kear & Galloway, 2000:139). According to Eckhoff (2008:462) through engagement in art viewing and art making experiences, visual art can be an important and rich domain of learning. As teachers and children

communicate with each other through an art-focused dialogue, they negotiate the meanings of the artwork and of art itself. It is precisely this process of meaning making that will support children's views of visual art in the present and on into their futures. Visual literacy, like language literacy, is culturally specific although there are universal symbols or visual images that are globally understood (Stokes, 2001:1).

According to Yenawine (1997:1) visual literacy also entails the ability to find meaning in imagery. This involves using a set of skills ranging from simple naming what one sees, to complex interpretation on contextual, metaphoric and philosophical levels. Many aspects of cognition are called upon, such as personal association, questioning, speculating, analysing, fact-finding, and categorizing. Objective understanding is the premise of much of this literacy, but subjective and affective aspects of knowing are equally important. Visual literacy usually begins to develop as a viewer finds his/her own relative understanding of what s/he confronts, usually based on concrete and circumstantial evidence. It eventually involves considering the intentions of the maker, applying systems for thinking and rethinking one's opinions, and acquiring a body of information to support conclusions and judgments. The expert will also express these understandings in a specialized vocabulary.

Digital storytelling relies on visual literacy. Many researchers specifically refer to students discovering and improving their visual literacy through the digital narrative activity. Jakes & Brennan's (2005:224) claim that improved visual literacy occurs because "using the latest technology to communicate imagery effectively is facilitated by students actively participating in the creation process of digital storytelling". Banaszewski (2005:18) connected visual literacy with the intellectual strength of "Visual-Spatial Intelligence – capacity to think in images and pictures, to visualize accurately and abstractly". He contends that using a digital imagery device allows the learner to capture a tangible image that comes from what they imagine, therefore demonstrating and strengthening their ability to communicate through visual cues.

Visual literacy and art appreciation is a learned skill, not an intuitive one. One becomes visually literate by studying the techniques used to create images, learning the vocabulary of shapes and colours, identifying the characteristics of an image that give it meaning and developing the cognitive skills necessary to interpret the ideas

that inspired imagery. This skill relates to a person's ability to interpret and discuss visual information. It is the first step in acquiring visual intelligence, essential for critical thinking in the 21st century. It is an important skill to have in the professional world where digital images are more often used as a means of communication (Burmark, 2002:v).

According to Wachowiak and Clemens (2007:6) art is a means of learning about oneself in the world. The language of art uses different symbol systems, fusing the cognitive, affective, psychomotor modes of learning. This provides for communication in a language that is not verbal or mathematical as dominating in the curricula. Visual literacy means understanding visual phenomenon. Cognition refers to way of processing information and becoming aware of self and environment through sight, sound, taste, movement. Visual education develops literacy in all symbol systems, all modes of thought and all means of enquiry.

Autobiographical learning in narrative research

Lieblich et al. (1998:2) offers the following definition of narrative research as 'that which uses or analyses narrative materials'. The data can be collected as a story (a life story provided in an interview or a literary work) or in a different manner (field notes of an anthropologist who writes up his or her observations as a narrative or in personal letters). It can be the object of the research or a means for the study of another question. It may be used for comparison among groups, to learn about a social phenomenon or historical period, or to explore a personality.

The most encompassing view of narrative is proposed by Roland Barthes's (1975: 287) when he states that:

Narrative is first and foremost the prodigious variety of genres, themselves distributed among different substances - as though any materials were fit to receive man's stories. Able to be carried by articulated language, spoken or written, fixed or moving images, gestures, and the ordered mixture of all these substances; narrative is present in myth, legend, fable, tale, novella, epic, history, tragedy, drama, comedy, mime, painting...stained glass window, cinema, comics, news items, conversation... Narrative is international, trans-historical, transcultural: it is simply there, like life itself.

Autobiographical learning fits into the realm of narrative research as it is defined as “storytelling” the curriculum (Rossiter, 2005). When incorporated into the educational experience, autobiographical stories serve as a primary and fruitful link between lived experience and curricular content, a connection integral to adult learning. These stories enable learners to identify congruencies and incongruities between their meaning systems and the concepts being learned. They also give adult learners increased insight into their own learning and development (Clark and Rossiter, 2006: 19). The autobiographical learning activity introduces the learner’s self-story into the educational experience and brings into focus those areas of dissonance around which learning is necessitated. Learners are involved with the content because the meaning of it matters to some aspect of their own story.

Autobiographical research, of whatever variety and regardless of its focus, relies upon narrative. This is because the way in which we gain access to ‘the person (who) comes through’ (Bullough, 2001:21), whether they be the teacher or the learner, to their understandings of the situations they experience, and to their identity/ies, is through the stories – the narratives – they construct and tell. Hall (1994:394) has noted that ‘identities are the names we give to the different ways we are positioned by, and position ourselves within, the narratives of the past’, thus emphasising the importance and centrality of biography to any investigation which seeks to investigate diversity and difference. Personal accounts or narratives are essential for autobiographical researchers for, stories are the closest we can come to experience as we and others tell our experience. A story has a sense of being full, a sense of coming out of a personal and social history.... Experience is the stories people live. People live stories and in the telling of them reaffirm them, modify them, and create new ones. (Clandinin & Connelly, 1994: 415).

Digital storytelling in Narrative research

Ohler (2008) takes Barthes (1975) and Lieblich’s (1998) definitions of narrative further and identifies the more global term, ‘new media narrative’, although he acknowledges that the term ‘digital storytelling’ is more recognisable; however, the term ‘new media narrative’ does help underpin the argument that the emphasis of digital storytelling has to be on the story itself, rather than the technology. Digital storytelling involves incorporating digital text, imagery, video, and audio ‘short,

personal multimedia tales told from the heart' (Chung, 2007) and is seen as an adaptation of the storytelling tradition which has existed for more than 6,000 years (Abrahamson, 1998). In terms of Art Education, digital storytelling offers students the affordance of stimulating aesthetics, critical thinking and problem solving skills in order to address relevant social issues and personal concerns while cultivating aesthetic sensitivities (Chung, 2007:22).

Bringing together 'new media' and 'narrative' rather than 'digital' and 'storytelling' Ohler (2008) underscores both the wide range of possible forms that this slant can be used for and that the ultimate products can take. According to Robertson, Hughes & Smith, (2012:87) and Sadik (2008:502), through the process of creating the digital story, students are encouraged to deliberate more acutely about the meaning of the topic or story and personalise their experience and also clarify what they know about the topic. Storytellers are also apt to seek meanings that help them cope with their circumstances (Hart, 202:155). As we, and other narrative inquirers now know, narrative inquiry, into those stories that people live and tell, also matters" (Clandinin & Rosiek, 2007: 70-71).

Fisher (1984:6) coined the term 'homo narrans' where humans as 'symbol using animals' use the 'master metaphor' in writing, to create an autobiography. A story develops which relates the truth about the human condition. The idea of human beings as storytellers or 'homo significans' i.e. the makers and readers of signs (Chandler, 1995) holds that symbols are created and communicated ultimately as stories meant to give order to human experience and induce others to dwell in them to establish ways of living in common. Digital storytelling as a process is also about the construction of symbols or signs, visual metaphors and artefacts (Lambert, 2010:17). By making use of the visual metaphor students are able to exercise creativity in artefact searches (Kader, 66) which extend any analogy created within the digital story in order to construct motifs within the story (Bell, 2003:99).

Digital storytelling is recognised to encourage emotional engagement with the task (Oppermann, 2008). Oppermann (2008) and Coventry (2008) recognise that digital storytelling works at the boundary of emotional and epistemological learning, linking theory and practice. Students become expressively engaged with the creation of the digital story leading to a 'spiral of engagement'. In essence, digital stories which are

rooted in the theoretical framework of emotional writing and autobiographical learning are built on the premise that personal narratives involve the retelling of significant events in life, which are emotionally charged and personally meaningful (Robin, 2008:224).

Reflection on critical incidents is one such example of how digital stories can be used to present stories (Jenkins & Lonsdale, 2008). Reflections are not just reports on past events but have a role in helping the individual clarify their own self-concept. They are then critical learning events in helping to develop individuals 'agency' (Hull & Katz, 2006). Digital storytelling as a teaching and learning approach has proven to aid creation and build communities, provide platforms for communication and reflecting on one's past (Condy, Chigona, Gachago & Ivala, 2012:238) and students will likely find that the technology is both enabling and powerful (Robertson et al, 2012:10).

The form of digital stories, being multi-layered and demanding 'compressed argumentation' (Coventry, 2008), means that students are challenged to consider how they present their ideas. This presentation of ideas leads to creativity in the construction of meaning, where 'narrative knowing' comes to the fore (Rossiter and Garcia, 2010:44). 'Narrative knowing' or the constructive, interpretive and contextual nature of the narrative means that the students become self-authors, who constantly rework and re-interpret the events in their lives in order to bring coherence and meaning to the whole life narrative (Rossiter and Garcia, 2010:45). Narratives in digital stories go one step further, by inviting students to create and represent, construct and interpret their identities, in mind and body (Benmayer, 2008:200).

Coventry (2008: 168) observes that 'digital storytelling encapsulates the important pedagogical principles of restatement and translation that are central to helping students engage with difficult material'. This statement is the essence of our project. Are students able to translate a symbol which they located within a painting and restate it within their own narrative? This communication of understanding with others allows a different perspective to be introduced and new questions to be asked, which can potentially prompt further thoughts and reflections. Learning is an iterative process and digital storytelling can make this explicit (Leon, 2008: 222).

Sadik (2008:448) defines meaningful technology integration as “curricula utilizing authentic tasks that intentionally and actively help learners to construct their own meanings from thinking about experiences and allows for more interdisciplinary project-based instruction”. Digital storytelling has been used in the classroom for various purposes, including teaching content to students, empowering students by making them active researchers and storytellers, teaching writing, and building communities through storytelling (Banaszewski, 2002, Dogan & Robin, 2008). The potential uses of Digital Storytelling by teachers or students are numerous as it has a broad range of possible applications (Dogan & Robin, 2008).

This research project aims to fill the gap that has been identified in the students’ ability to appreciate art, through the use of autobiographical digital storytelling in Art Education.

RESEARCH METHODOLOGY

In order to determine if students were able to engage in reading and interpreting visual stimulus, the following research question was posed: How can autobiographical digital storytelling be used as a tool for engagement in art appreciation for 2nd year BEd students at a University of Technology in the Western Cape? For the sake of this study, the researcher aimed to probe and work towards an in-depth understanding of patterns of meaning-making among a relatively small group of people involved in a university based Art Education programme. What storylines and metaphors guided their undertakings? In what sense did their storied practices attest to possibilities of engaging with the art work that was being analysed?

This study drew on the epistemology of autobiographical learning (Rossiter and Garcia, 2010) and employed the qualitative methodology of content analysis (Bozdogan, 2012) of digital stories which were created by the participants. Storytelling is recognised as a narrative research technique in qualitative analysis (Sandelowski, 1991:165) and as such, content analysis is particularly relevant as a research methodology, where personal experience stories and first person narratives (Willox, 2013:137) are analysed. The researcher employed content analysis in order to identify narrative threads or what Bell (2003:98) calls the ‘weave of stories’.

The participants were all Bachelor of Education (Foundation Phase) pre-service teachers (n=6), in their second year of a four year degree, who had enrolled for the second semester Art Education module. The participants were homogeneously grouped (i.e. females), due to the fact that there are no male students registered in this course. All the participants (n=120) in this second year course were invited to take part in this project, and initially thirteen participants (n=13) indicated that they would like to take part.

Ethical clearance for the project was obtained from the Ethics Committee of CPUT and strict ethical measures were taken to ensure that none of the participants came to any harm or were in anyway compromised or coerced. Due to the sensitive nature of the stories which were told, confidentiality and anonymity were guaranteed. Furthermore, the researchers made it very clear that these digital stories would only be published with the explicit consent of the participants and that these stories would not be used for promotional purposes or financial gain.

The fact that the participants were entitled to withdraw from this project at any stage is evidenced in the high attrition rate experienced in the sample. Of the original 13 participants, only 6 finally completed the project. Reasons cited for withdrawal were full academic timetables and time constraints.

The narration, or symbolic actions of the storytellers were interpreted and narrative threads were generated which defined the core themes within this form of digital communication. Narrative threads were identified using three main stages of analysis. Firstly, the digital story scripts were analysed using first and second order coding. Secondly, an inductive approach was taken and narrative thread descriptions emerged from the data. In total, eight narrative threads were identified. Thirdly, although the threads did not emerge from the data in temporal order, they are presented this way for clarity. In order to ensure credibility within the research process, the digital stories and reflective essays were transcribed and analysed using Atlas.ti (Lewis, 2004).

FINDINGS AND DISCUSSION

In order to answer the research question which had been posed: How can autobiographical digital storytelling be used as a tool for engagement in art

appreciation for 2nd year BEd students at a University of Technology in the Western Cape?, the data were analysed and eight narrative threads were identified and then presented as a 'weave of stories', or one ultimate generic storyline, which has been developed by the researcher in order to 'story' the process of autobiographical digital storytelling in Art appreciation. The narrative threads are unpacked in table 1.

Table 1: Narrative threads for Art students' digital stories and reflective essays

Narrative threads:	Explanation
Narrative thread 1	Art appreciation using digital storytelling
Narrative thread 2	Concerns itself with the identification of a symbol
Narrative thread 3	which morphs into a 'master metaphor'
Narrative thread 4	so that the retelling of
Narrative thread 5	an emotional experience
Narrative thread 6	becomes a journey in self-exploration
Narrative thread 7	making sense of loss
Narrative thread 8	and finding a purpose in life

Art appreciation using digital story telling

The first narrative thread summarises how the participants engaged in the art appreciation process. All the participants related that the process of engaging with the art work and creating the digital stories was a positive experience. Specific positive statements regarding the fact that the digital story telling engagement process include:

Since I have done the digital storytelling, I saw that an artwork had a deeper meaning than just what you see when looking at it.

I have come to the understanding that it doesn't matter if your painting doesn't have a specific form. It's what YOU take out of it and how you interpret it that's important. That's the beauty of art.

At first it was a very difficult piece of art to discuss but after thorough research the artwork became clear and it was easy to attach my personal reflection and interpretation to the knowledge I gained.

I've always loved art and am intrigued by all the different aspects of it. I also learned that different people take different messages from different works of art.

Not only were the participants able to engage with the art work and develop a deeper understanding of the art work, they were able to relate an emotional connection to the process. Comments relating to the emotional element include:

From now on I will look deeper at an artwork by seeing the emotional element in an artwork.

I appreciate art more. It made me see that people have different ways of expressing their feelings.

It makes life more interesting - if all of us expressed our feelings in the same way, life would have been boring.

I have learned that you must appreciate art because it is the way the artist express his/her feelings.

For a long time I loved discussing various art pieces. I never thought I would be able to combine my love for art with my love for writing and use it to heal emotional pain.

...concerns itself with the identification of a symbol...

Four of the six participants in this study were able to identify a symbol within their selected art work, with which they could make a personal connection. The second narrative thread summarises how the participants located a symbol within the art work, a symbol with which the participants could resonate. The symbols were: a photograph, a bird, a pile of garbage and an elephant. The first participant analysed the painting 'Dora and the other woman' by Penny Siopis (1988) and was able to focus on the symbol of 'the photograph'.

When I started this project, I received the painting of 'Dora and the other woman' of the artist Penny Siopis. When I looked at this painting I wondered how I could relate this painting to something in my life. The photos was about her past, what she remembered about it.

The second participant analysed 'Migrants' by Penny Siopis (2008) and focused on the imagery of a 'bird'.

When I saw this painting, I immediately noticed the definite outline of a bird. This painting by Penny Siopis is creative but has no definite form of a living organism except that one bird.

'Patience on a monument' by Penny Siopis (1988) provided the participant with the symbol of a heap of garbage:

The fact that the woman sat patiently on a monument of a pile of waste, is she waiting for freedom? For the truth to be revealed?

while 'Heathen Wet-Lip' by Alan Alborough provided the imagery of an 'elephant':

My inspiration, Heathen Wet Lip..... This led me to the main theme under which I was going to write my digital story – Elephants.

...which morphs into a 'master metaphor'...

Further analysis of the data reveals that the participants were able to take the initial identification of the symbol and develop it into an extended metaphor which runs throughout the digital narrative, providing an analogy for the difficulties that the participants have experienced. The symbols of the photograph, a bird, the pile of garbage and the elephant become master metaphors through which the participants come to 'narrative knowing'. This is encapsulated in the following statements:

The photos was (sic) about her past, what she remembered about it. Dora is in a struggle because she lost everything she had and all she had was the memories of her past. Dora reminded me of myself because I can't always remember what exactly happened in my past but I have the photos

That I am meant to do something great, I am meant to stand out in the chaos like that bird.

Today I am standing patiently on a monument, not made out of a pile of waste, but a pile of sand, under me is a strong rock, the holy rock, which is God.

I decided to write my story around idioms consistent of the word "elephant", but also idioms I could make applicable to my story about abuse..... I used this idiom to show that the memory of abuse is like a white elephant.....

...so that the retelling...

Each of the participants was able to relate the symbol within their chosen painting to an autobiographical aspect of their lives, while still developing the extended

metaphor in their story. Here are some of the autobiographical statements identified in the content analysis of the digital stories and the reflective essays:

I related this element to my life because I lost my mother in a car accident when I was 11 years old.

I got very sick and was in and out of hospital for the next two years of my life.....

Then the dark night of the accident happened.....Daddy is dead

Some nights my memories of abuse are like a white elephant, a nuisance, an expensive burden I carry with me on my journey to finding myself.....what happened to me is an elephant in the room of society, they are aware of our suffering and the price being paid by victims but some chose to overlook our suffering

The participants who did not link their story to a symbol within the painting were still able to relate an autobiographical aspect within the storyline of their digital story.

Especiallly from my grade 9 year, I always dreamed of being a thinner version of myself but yet I was an overweight teenager.

2010 was a difficult year for me, in every month of that year, someone close to me died.

...of an emotional experience...

All the participants were able to elucidate the emotional impact of the retelling of a story from their past. Words which were used were 'never really made peace', 'it breaks me', 'I wasn't happy', 'It isn't always nice to tell about bad times in your life' and 'things I couldn't tell anyone else'. Other statements related to difficult emotional experiences were:

My mother's death was a negative in my life

It got so bad that at one point the doctors told my parents that they were going to have to say goodbye.

It breaks me to think what my mother must have gone through.

The memory is a nuisance in life, keeping you from becoming who you could be and "expensive" because it is an emotional proses to healing that never

ends.....In my story I used this metaphor to describe abuse in the everyday life.....

I wasn't happy in the body I was trapped into.....a statistic.....an obese teenager

...becomes a journey in self-exploration...

Although it was not explicitly taught during the writing workshop, many of the participants were able to make the transition between a difficult situation in their lives and how this has led them on a journey toward clarifying their self-concept, in essence, 'finding' themselves. The following statements attest to this fact:

I once heard before that we develop from negative experiences. My mother's death was a negative in my life, but I developed from it...

Being the determined person that I have learnt to be I have already made some of my dreams come true.....just like that bird in the chaos of life, I have tried and often lost, lovers, friends and also family. But the most important thing is that I keep trying.

Leading me to finding myself, leading me on the journey to find my face hidden behind pain.

After school, I wanted to find my purpose in life, then I found it in teaching. By touching children's lives and by treating them with love and kindness.

My life changing story began when I woke up one morning and decided that I needed to do something if I wanted to become a happier version of me.....

I have to believe that I am strong and that there is a reason for my existence.

....making sense of loss...

Identifying an emotional experience which the participants were able to relate to the symbol which they had identified, not only led to a reordering of their self-concept, it also encouraged the unexpected bonus of making sense of the loss that they had experienced. This sense of 'loss' was related to the death of a loved one, the forfeiture of innocence and the retardation of confidence. These epiphanies are captured in the following statements:

This digital story means a lot to me. The things I couldn't tell anyone else (especially without crying), the things that went through my mind then, and what goes through my mind when I look at the pictures and think back to

those incidents, that I could tell in this digital story. Now the people who watch it, can see what I felt and still feel

I reflected back on my childhood and what is important in life. It also humbled me to think back on how far I've come and all the blessings I have in my life.

During the making of the digital story, I went on a spiritual adventure by making peace with what happened in my past. Now I do believe that everything happens for a reason. That is what I learned by doing this digital story.

After experiencing and surviving abuse you become wiser in life and "emotionally smart". Writing this digital story was part of my healing process. I enjoy writing and this was a chance to enjoy writing but also heal. I still have to see the elephant. The experience of abuse has provided me with the strength to look the world in the eye and carry my memories to death.

Losing weight was great, but I still needed to grow my confidence

...and finding a purpose in life.

Once the participants had made sense of the loss that they had experienced, each of them was able to articulate how they planned to use this experience to further their growth as individuals, in particular, in finding a purpose for their lives.

I am meant to make a difference, if not in my life then in the lives of others.

I wanted to find my purpose in life, then I found it in teaching.

I am a young female hoping to become a strong South African helping those and supporting those who are paying the price of abuse with me.

Within the narrative thread of 'finding a purpose', it is noteworthy to state that a sub-narrative thread of religious support or certainty emerged. Statements like:

Now I see that God has a reason for things happening,

God, the Holy father was there all the time.

I thank God

When we are weak, God is strong.

attest to the fact that many of the participants found strength in their religious convictions which gave them a purpose with which to carry on their lives.

CONCLUSIONS AND RECOMMENDATIONS

Given that human beings are by nature, storytellers (Chandler, 1995) and that autobiographical learning allows students to 'story' the curriculum using their own stories (Rossiter, 2005), digital storytelling allows students the opportunity to engage in art appreciation by linking their own life stories with the process of art appreciation.

The research question that guided the narrative design of this project asked how autobiographical digital storytelling could be used as a tool for engagement in art appreciation for 2nd year BEd students at a University of Technology in the Western Cape. The narrative threads which were identified can be restated as a 'weave of stories' and be expressed as the following:

Art appreciation in autobiographical digital storytelling concerns itself with the identification of a symbol which morphs into a 'master metaphor'... so that the retelling of an emotional personal experience becomes a journey in self-exploration, making sense of loss and finding a purpose in life, thus linking the curriculum content with personal experience.

For all the participants, their 'storytelling' started many years before the creation of these digital stories or their lessons in art appreciation. A benefit of the process was that the participants were able to draw on their skills of art appreciation and identification of symbols within an art work, to make an emotional connection with the art pieces that they analysed and that the process was enjoyable. Traumatic events like the death of a loved one, childhood illness, sexual abuse and obesity, deeply affected them and had a negative impact on their lives. However, it has become evident through the process of creating the digital stories and reflecting on the process, that the students who took part in this study were able to move past the negativity they had experienced in their past and embrace their futures positively. As such, it must be stated that digital storytelling can be used as a tool for engagement in Art appreciation, not only to aid in the analysis of a piece of art work, but in the enjoyment and reflective nature of autobiographical writing, thus linking specific Art Education content with personal experiences.

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'CONSTRUCTING' A BRIDGE BETWEEN LESS AND MORE

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ABSTRACT:

When selected B Ed courses were subjected to an HEQC audit, reports from the panel expressed concern about curriculum overload. To address this and to carry out some of the other amendments that were suggested by the panel, the process for the re-design of the B Ed curriculum began, following the principle of 'less is more'. For some subjects, especially art education, this proved to be a matter of 'less is a mess', because there was less time for the nurturing into the art of teaching art, which required time to practice skills, time to focus and reflect on the potential for rich and varied learning that is possible through quality visual art education (Westraadt, 2010:30). Most students entering the B Ed programme have not experienced quality art education while they were at school, so they did not have a thorough understanding of the subject that they needed to teach nor of the creative development of children and how art education could support this development. In this paper comparative tables for the foundation phase that indicate how less time was allocated to subjects and more time to academic literacy, professional studies and education, will be discussed. The extent to which the marked decrease in time impacted on the art education subject knowledge of the students will be reported, as well as findings demonstrated by an art education project that was conducted with pre-graduates in the foundation phase to provide a solution to the mess caused by the less time for art on their time-tables. To conclude, there will be some recommendations with regard to teacher training in art education, based on the literature study and findings from this research.

Keywords: *Quality and meaningful art education, foundation phase, curriculum, practical teaching, reflection, less is more.*

BACKGROUND

The closure of teacher training colleges and merger into higher education led to the design of B Ed curricula for teacher training. During 2007, while producing teachers that were sought after in the Western Cape and wider, as well as abroad, some of the B Ed courses were subjected to an HEQC audit. One of the aspects that were mentioned in the HEQC report was the overloaded curriculum, especially for the

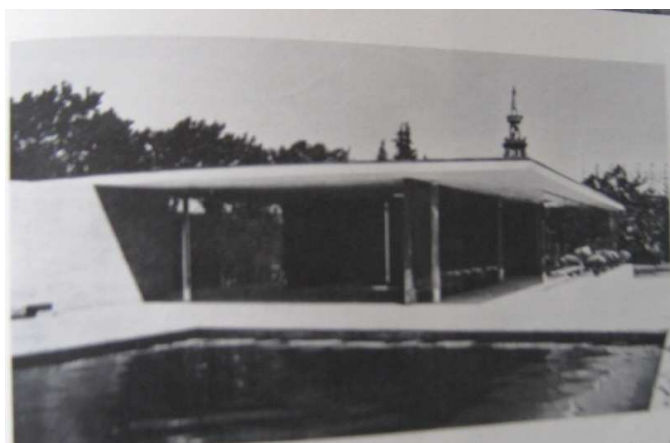
foundation phase. A reduction in the volume, as well as in contact time was recommended, whilst more emphasis on research and a higher academic standard was suggested (HEQC report, 2007). A curriculum committee was appointed and the process of re-design of the B Ed curriculum started with the assistance of consultants, with the concept 'less is more' as a guiding norm.

This revised B Ed had been introduced in phases and the first teachers to graduate after completing the new curriculum over the four years of their training received their qualifications in 2013.

LESS IS MORE

'Less is more', a phrase espoused by the architect Mies van der Rohe in the 1930's led to Minimalism in architecture in which form followed function. This is also seen in the Bauhaus principles of Walter Gropius of the same time. It set out to expose the essence or identity of a subject through eliminating all non-essential forms, features and concepts. Architecture and art of the Modern Movement followed and it lasted into the 1970's. The 'less is more' principle extended to music, literature and design and led to creations stripped to its essentials (De la Croix and Tansey, 1970:743).

Ludwig Mies van der Rohe, German Pavilion, Barcelona International Exhibition: 1929



De la Croix & Tansey 1970:741.

The design principle of 'less is more', a phrase that has been adopted widely in the business field and more recently in education, especially in the field of teacher training, was followed in the process of the re-design of the current B Ed curriculum.

Art education forms a compulsory part of the B Ed curriculum. This part of the curriculum was also treated with 'less is more' as guideline. For knowledgeable art educators this was like a divide, a crevice, rather than a principle, for the quality of art education suffered markedly because of this.

LITERATURE REVIEW

In order to underline the extent of the damage done by the decrease in time, it is essential to understand how quality in an effective art education can be determined. Therefore, existing literature dealing with quality and meaningful art education was consulted.

Quality and meaningful art education

There are various descriptions of what constitutes quality and meaningful art education. According to Remer (2010:86), there is no single, widely accepted definition of what constitutes an effective arts education program. The educational potential of art can only be fully reached if that which is taught is of a high educational quality. According to Wachowiak and Clemens (2007:7) learners should be led to total involvement in meaningful experiences of drawing, painting, printing, modelling, construction, and new media during lessons presented with the use of the terminology and in the structure of the elements of art. Design, structure, composition, line, form, colour, contrast, pattern and the other aspects of art should be dealt with to develop the aesthetic awareness of learners. From a young age, concentration should be maintained in the expression of their own experiences from the initial drawing till the completed project. These projects might need several sessions, but should be completed. It is important to persevere with a project otherwise it might seem a meaningless activity. An effective and productive atmosphere in the classroom is important. Good preparation and well-planned projects that stimulate the imaginations of the pupils will be required. Learners must be aware of the purpose of the project and that every lesson is an opportunity to learn through observation, analysis, compilation and communication.

Art education is far more than aesthetically pleasing activities. It provides holistic and multi-symbolic learning opportunities through which children can gain enhanced cognitive performance and become visually literate. Children learn to read and use

symbol systems in a world where the visual is becoming increasingly important (Deans & Brown, 2008:342).

Through quality art education intellectual and interpretive processes take place during the appreciation of the language of the visual elements. These unique experiences cannot be replicated by any other area of the curriculum (Hickman, 2000:146).

Although Eisner (2002:48-50) is of opinion that learning through art is often a kind of learning that standardised tests cannot gauge, with the effect showing up long after students leave school, the quality of art can be accounted for. Remer (2010:88) suggests acceptable methods of accounting for art education, like the following:

- Arts assessment is primarily about teaching and learning in and through art. In other words, assessment needs to be correlated with specific goals for arts learning.
- Generally, local assessments focus on the learners' knowledge, skills, and understanding as gathered by observers and the students themselves.
- There are a number of methods that can help validate findings, like using multiple methods, lenses, and observers to analyse and confirm findings.
- Be sure to identify the specific purpose of any assessment and how it will help improve the teaching and learning in art.
- Journals can keep track of the process.

Bolton (2006:66-73) states that the visual nature of art limits tightly-defined criteria but the older children get, the more will the following criteria be agreed upon as indicative of quality in school art: originality, conceptual content and technical competence. Qualities to look for in learners' work pose multi-layered and complex judgments. Although mostly applicable for secondary school art, assessment can be grouped in four categories with both intrinsic and extrinsic value.

- Firstly there should be originality which demonstrates creativity or imagination.
- Secondly technical competence led by an ability to manipulate the elements of art and art materials.
- The third is the conceptual content whereby ideas and feelings are conveyed.

- The fourth is the ability to criticise or make visual analyses of art.
- Pervading all of these is the criterion of aesthetic sensibility.

With quality art education in mind as discussed in the literature, the B Ed programme for art education in the foundation phase, on which the cuts in time was most dramatic, will be investigated.

The B Ed foundation phase programme and art education

The revised B Ed had been introduced in phases from 2009 onwards and the first teachers to graduate after completing the new curriculum over the four years of their training received their qualifications in 2013.

In the following table the revised curriculum for the foundation phase is compared with the curriculum that was phased out. The decrease in time allocated to art education is clear from these tables.

COMPARING THE CURRENT CURRICULUM FOR ART WITH THE PREVIOUS CURRICULUM:

Foundation Phase

	Previous curriculum (2001 – 2008)	Current curriculum (2009 – 2015)
Year 1	Art in Education 1; 4 credits; 2ppw; 25wks Introduction and application of variety of media and techniques suitable for Foundation Phase. Application of Elements of Art Insight into the stages of development and the importance of Art in the development of the child Introduction to Method of Art Education	Art in Education 1; 5 credits combined with Music, Drama/Dance; 2ppw; 13 wks Introduction and application of variety of media and techniques suitable for Foundation Phase Application of Elements of Art Stages of development and the importance of Art in the development of the child
Year 2	Art in Education 2; 4 credits; 2ppw; 25wks Practical work focusing on media and techniques suitable for application in G1-3 Preparation for teaching practice Art appreciation Study of Art forms of different Cultural groups in RSA.	Visual Art as possible elective; 2 credits: 2ppw; 13wks (choose 2 Art forms out of three) Practical work focusing on media and techniques suitable for application in G1-3 Preparation for teaching practice Art appreciation
Year 3	Art in Education 3; 4 credits; 2ppw; 25 wks In-depth experience of the following: Picture-making projects, Craft Art and Culture in the RNCS Integrated lessons Assessment of Art projects	
Year 4	Integrated Arts: Drama, Music, Visual Art, Dance Knowledge of theories on creativity Art appreciation Exhibitions, budget, ordering of stock Integrated programme of practical work	

Building the bridge: The B Ed art education project

The motivation for the project was derived from the following literature review: In most countries there is an outcry from teachers responsible for art education. Sevigny (1987:118) questions whether generalist trained teachers have the capacity to acquire, in short term programmes, the breadth of knowledge, competencies, skills, attitudes, and modes of inquiry that are essential to the four domains (dance, drama, music, visual art) of the arts.

McArdle (2008: 368) is concerned about teachers' lack of knowledge about art and how to teach it and pleads for an increase in the teachers' knowledge about art. Most teachers will be the first to admit that they lack skills in this field and report that those who teach art are constantly called on to justify the existence of the field. Along with the raise in the status of art in schools and the recognition as a legitimate school subject and not just a frill, come all the structures and expectations like syllabi, outcomes, levels and assessment. Unfortunately, in many classrooms, children are seldom invited to genuinely express themselves through art, nor instructed in how to do this and art most often exists as a marginalised field of study, devalued in the school curriculum as indicated by the allocation of time, space, and position on the report card. Art is often an add-on, an aside.

Pertaining to teacher training Dinham, Wright, Pascoe, MacCallum and Grushka (2007:8-11) report that as new courses are brought on stream for primary teacher training, the trend is for the reduction of hours devoted to art education. As one university academic claimed, 'they've reduced the two arts units we currently have to one, which will be impossible. I argued strongly against it but there is no time in the new structure, so we're diminishing rather than expanding'. Another factor in the diminution of visual art is the nomination of *Learning Areas*, or their equivalents, as organisers for the school curriculum. Teacher education courses typically allocate a set number of units to curriculum studies. Competition for these timeslots by the different areas of the curriculum is fierce and it is difficult to argue for extra units so that the different subjects within a *Learning Area* can be addressed separately. In the courses examined, the

researchers found that curriculum and pedagogic learning was consistently privileged over the development of subject knowledge.

The situation was seen as being a direct result of the limited hours available for visual art education in the *Early Childhood and Primary* courses. Emphasis on curriculum and pedagogical studies had led to a concomitant de-emphasis on student-teachers' own visual art learning. Interviews with academic staff working in visual education subjects revealed a consistent concern that overall, there was not enough time in the course for the development of what they regarded as a satisfactory level of capacity and understanding within the discipline for all student-teachers (Dinham, *et al.* 2007:8-11).

The focus on valuing visual art in education was based on the belief that unless student teachers appreciated and believed in the value of visual art education, they would not take responsibility for incorporating it into their teaching nor be able to distinguish authentic visual art education from poor. Research shows that *Early Childhood and Primary* teacher education students were mostly ill-equipped to teach art as they have had little art experience prior to enrolling in their pre-service course and were not confident in the area. Whilst the majority of student-teachers nominated 'developing imagination and expression' as the most important role for visual art in the school curriculum, their understanding of what this means and how it is fostered, was untested (Dinham, *et al.* 2007:8-11).

According to Deasy (2008:6) various factors have contributed to the low priority and marginal role of art in education. Lack of financial resources is usually blamed first, but the major factor is the lack of clear understanding of the nature of the learning that occurs in art and the power and relevance of that learning in addressing personal, societal, cultural and economic needs. None of those needs will be fully met and young people will not be empowered with 21st century skills unless art is fully and robustly present in the curriculum and life of schools.

Beveridge (2010:5) is concerned about the underlying message that art does not require skills, knowledge, commitment, or work, and that as long as the learners produce something, the quality of performance does not matter. State and national art

standards for grade appropriate performance are often ignored. Students in art classes receive the message that the effort they have put into learning these subjects is not valued. In some cases art classes are treated as merely for 'fun'. This undermines the professionalism and knowledge of any art educator, casting them as peripheral, rather than essential, players in a students' education

Alter, Hays and O'Hara (2009:22-27) report that generalist primary teachers are ill-equipped to teach art. Key issues after interviewing the teachers were that they felt overwhelmed with the needs of all of the curriculum areas and a reduction in the time that was devoted to creative arts education. Many participants expressed the view that their art experiences in the tertiary education environment had been limited and therefore they lacked confidence in teaching art. There was a direct relationship between the participants' skills, knowledge and their confidence to teach the subject. All the participants believed that the time devoted to teaching art did not adequately prepare them for their responsibilities in the primary classroom.

Davies (2009:630) report on findings from surveys of primary initial teacher education which suggest that the time allocated to art is limited and that beginning teachers felt inadequately prepared to teach this area of the primary curriculum. The lack of preparation for teaching art in initial primary education can be linked to increased government control of the training curriculum as well as assessment and quality assurance procedures. The increase in school-based training offered the potential that student teachers could learn about and practice teaching art during their time in schools. However, surveys of primary pre-service teachers found few opportunities for respondents to either observe or teach art in primary schools.

Coutts (2004:43) despite the clear advice on art education in guidelines for teachers, a crowded curriculum and increasing bureaucracy act as inhibitors.

CONSTRUCTION OF 'THE BRIDGE' BETWEEN LESS AND MORE

In 2010 when the first group of B Ed foundation phase students completed their one semester of two art disciplines as per the table on p 5, they wrote a letter signed by 30

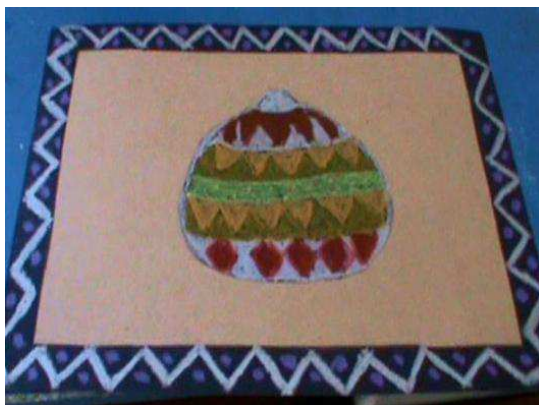
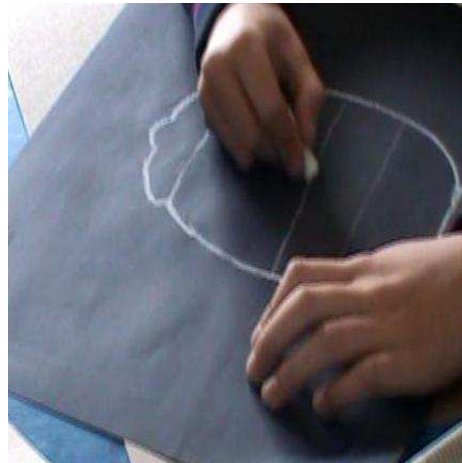
students, in which they pleaded for an extension of the curriculum for the art subjects. Their motivation was that in the foundation phase class teachers are responsible for the teaching of most of the subjects in the curriculum. They had already been introduced to the CAPS (Curriculum and Assessment Policy Statement), the new curriculum for schools, and in that document the art subjects were allocated 2 hours per week teaching time and they had become mindful that their subject knowledge after only two semesters, was insufficient. Furthermore, many of them experienced the same vulnerability that was mentioned in the literature, as during their own schooling many of them were deprived of quality art education. A positive outcome about the new curriculum was the higher academic standard and research opportunities that were incorporated into the new B Ed, which resulted in the students becoming far more aware of the learning that occurs in art and the power and relevance of that learning in addressing personal, societal, cultural and economic needs.

Lecturers responsible for the art subjects were very concerned that with only two semesters of art education, aspiring teachers would not be equipped to teach the art subjects to a satisfactory level. Less contact time in this particular field, does not allow for sufficient practical experience during which students would become proficient in the art of teaching art. There is less time for the nurturing into the art of teaching art, which requires time to practice skills, time to focus and reflect on the potential for rich and varied learning that is possible through quality art education (Westraadt, 2010:30).

Case study visits to schools revealed problems that affect the quality of art education as being the lack of subject-specific knowledge and experience plus a poor awareness of how children learned and what needed to be taught through art education. Teachers reported insufficient knowledge with regards to age-appropriate subject matter, the presentation of the elements of art in their teaching, lack of knowledge about media that would be suitable for projects and how and where to obtain it. This situation affected their confidence when teaching art. Due to lack of confidence and experience teachers could not inspire the children to be creative (Westraadt, 2010:30). In an attempt to supplement their shortfalls in the teaching of art, some of them depended on and

uncritically used prescriptive literature and resource material which curtailed creativity and restricted teachers to unimaginative lessons.

An unimaginative, stereotype lesson example from one of the available publications that was followed by a student upon recommendation by the class teacher:



To counteract the detrimental effect that examples of this kind of work could have on the student teachers' practice teaching experience; to contribute to their experience in the teaching of art and to build their confidence in their own teaching ability, the following assignment was set for the first group of 2nd year foundation phase students in 2011:

Teaching Practice Assignment

During weeks 2 and 3 time will be devoted in class to the planning of a drawing lesson. Your lessons will be peer assessed in class. During the March teaching practice period you have to teach the lesson at the school during your teaching practice. Please ask the teacher to sign the form as proof that you have taught the lesson.

When you return to campus, please bring one example of the lesson, or a photograph of the result. Hand this in with the signed lesson plan and a written reflection of the lesson. In this reflection, please cover the teaching and learning process, your organisation in the class, presentation and what and how the children learnt during the process.

Assessment rubrick:	Lesson planning	10
	Reflection	8
	Lesson example	2
	Total	20/2 =10

It was stressed that anonymity of the schools visited would be maintained and the circumstances at the school were not to be mentioned in the reflection or feedback. The lack of media was addressed with the preparation of a drawing lesson, requiring the minimum of media and which could be conducted anywhere. Foundation phase pupils do their art in their own classroom in most schools anyway, so that was not accepted as an excuse. To have a special art room with a fully qualified art teacher is for the privileged few and many teachers do excellent art in an ordinary foundation phase classroom.

Many students returned after practice teaching with the excuse that there was no art at the school, nor any facilities or media and some wrote one paragraph for the reflection. It was evident that many of the class teachers did not model or promote practice that exposed the students to quality and meaningful art education.

From the results it was clear that only some pre-service teachers had an understanding of the subject matter that they needed to teach for art. To ensure quality and meaningful visual art education, they needed to know more about the subject. They needed to understand the development of children and how art education could support this

development. For instance, although it was emphasised during preparation that composition had to be dealt with when drawing people, to use the paper in portrait and fill the entire picture plane, few succeeded in motivating the learners to follow their instructions. Stereotypes were ample and old habits of painting blue dye over everything persisted. All of these were shown to the group and discussed with contributions from the class.

The fact that all these important didactical principles had already been dealt with in the first semester of their first year, they have written a test on the theory and have completed a practical portfolio during which all the elements were applied, yet the majority still could not successfully present it in their lessons, was an indication that more time would be needed to strengthen their art teaching abilities.

Grade 1 results from the 2011 April/May teaching practice period:



'Constructing' a bridge between less and more

There were some results which proved that certain students could master the didactics taught to them during the first year, however, these were in the minority. In the following example, the student used recycled paper, but managed to teach the children to fill the picture plane with the lesson topic: themselves in school uniform, because she instructed them to use the paper in portrait and to draw themselves big.



The problems and pitfalls that were identified in the feedback from the first group (2011) second year students was addressed the following year (2012), with emphasis on the fact that this assignment was part of their practice teaching portfolio, it included an explanation and friendly request to the class teacher to allow the student to conduct the drawing lesson and with advice to the students to be persistent in their request to teach the lesson by showing the assignment to the teachers at the schools. Furthermore,

guidance was provided for the reflection and the mark allocation for the reflection increased, to ensure that students really reflected on their own practice and not write down a superficial report on anything that happened during the lesson.

Teaching practice assignment

During week 7 en 8 a drawing lesson will be planned in class on a lesson planner for visual art. Your lesson plans will be peer reviewed and returned to you so that you can present the lesson during the April/May teaching practice. Please ask the teacher to sign the form as proof that you have presented the lesson.

When you return to class, please hand in the following:

The signed lesson planner;

One example of the drawing lesson by a child in the class, or a photograph that you can show to the class using the whiteboard.

A typed (Arial 12) reflection on your lesson. For this this reflection, use your lesson preparation notes as reference, and write your reflection under the following headings:

Lesson planning and the subject that you chose,
Classroom organisation and management,
Presentation strategy and motivation,
Media and the distribution thereof,
How the lesson developed,
Assessment of the project,
Tidying up,
Results and what and how the children learnt through the project.

Mark allocation:	Lesson planning	8
	Reflection	12
	Total	20/2=10

'Constructing' a bridge between less and more

Examples that were shown to the class:



Family in the lounge



Myself watering the garden



Watering the garden

Although there were slight improvements visible with regards to the reflection and the novel and ingenious lesson some students attempted with the learners, it was clear that the quality of art was still not at all what it should be and the elements of art neglected in the teaching of the lessons. Furthermore, it seemed that students did not apply their theoretical knowledge to their practical teaching.

Taking the requests of the students into consideration, especially their awareness of their own shortcomings after two semesters only of art education, a proposal was drawn

up and presented to the curriculum committee for approval. The proposal that was presented was the following:

PROPOSAL FOR ADAPTATION OF THE NEW CURRICULUM FOR B ED FOUNDATION PHASE

ART SUBJECTS

For attention: Curriculum Committee:

This proposal has been drawn up after discussions and collaboration with the majority of the lecturers involved in Arts Education from both campuses.

Reasons for proposing changes:

- Discussions and requests from students completing their second year
- Foundation Phase teachers have to teach all subjects
- The Arts are important learning tools in the Foundation Phase
- The Art subjects are new to the majority of students
- By the end of their second year they only begin to grasp what Arts Education is about
- The practical nature of the Art subjects require more time
- There is a theoretical/research component in the course as well
- Connectivity can be achieved in the first year with Grade R work in Professional Practice
- Teaching Practise as an application of the Art subjects will be possible
- There is ample space on the time-table for the art subjects in the third year

A possible model is proposed as set out on the following pages:

First page shows the current model, with the suggested increase in time in blue

Second page is our adapted suggestion

The Arts are indicated in **bold**

The model suggests a different spread of credits over the three years of study.

COMPARING THE CURRENT CURRICULUM FOR ART WITH THE PREVIOUS CURRICULUM:

Foundation Phase

	Previous curriculum (2001 – 2008)	Current curriculum (2009 – 2015)
Year 1	Art in Education 1; 4 credits; 2ppw; 25wks Introduction and application of variety of media and techniques suitable for Foundation Phase. Application of Elements of Art Insight into the stages of development and the importance of Art in the development of the child Introduction to Method of Art Education	Art in Education 1; 5 credits combined with Music, Drama/Dance; 2ppw; 13 wks Introduction and application of variety of media and techniques suitable for Foundation Phase Application of Elements of Art Stages of development and the importance of Art in the development of the child
Year 2	Art in Education 2; 4 credits; 2ppw; 25wks Practical work focusing on media and techniques suitable for application in G1-3 Preparation for teaching practice Art appreciation Study of Art forms of different Cultural groups in RSA.	Visual Art as possible elective; 2 credits: 2ppw; 13wks (choose 2 Art forms out of three) Practical work focusing on media and techniques suitable for application in G1-3 Preparation for teaching practice Art appreciation
Year 3	Art in Education 3; 4 credits; 2ppw; 25 wks In-depth experience of the following: Picture-making projects, Craft Art and Culture in the RNCS Integrated lessons Assessment of Art projects	Choose one Art form; 2 credits as part of Professional Studies. 2ppw; 13 wks Practice orientated work: lesson preparation, teaching, application of Art making techniques as for teaching in the Foundation Phase
Year 4	Integrated Arts: Drama, Music, Visual Art, Dance Knowledge of theories on creativity Art appreciation Exhibitions, budget, ordering of stock Integrated programme of practical work	

Foundation phase: suggested curriculum							Design Purpose : the best FP course possible within our parameters	
Time: 60 minutes pp								
Credits: 5 cr = 2 periods per semester			10 cr = 2 periods oer year					
	B. Ed 1		B. Ed 2		B. Ed 3		B. Ed 4	
1	Opv. [3]	Opv. [3] 20	Opv. [3]	Opv. [3] 20	Opv. [3]	Opv.[3] 20	Opv.[3]	Opv.[3] 20
2	Prof. Stud[4]	Prof. Stud [4] 10 + 5 (o.prak.)	Prof. Stud [4]	Prof. Stud [4] 10 + 5 (o.prak.)	Prof. Stud [4]	Prof. Stud [4] 15 + 15 (o.prak.)	Prof. Stud [2]	Prof. Stud [2] 15 + 15 (o.prak.)
3	Tale Ond Gelett. T1[2]	Tale Ond 20 Gelett. T1 [2]	Tale Ond. Gelett. T1 [2]	Tale Ond. 20 Gelett T1[1 + 1] Gelett T2 [1}	Tale Ond. Gelett T1 [2] Gelett. T2 [1]	Tale Ond. 20 Gelett T1 [1 + 1] Gelett T2 [1 + 1]	Tale Ond. Gelett T1 [2] Gelett T2 [1]	Tale Ond 20 Gelett T1 [1 + 1] Gelett T2 [1 + 1]
4	Wisk. Ond [3] Did. 2 Wisk. 1	Wisk. Ond [3] 20 Did. 1 Wisk. 2	Wisk. Ond [3] Did. 2 Wisk. 1	Wisk. Ond [3] 20 Did. 1 Wisk. 2	Wisk. Ond [3] Did. 2 Teor. Fund. 1	Wisk. Ond [3] 20 Did. 2 Teor. Fund. 1	Wisk. Ond [3] Did. 2 Teor. Fund. 1	Wisk. Ond [3] 20 Did. 2 Teor. Fund. 1
5	LV Lewensoriënter ing [2] M. Beweging [1]	LV 15 Gr. R [2] Lewensoriënt. [1]	LV Did. [1] / NW [2]	LV 15 Did. [1] / Teg[2]	LV Did. [1] / MSW [2]	LV 15 Did. [1] / EBW [2]		
6	Arts Art [1]	Arts Drama [1]	Arts Elect A [2]	Arts Elect B [2]	Arts Elect 1	Arts Elect 1	Inklusiewe O [4]	Inkl. O [4] 15
7	Arts Music [1]	Arts Dance [1]	M. Beweging [2]	M. Beweging [2]	M. Beweging [2]		Graad R [2]	Graad R [2] 15
8	Taal 1 [2]	Taal 1 [2] 10	Taal 1 [2]	Taal 1 [2] 10				
9	Taal 2 [2]	Taal 2 [2] 10	Taal 2 [2]	Taal 2 [2] 10				

'Constructing' a bridge between less and more

1 0	Akad. Gelett. [3] Rek. / Bib. / Akad. skryfwerk	Akad. Gelett. 10 Rek. [1]	Xhosa 3 [1]	Xhosa 3 [1] 10	Xhosa 3 [2]	Xhosa 3 [2] 10		
	23	23 130	24	25 135	18	18 120	18	19 120

After careful consideration of the proposal, the curriculum committee agreed that an adapted proposal would be accepted on the one campus as a pilot, because the lecturers were willing and able to accommodate the third year students. There were certain guidelines given which had to be adhered to, so as to ascertain that the curriculum would not become too overcrowded again.

According to guidelines from the curriculum committee, if any changes to the curriculum were to be accepted, it meant that all the lecturers involved in the teaching of the subject would have to agree and put their signatures of approval on the suggested changes. This required returning to the drawing-board three times with three suggestions. Eventually the third suggestion was considered, signed and approved with certain amendments and conditions by the curriculum committee to be trialled as a pilot on the one campus

Conditions laid down by the curriculum committee prior to approval:

- In the third year students would elect one of the art forms for one semester only.
- The art of the third year foundation phase would not be a subject on its own, with its own code, but form part of Professional Practice with a maximum of 10% mark allocation.
- The emphasis would be on practical application in the teaching situation, no tests or assignments were allowed.
- Students would apply the didactics in the practice teaching period, so the planning and presentation of art lessons would form the main body of the course.

COURSE OUTLINE FOR THE ARTS SUBJECTS FOR B ED 3 FP

Implementation from 2011.

B. ED 3 FP

Second semester, beginning week 15 on 6 June and running until week 27, ending 28 October.

2 periods per week (90 minutes).

'Constructing' a bridge between less and more

Students select one of the Art subjects, namely Drama, Dance, Music or Visual Art. It is a prerequisite that the students select one of the Art forms that they have passed in their second year.

Weekly planning

Week 15, 16, 17

Lesson planning and preparation for the teaching practice period in July/August.

Presentation of these lessons during the July/August teaching practice.

Week 18, 19, 20

Reflection and feedback on the lessons presented at schools.

Presentation of these lessons during the July/August teaching practice.

Week 21 – 27

Practical work to address the teaching of the Art subjects in the Foundation Phase. Assessment will be continuous. A student portfolio will be assessed.

Marks allocated to a weight of Professional Practice.

B Ed 3 FP art education project:

To prove the progress and benefit of the extra component and to establish the success of the B Ed 3 FP arts project, the same assignment that was set in the second year was now set for the third year, but broadened to a picture-making project in mixed media, as set out in the CAPS document: Create in 2D.

The assignment that was given, was the following, indicating the progression from the second year, which was only a drawing lesson, to the third year where the students were required to attempt a picture-making lesson in mixed media:

Teaching practice assignment

Study your notes on lesson planning and preparation very well and make sure about the steps that are suggested for picture making.

During weeks 15 and 16 a picture making lesson will be planned in class on the lesson planner for visual art. These lessons will be peer reviewed and returned to you so that you can present the lessons during the July/August teaching practice. You can adapt the lesson or teach it as it is, upon consultation with the class teacher. Please ask the teacher to sign the lesson planner as proof that you have presented the lesson.

Bring an example of your lesson, or a photograph of the lesson to show to the class.

Hand in the following:

A signed lesson planner,

One example of the lesson done by a child during the teaching practice, or a photograph thereof to show on the whiteboard.

A typed, (Arial 12) reflection on your lesson.

Your reflection should cover the entire process, from the planning, your classroom organisation, your presentation and how the lesson developed. Please indicate how and what the children learnt during your lesson. Use your notes as reference. Write your reflection under the following headings:

Lesson planning and choice of subject,

Presentation: teaching strategy and motivation,

Selection and distribution of media

How the lesson developed and your management of the class,

Assessment of the project,

Tidying up,

Discuss the results and what and how the children learned during this lesson.

Mark allocation: Lesson planning	10
Reflection	12
Presentation and lesson example	8
Total	30

After a study of examples of excellent practice, collected from several schools in the Western Cape where the quality of art education is high, as well as a literature study using Wachowiak and Clemens, Kellogg, Edwards, Eisner, Gaitskell, Hurwitz and Day, Jameson, Kear and Callaway, Lark-Horovitz, Lewis and Luca, Lowenfeld, and Brittain, as well as thorough scrutiny of the notes on lesson planning and preparation, prototype lessons were planned and peer reviewed. Students were advised to use the same lesson, or to adapt the lesson to the circumstances at the school.

RESULTS AFTER THE TEACHING PRACTICE

Mark schedules for the students enrolled for Art:

2011 2nd year **79** students: **41%** average for the teaching practice assignment, with **19** allocated a mark of 0 (not attempted).

2011 3rd year **40** students: **60%** average for the teaching practice assignment, with **1** allocated a mark of 0 (not attempted).

2012 2nd year **76** students: **40%** average for the teaching practice assignment, with **11** allocated a mark of 0 (not attempted).

2012 3rd year **45** students: **69%** average for the teaching practice assignment, with **5** allocated a mark of 0 (not attempted).

2013 2nd year **83** students: **53%** average for the teaching practice assignment, with **7** allocated a mark of 0 (not attempted).

2013 3rd year **42** students: **60%** average for the teaching practice assignment, with **6** allocated a mark of 0 (not attempted).

It was remarkable that the amount of students who did not manage to teach the lesson at the schools that they visited for practice teaching, is decreasing. Fewer students contact me for help and guidance while they were away at the schools and less ask for assistance with media.

If taken into consideration that the assignment set for the third year entailed much more, being a picture-making project in mixed media, it is significant that the marks portray how the extra semester in their third year was to the advantage of the students' art education practice and subsequently the quality of the art lesson that they presented. This could not have been achieved after only one semester in the first year and one semester in the second year as the original curriculum had proposed.

During the report-back session, every student had the opportunity to show an example of their lesson and report to the class how they went about achieving the results. No mention of the conditions at the school was made, only what they did to teach the lesson and achieve the result they had. 98% of the class attended to observe and critically comment on the work that their fellows presented. This was in itself remarkable, because students often do not pitch if there is no assessment done. The objectivity of the comments was remarkable, where in the past they would have been kind to their mates, there was at this stage real critical analysis. The results of the lessons are improving, with some by their third year, already showing astoundingly high quality in the art lessons that they presented.

There was a marked change in the response from the teachers at the schools with regards to the assistance that they provided for students to teach the lessons and the encouraging and favourable remarks on the lesson planners. In 2013, only 5 planners were not signed, where in the past, (according to the students) often teachers were reluctant to put their signature on it. Students reported that several teachers remarked on how much they themselves have learned through observation of the student teaching the art lessons.

Examples of the B Ed 3 FP lessons:



'Constructing' a bridge between less and more



CONCLUSION

The 'less is more' principle led to gaps in the armour of foundation phase teachers responsible for the art education of their learners. With regard to art education it is impossible to achieve more in less time. As part of the new curriculum this project presented a raise in the level of work from the students that led to a much higher quality and markedly more meaningful art education, ultimately to the benefit of many foundation phase learners in schools in the Western Cape.

RECOMMENDATIONS

'If our antecedents have taught us any lesson, it is that any attempt to implement a new curriculum will be short-lived unless specific teaching contexts and instructional competencies are taken into consideration' (Sevigny, 1987:118).

Autonomy of universities can be threatened by quality assurance and accountability. The Dean of a Faculty of Education, Jonathan Jansen (2004) analysed the role of the state as follows: Government, through NQF and SAQA determines curricula of courses and decides on trustworthiness of qualifications, programmes and institutions by means of quality audits and whether institutions will continue to exist. He cautions that overt national governmental involvement and bureaucratic administration could impact negatively on the academic profession and recommends that redesign, informed by thorough research could redress and insure that universities remain the citadel from

where the wise could give counsel (Wolhuter, 2007:217). Higher education has to identify the learning needs of private and public sectors and reorganise curricula to match desired outputs.

Teachers need to have a foundation consisting of a body of knowledge of the subject matter that they need to teach (Darling-Hammond & Baratz-Snowden, 2005:5). Furthermore, they need to understand the development of children and how instruction can support this development. In visual art, due to the practical nature, this takes time. There should be opportunities for practice teaching which are tied to the learning of constructs and be provided with examples of what good teaching looks like and consists of (Darling-Hammond & Baratz-Snowden, 2005:10 – 38).

With the introduction of the white paper for teacher education, *The Minimum Requirements for Teacher Education Qualifications* in 2011, all B Ed curricula have to be re-conceptualized to meet the requirements as set out in this document. The newly designed curricula will be phased in from 2016 onwards. It is recommended that there should be sufficient time for art education, increased and expanded into the fourth year, culminating in the teaching of high quality art lessons with emphasis on the integration of the arts as set out in CAPS for foundation phase as indicated in red on the table on p 24.

The Minimum Requirements for Teacher Education Qualifications pays close attention to the various types of knowledge that underpin teachers' practice, while encapsulating all of these in the notion of integrated and applied knowledge. Integrated and applied knowledge should be understood as being both the condition for, and the effect of scrutinizing, fusing together and expressing different types of knowing in the moment of practice. This is closely related to the notion of applied and integrated competence but, by explicitly placing knowledge, reflection, connection, synthesis and research in the foreground, it gives renewed emphasis to what is to be learned and how it is to be learnt (NSE, 2011:7).

'Constructing' a bridge between less and more

The following table suggests the time that would be necessary to train teachers in the B Ed FP sufficiently to be able to teach quality and meaningful art lessons, with recommendations in blue.

Foundation Phase

	CPUT curriculum being phased out	CPUT Curriculum being phased in
Year 1	Art in Education 1; 4 credits; 2ppw; 25wks Introduction and application of variety of media and techniques suitable for Foundation Phase. Application of Elements of Art Insight into the stages of development and the importance of Art in the development of the child Introduction to Method of Art Education	Arts in Education 1; 5 credits combined with Music, Drama/Dance; 2ppw; 26 wks Introduction and application of variety of media and techniques suitable for Foundation Phase Application of Elements of Art Stages of development and the importance of Art in the development of the child
Year 2	Art in Education 2; 4 credits; 2ppw; 25wks Practical work focusing on media and techniques suitable for application in G1-3 Preparation for teaching practice Art appreciation Study of Art forms of different Cultural groups in RSA.	Arts in Education 2; 5 credits: 2ppw; 26 wks Practical work focusing on media and techniques suitable for application in G1-3 Preparation for teaching practice Art appreciation Arts based research
Year 3	Art in Education 3; 4 credits; 2ppw; 25 wks In-depth experience of the following: Picture-making projects, Craft Art and Culture in the RNCS Integrated lessons Assessment of Art projects	Arts in Education 3; 2 credits as part of Professional Studies. 2ppw; 26 wks Practice orientated work: lesson preparation, teaching, research and application of the Art subjects for teaching in the Foundation Phase

Year 4	Integrated Arts: Drama, Music, Visual Art, Dance Knowledge of theories on creativity Art appreciation Exhibitions, budget, ordering of stock Integrated programme of practical work	Practice orientated work: lesson preparation, teaching, application of integrated arts: Drama, Music, Art and Dance teaching in the Foundation Phase culminating into reflective practice and arts related research

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PHONE TO PHOTOSHOP: MOBILE WORKAROUNDS IN YOUNG PEOPLE'S VISUAL SELF-PRESENTATION STRATEGIES

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ABSTRACT

Relatively few young South Africans are equipped to enter the creative industries, since access to these occupations requires a combination of economic, social and cultural capital. The South African schooling system does little to assist students to overcome the income and class barriers to these industries. Increasing use of online portfolios for professional self-presentation in creative fields constitutes another key hurdle to tertiary studies at elite institutions and also to freelance employment, given the local context of unequal access to digital technologies.

While mobile phones are the most accessible form of digital media in the South African context, their use in portfolio creation necessitates extensive resourcefulness for mobile-centric students. This paper explores how mobile technologies are implicated in digital self-presentation and in the creation of e-portfolios, which involve both specific forms of cultural capital and specialised infrastructure. Similarly digital portfolio creation requires infrastructure which exceeds the capacities of most South African schools.

We document the barriers and opportunities presented by digital networking for two young South African Visual Arts students. These

two students attended very different secondary schools but both learned to showcase their work in digital portfolios and develop professional self-presentation strategies. We describe the visual strategies they adopted as they negotiated an unequal education system in two different parts of Cape Town. Their experiences suggest that educators should be open to accommodating the mobile practices and genres that young people already use as they help them assume and challenge 'disciplined' identities in the visual arts.

Keywords: *Design education, Mobile photography, Mobile-centric, Resource constraints, Communication ecologies, Class distinction, E-portfolio*

INTRODUCTION

Increasingly, people represent their everyday selves through media captured on mobile phones and shared on social networks. Professional promotion in creative disciplines such as visual art and design also relies on such platforms. As interfaces, content and infrastructure are becoming more broadly accessible, they are blurring the distinctions between professional practice and everyday creativity. At the same time, and particularly so in highly unequal countries such as South Africa, income differences and complex forms of cultural knowledge create barriers for young people entering creative fields. This paper explores the experiences of young Visual Arts students learning to showcase their work in digital portfolios and to develop self-presentation strategies associated with recognisably professional identities and oeuvres of work.

We present two different case studies of schools in Cape Town, South Africa. These case studies show how state initiatives such as Arts and Culture schools have broadened access to art and design education to a small degree, but that major inequities still divide even the relatively privileged young people who are able to attend schools which offer Visual Art. Access to ICT infrastructure and digital media production are key dimensions of inequality and shape the media and communication ecologies of aspirant visual creatives.

Here, as in many other places, not all youth can access a high-speed, reliable digital network or software and hardware for digital media production. Construction and maintenance of web-based e-portfolios require extensive access to school and home infrastructure. Existing social inequalities are deepened by the designs of hardware and software which assume internet access and desktop computers. We attempt to understand such creative appropriations and negotiations to ensure that software better supports mobile-centric users whose access to privileged digital ecologies is expensive, intermittent, or occasional (Donner et al. 2011a). These mismatched digital media ecologies elicit complex workarounds.

Portfolios of privilege in art education

To a great extent, in South Africa, training in the visual arts and subsequent participation and employment in the creative industries builds on and extends middle and upper class privilege. Bourdieu argued, in a very different context, that the cultural realm disguises class differences in a society – we celebrate the ‘talent’ of those successful in visual art, literature or music, while ignoring the leisure time, educational access and cultural capital which their success requires. Similarly, education certifies the abilities of the middle classes, while hiding the fact that their apparent ‘distinction’ both requires a history of privilege and guarantees future opportunities (Bourdieu 1984; Burawoy & Von Holdt 2012). Participation in cultural activities and practices involve, to use Bourdieu’s terms, forms of class ‘distinction’ and ‘habitus’ or access to the class-based cultural resources which make the practices of the dominant culture possible. In South Africa, even as the hegemony of Western middle class culture is heavily contested from a post-colonial perspective, educational institutions continue to grant access on the basis of portfolios of privilege which index class and race. Increasingly such privileges involve the ability to access infrastructure for digital media production, and to activate social capital through digital networks.

CONTEXT

Visual Art and Design education barely feature in low-income township schools in Cape Town today and young working class people who attended township schools remain under-represented in tertiary design education and industry (Sutherland 2004; Sauthoff & van Eeden 2010; Joffe & Newton 2008).

At the same time, there is an opening up of opportunity, as, globally, researchers have shown how young people are able to leverage digital media and networks, later turning their online interests into careers (Ito et al. 2010). But shifting participation in this way from social sharing to fan activities to professional involvement is not a trivial matter, particularly for young people without easy access to either digital infrastructure, or the requisite economic and class cultural capital (Bourdieu 1984). Even in contexts where young people are not able to study Visual Arts as a subject they go to great lengths to develop their own visual voices and counter the limitations of their environment (Walton et al. 2012; Walton & Haßreiter 2012). Case studies in this paper show that even in specialized schools offering Visual Arts, young people still confront significant obstacles to creative digital participation. This paper focuses on the role of infrastructural obstacles in young people's self-presentation strategies in two South African schools, one public and one private.

ICT ecologies in South Africa

Only 2489 of the 24793 government schools in South Africa have computer centers (Equal Education 2012). While Cape Town schools were among the few to have had computer labs installed, use of these labs is curtailed by the fact that recurrent costs must be raised from parents, who in many cases struggle to pay even minimal school fees. Such costs include maintenance and replacement of equipment, monthly telecommunication and broadband charges and software licenses.

Access to computers and internet at home is also skewed. A survey published in 2012 found that there were 12,3 million internet users above the age of 15

in South Africa (de Lanerolle 2012). Many of these internet users relied heavily on mobile access, confirming findings which documented the rise of South Africa's largely "mobile-centric" internet users (Gitau et al. 2010; Kreutzer 2009). Only 18% of those surveyed owned a computer, of which roughly 90% were connected to the Internet. Of the 84% who owned a mobile phone, 67% had Internet capabilities and of those, 71% used the phone to go online. Low income South African urban users are thus using their mobile phones as primary devices to gain access to the internet and via social media such as Facebook, Mxit and Twitter, to engage, and participate online (Donner et al. 2011b; Hassreiter et al. 2011; Walton 2010; Schoon 2012).

This picture of expanding online participation does not adequately give us a sense of what digital media is created and shared – and when and how this is done. Internet use is constrained by high cost of prepaid data and the limitations of feature and low end smartphones (Walton & Leukes 2013). For example, in a study of teenagers who use libraries and cybercafés, few young people report participating actively in fan communities or other forms of networked learning (Walton & Donner 2012). This paper echoes these findings in relation to the constraints of school media ecologies.

Art Education in South Africa

Art education and young people's development of visual creativity lies at a complex intersection of education, technology and culture in contemporary South Africa. Post-colonial critique and celebration of local heritage may be the public face of the South African design industry, but to a large degree Bourdieu's analysis of the role of 'cultural capital' and 'distinction' in reproducing class and populating cultural industries still holds explanatory power (Bourdieu 1984; Burawoy & Von Holdt 2012). The privilege of participating in both cultural industries and visual art education relies on access to infrastructure and cultural resources closely linked to the dominant culture. Furthermore educational distinction (Bourdieu 1984) is related to middle class privilege in general and whiteness in particular. Postcolonial challenges to Western cultural hierarchy (Haupt 2008) may inform curriculum statements but local educational policies and their implementation are

exclusionary in practice. Apartheid education systematically neglected Visual Art in black schools. Visual Art and Visual Design are seen as relative luxuries, requiring specialised staff and expensive infrastructure. Consequently, as few as 26% of secondary schools in the metropolis of Cape Town offer art- or design-related subjects at a Senior certificate level (Joffe & Newton 2008; Graan 2005). Historically, most township schools have not offered specialised arts or design-related subjects, while wealthier schools offer the privilege of choosing from several visual art disciplines. Thus the education system plays a vital role in reproducing class, cultural and income hierarchies. To a great degree, in South Africa, training in the visual arts and subsequent participation and employment in the creative industries reflects social privilege.

Private schools serve a tiny minority and charge much higher fees than government schools. As will be discussed below, in such schools the visual arts function as marks of class 'distinction'. Such schools commonly employ specialized teachers in order to offer both visual art and graphic design.

In government schools, by contrast, in 2013, only 6755 of South Africa's 562 112 Grade 12s studied Visual Art. Consequently, young working class people who attended township schools without specialized teachers or the equipment needed for Visual Art remain under-represented in tertiary education and design industry alike (Sutherland 2004; Sauthoff & van Eeden 2010; Joffe & Newton 2008). As a result, working-class students have little chance of being accepted to pursue art and design courses, let alone to entry-level jobs in the creative industries. (Booyens 2012; Joffe & Newton 2008)

These inequalities are magnified if we consider inequities in provision of infrastructure for digital art. The ICT facilities on offer in private schools serve a similar function to specialized subjects – namely signifying class 'distinction'. Consequently private schools were the first South African schools to embrace the use of laptops and later tablets by students. By contrast, in the minority of schools which have computer labs, available IT resources are channelled to support 'basics' such as literacy and numeracy drills in primary schools, while in secondary schools, labs are often reserved for the use of the relatively

small number of students who take IT courses (Prinsloo & Walton 2008; Walton 2007).

Both the infrastructure and curriculum for visual art and digital design can thus be seen as markers of educational 'distinction'.

METHOD

Our case studies are drawn from first author Travis Noakes' long-term study exploring the use of digital media for young people studying visual art in two quite different high schools in Cape Town. In the first site, twelve volunteer Visual Arts students at a specialised co-ed state school (six males and six females) attended extra classes to develop digital skills and to construct electronic learning portfolios (e-portfolios). In the second site, seventeen male students enrolled at a private boys' school were required to create e-portfolios as a compulsory component of their Visual Arts syllabus.

Creating e-portfolios for Visual Arts students

Over four years of action research in these sites Travis observed students producing e-portfolios to showcase their visual art. These e-portfolios featured personal profiles, their own original artworks, including digitized drawings and paintings, a range of visual designs, photographs, as well as visual material that had inspired them. They used free membership of online portfolio service, Carbonmade (www.carbonmade.com).

Although one school was privately owned and the other state-owned, students at both schools enjoyed considerably better resources than the vast majority of South African students do, given their access to computers and the availability of Visual Art subjects.

The state school was situated in one of the areas demarcated 'coloured' under apartheid's Group Areas Act. Only a minority of students lived in the immediate neighbourhood. Most students were from working class families who struggled to afford the R1200 (\$110) monthly school fees and transport costs from poorer areas, such as; Delft, Guguletu, Hanover Park, Khayelitsha,

Langa, Maitland and Mitchells Plain. An Arts and Culture Focus school, this state school nonetheless had an excellent Art teacher and a working computer lab. Problems with Internet access led to a two-year delay before the e-portfolio project could be introduced.

Only Information Technology students had regular use of school's the general computing labs, and consequently only a few students were proficient at using computers. The e-portfolio lessons were presented during Visual Arts class times, and continued during lunch times. The creation of e-portfolios was not compulsory, because the teacher believed that certain students would not do the extra work that e-portfolio creation and research participation would necessitate. Nonetheless twelve students volunteered to create e-portfolios under Travis's guidance using a loaned scanner and cameras.

In addition to lesson observations and questionnaires, seven students were interviewed about their use of e-portfolios.

The second research site is an independent secondary school for boys, where a class of seventeen students created portfolios between 2010 and 2012. This elite private school attracted students from affluent homes, and is one of the most exclusive (and expensive) institutions of its kind in the country, charging fees of R6000 (\$552) per month.

The private school students all had laptops and Wi-Fi was accessible from almost anywhere on the school grounds. Scanning equipment and digital cameras were readily available. The e-portfolio curriculum was compulsory and was used to help students self-curate works for their end-of year exhibitions. In addition to classroom observations and questionnaires, seven students were interviewed.

GOVERNMENT SCHOOL

Despite more limited infrastructure, the students at the government school benefited considerably from the dedicated guidance of their Visual Arts teacher. Most of the students who volunteered to participate in the voluntary e-portfolio sessions aspired to study and work in careers involving creative

production. Many, like Masibulele believed their e-portfolios could help them to gain access to tertiary studies 'I immediately saw that this is something that I could use in my near future for Tertiary studies.' Furthermore, Masibulele believed his e-portfolio work would help him gain access to professional networks in "the art industry".

Overall, this group had a strong foundation in drawing and painting, but only one student was able to attend an extra-mural activity which extended her involvement in visual culture. Nevertheless, their e-portfolios expanded the range of visual genres beyond those emphasized at school and encompassed works from youth culture such as manga, graffiti, and textile prints.

Mobile-centric ecologies

The young people attending the government school had access to computers and the internet at school, although only during e-portfolio classes and recesses.

By contrast, cell phones were ubiquitous, and eleven of the twelve students provided personal mobile phone numbers as their preferred daytime contact number. These young people thus shared the broadly mobile-centric digital habitus of most South Africans (Donner forthcoming)

Only a quarter of the students had internet access at home, but eleven could 'always or often' access computers outside school. They all had extra-mural access to the computer lab at the school. According to questionnaire feedback, most students could easily complete e-portfolio digitization work outside class; ten students 'always or often' had access to cameras, five 'always or often' to scanners.

This group had some prior experience of computers and email, but their irregular use patterns meant that they easily forgot passwords. Their ability to change passwords was limited by the fact that their access was distributed across multiple email accounts, and to open their email they needed devices such as cell phones and laptops which belonged to other people, and which they could not access during class.

Mobile genres

Of the twelve students who attended the voluntary e-portfolio lessons, their "About" pages showed the strong influence of mobile genres on their self-presentation, with a third of the group choosing to use mobile phone 'selfies' as their profile image on their e-portfolios (see Figure 1).



Figure 1: Examples (anonymized) of mobile phone 'selfies' uploaded as profile images by government school students.

Five students did not upload any images of themselves. In one case this was because the student had privacy concerns. In the other cases infrastructural obstacles stopped them from taking pictures or transferring files.

Bandwidth

None of the students were satisfied with the bandwidth available in the school lab, where internet was slow and unreliable. As a result, they had to upload one image at a time, try different computers, and experiment with uploading at various times of the day. Slow uploads appear to be more error-prone, giving rise to duplicate uploads, images and a relatively large number of images uploaded in the incorrect (portrait/landscape) orientation or posted to the incorrect folder. The students were reluctant to delete imagery uploaded, even

if it was incorrect because each file took so long to upload in class. They felt having 'incorrect' imagery was preferable to 'wasting time' uploading corrected versions.

Despite being shown how to reduce file size and advised to work with small files, several students used the large, default settings of their high-res mobile phone cameras. These generated 2MB sized images, which took too long to upload from the lab.

After failing to upload more than two images in one lesson, Herschelle decided to use his mobile phone to upload images. Two others attempted this mobile strategy, but were unable to do so, owing to the relatively high resolution images, and possibly their limited airtime.

Given these complications of low bandwidth on both the lab and mobile phones, the three students who had Internet access at home were at a major advantage. They were able to upload all their images at home, and were thus able to focus their time in class on improving the design of their e-portfolios, thus gaining self-presentational advantages.

INCOMPATIBLE ECOLOGIES

Almost all the young people were familiar with using simple folder structures from using Bluetooth to transfer files on their mobile phones, but they struggled to manage folders and locate files on a desktop computer or to use email attachments. Here the numeric default filenames created by cameras and scanners proved particularly unhelpful.

Getting images onto and off phones was particularly difficult. Students struggled to connect phones to the lab's desktop computers because the computers neither detected the phones, nor suggested the necessary drivers be installed. Tazneem tried several methods of transferring files, eventually resorting to sharing the image via Facebook, then downloading it to a lab PC and finally uploading it to Carbonmade.

MASIBULELE

We now turn to the story of Masibulele¹, a highly motivated and creative student from the government school. Masibulele's story provides a case study of a student who overcame barriers of infrastructure and who challenged cultural exclusion through his e-portfolio.

Masibulele loved drawing, was a top student and enjoyed a close relationship with the Visual Art teacher. His parents were not involved in his intense passion for art, nor had they seen his online portfolio. 'I wouldn't speak about it to them.' Instead, he shared pictures of his creative work with his peers via Facebook and looked forward to the day when he would have enough of a digital oeuvre to set up his own Facebook page. On Facebook he had not applied any privacy settings. Here, as on Carbonmade he prioritized being findable via search and email. For this reason he refused school-based limitations such as restrictions on providing email addresses and other cautionary measures to protect online 'safety'. He knew the power of social networks was to make new connections and he prioritized remaining open to sharing and connecting with others. Unfortunately his main form of internet access outside of limited school lab hours was via his mobile phone. This was costly and often ran out before he had the cash to replenish it.

He used his e-portfolio to present an online identity that revealed the breadth of his engagement with visual culture, rather than limiting him to an online presence as a Visual Arts student. He used the space to show his versatility and how his capabilities went beyond the school curriculum which focused on painting and drawing.

Part of the significance of Visual Art to Masibulele was his interest in asserting black identity: "my culture, where my background is from". Masibulele believed that blackness was not sufficiently accommodated by the school curriculum in Visual Art. He filled this gap in the formal curriculum by drawing

¹ Not his real name. All names which follow are pseudonyms, anonymised to protect participants' privacy.

in his spare time. These drawings explored black identity, as in his pencil sketch 'Black Beauty Feel' in Figure 2.

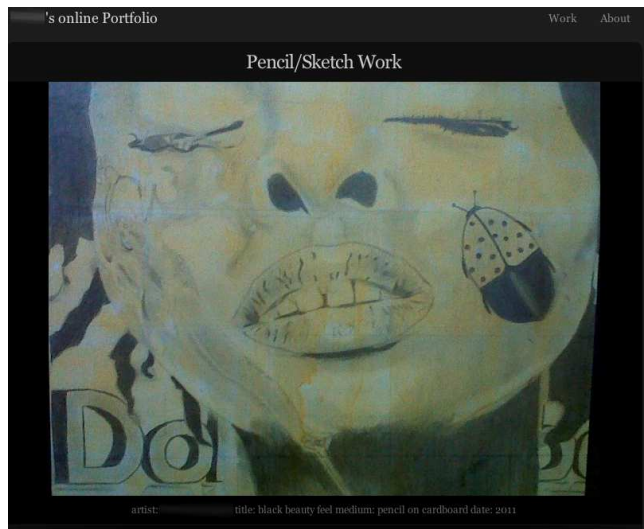


Figure 2: Portfolio item by Masibulele: "Black Beauty Feel", 2011, pencil on cardboard

Blackness was thus linked to an out-of-school sense of identity. Masibulele's awareness of cultural exclusion is further apparent from his sense that the school curriculum precluded creating works in mixed media which he associated with traditional crafts and local South African cultural identities.

Masibulele's initial e-portfolio did not attempt to reflect blackness, and also excluded other important dimensions of his identity. For example, an important part of his out-of-school sense of himself was his extra-mural involvement in fashion design and a small clothing business of which he was 'Founder/producer/CEO'. His initial e-Portfolio did not include any examples of these designs, despite the fact that he had developed his own clothing line, which he named 'SoiL' (an acronym of 'Style Over Intimate Levels'™ - see Figure 3). He had exceptional entrepreneurial flair. He sold t-shirts, sweatshirts, sweat pants and 'booty' shorts (for women only) and was planning to save sufficient money for a textile printer.

Masibulele added the SoiL folder to his portfolio after an interview for this study encouraged him to feature this extra-mural work. Once he had decided to include his clothing designs, however, he documented them extensively.

His ePortfolio annotations adopted the register and address of a proud entrepreneur marketing his wares, with a hint of the conscious “awareness” that he valued ideologically: “[SoiL] is a Clothing Line for both male and females and in the mere future for Kids too. Established last year but recognised and made more aware this year February.”



Figure 3: Portfolio item by Masibulele "These are different designs for Booty Shorts of local streetbrand, SoIL I am the proud founder/producer/CEO of SoiL. Est 2013"

Masibulele used his e-portfolio in support of his application to study surface design at the Cape Peninsula University of Technology, where he is now a first year student. Unlike most of his classmates Masibulele was able to overcome the many obstacles which stop young people from gaining access to tertiary studies – cultural exclusion, application fees, bursary application processes, and academic pre-requisites.

PRIVATE SCHOOL ECOLOGIES AND DISTINCTIONS

By comparison to their peers at the government schools, the Visual Arts students at the private school had access to considerably more digital and other infrastructure for creative production. Given the facilities available here,

it is not surprising that the e-portfolios were adopted so much earlier, more easily and more universally than in the government school. A large majority, or thirteen students were able to upload at least 20 artworks each.

Private school students' feedback suggested that they enjoyed extensive exposure to the visual arts, both at home and as extra-mural activities. Just under half of the students were involved in extra-mural societies related to visual culture.

The teacher at the private school adopted the e-portfolio curriculum almost immediately it was suggested to him. He nonetheless put his stamp on the project by imposing somewhat elitist requirements which removed it from the students' domain of popular culture. While the government school students were able to use mobile genres and challenge the Eurocentrism of the Visual Arts curriculum in their portfolios, private school identities were far more tightly policed into disciplinary identities. They did nonetheless showcase their conspicuous consumption of digital and consumer electronics. Eight private school students integrated extra-curricular digital visual modes such as photo-editing and videography into their portfolios, although these media were not part of the formal Visual Arts curriculum.

By the final year of the project and during their final year at school, six of the seven students interviewed said that their work on their e-portfolios was primarily motivated by a desire to gain better grades for the e-portfolio assessment. Ironically, given their advantages over the government school students, few of the private school students aspired to careers in the arts, instead their extensive access to consumer electronics for visual creativity and their immersion in art-related activities were all markers of class distinction, perhaps equipping them to invest in artworks at a later stage rather than requiring them to earn their living in creative industries.

Extended ecologies

In interviews, most students at the private school reported that it was not difficult to complete work for their e-portfolios outside class. As the school required each student to have their own laptop, almost all had easy ('always

or often') access to computers, but also to mobile phones and cameras. Over half had access to scanners. Photography and photo-editing software were highly accessible and mentioned by many in their profiles. (By contrast, only a couple of students at the government school had referred to this). Two students documented their activities as body boarders using footage from their own individual waterproof action cameras.

SLOW AND UNRELIABLE BROADBAND.

Despite its well-appointed facilities, the private school was still negatively affected by disruptions to broadband. These included challenges outside the school's control, such as; power failure, copper cable theft, or local and international broadband cable failures. Problems inside the school included Internet traffic not being shaped to prioritize pedagogical usage. The day scholars, who lived with their parents were not restricted by these occasional failures, as they had alternative points of access at home. Despite the advanced infrastructure at school, over a quarter of the class reported that they preferred home infrastructure to school wifi, and they used the cheap broadband at home to complete classroom activities after school, effectively 'flipping the class'. Four of the seven students interviewed at the private school preferred to use the Internet at home, where was faster and more reliable. This meant that they could use class time for tasks other than uploading imagery.

Passwords were a problem, just as they were at the government school. The students' distributed ecology across devices was more accessible because their individual laptops were allowed at the private school, which was not the case at the government school. Instead security features and spam filters implemented on the school network were the major stumbling block, blocking password reminders sent to school email addresses. Ironically, the frustrations caused by these features often resulted in students resorting to (less secure) cloud-based services.

The limits on Carbonmade's freemium package chafed the private school students, who were accustomed to more capacious storage, both on their

laptops and in cloud-based archives. They were already exploring creating an online presence on other sites. Three students had already created such portfolios to showcase their online photography and videography portfolios, and in one case, on a personal blog. Rather than paying to upgrade to premium Carbonmade accounts (which required both credit cards and foreign currency), Kyle, Hui and Gary linked to these supplementary photographic and video portfolios, which they created on other platforms (including Flickr, Wix, Vimeo and/or Youtube). The teacher needed to request the IT department to whitelist Flickr, previously blocked by the school's 'nanny' software.

Specialised peripherals such as scanners were not easily accessible from the students' laptops, and the teacher made his own laptop available for scanning, a strategy he also used to give them access to image editing software. Here again, some individuals were able to gain an advantage by using their own copies of Adobe Photoshop in class, while two resorted to Microsoft Paint to crop and resize their pictures.

Disciplined genres

Despite the accessibility and importance of photography in their 'About Me' narratives, the private school students were instructed to use self-portraits in media other than photography, such as drawing and painting. Most of the group complied with this instruction (a few included more conventional photographic portraits or group portraits). None used the mobile phone selfies popular in the government school.

This avoidance of photography and particularly mobile phone photography can be interpreted as a mark of distinction, or a class-based preference for the exclusivity of 'fine arts', and a marker of the disciplinary foundation in drawing which the teacher wished to emphasize. This use of the self-portraits subtly shifted these students' identities to a professional, disciplined identity, that focused on the work rather than the person.

GEORGE

We now introduce George, a gifted and conscientious private school student, who closely reproduced the prescribed guidelines for a Visual Arts e-portfolio showcase whilst 'making it his own thing'. George did not face any infrastructural challenges, as he had ready access to a phone camera and scanner to digitise his work, software to edit these images and fast broadband access via his laptop to upload and organise these images via Carbonmade.

An exemplary student, George enjoyed drawing and sketched every day. Both his parents worked in advertising and his own identity was closely linked to being a Visual Arts student. His 'About Me' page mentions local and overseas gallery visits, and he describes himself as a 'big fan of abstract, modern and conceptual art' (EG1, about page, 2012). He supplemented these interests with online activities, pursuing his interest in art by participating on Facebook, Twitter and art network deviantART, while also keeping up with art websites and specialist blogs.

At school, George was a leader in the Accelerated Art program, and a member of the Digital Design society. He won the Visual Arts subject prize in his final year at school. Over the course of the project he grew to appreciate his e-portfolio as a reflection of his abilities and as a source of high grades he needed to maintain in order to keep the place he had been offered studying Medicine at a local university.

George's e-portfolio design was simple and elegant, with a plain white background intended not to distract attention from the artworks themselves. He differed from Masibulele and most of his classmates in that he had aimed to emulate a '*clean type of gallery look*'. As a result, he chose to use the metaphor of a clean, white gallery in carbonmade to simulate the experience of gallery viewing and foreground his Fine Art creative works.

His captions for his portfolio items, (even those created out of school) were formal, revealing none of the persuasive register or marketing address which Masibulele had adopted, as in the following caption for a self-portrait: "'Sitting Down' August 2011 Oil Paints on Board Completed as part of a Painting

Course 480mm x 480mm". In this caption, George's language mimics the understated address of a gallery presenting salient details about objects of distinction to an audience of discerning potential buyers.

Apart from his instrumental approach to maximizing his grades, George was also motivated by interactions with the online audience that Masibulele courted. While Masibulele connected primarily with his peers via Facebook, George received feedback from both his parents and his classmates about his Carbonmade e-portfolio, and had a strong sense of an appreciative online audience. He planned to maintain his portfolio after school to continue sharing his drawings with a broad audience because he also enjoyed the positive attention from people who had commented on the other sites where he uploaded his work. *'It is one of the main reasons I put things online - so I can see how people around the world feel about it.'*

George also had a photographic portfolio on Flickr. This service was blocked by the school and George chose not to link to it from his e-portfolio since he felt the 'blocked' message might confuse the invigilators of his matric exam. In this decision, George echoed his teacher's preference for disciplinary markers of a 'fine art' identity – he explained that he wanted the examiners to focus on his 'style of art' in the traditional disciplines of drawing and painting.

Presenting himself as a traditionally trained artist to examiners, and using his extensive knowledge of conventions in the art world, George thus used the e-portfolio to showcase privilege, confirm his insider status and establish a claim to disciplinary and creative identity.

CONCLUSION

Given these two case studies of successful and motivated young Visual Arts students it is worth remembering that the overall background to this study is one of exclusion and that just under 99% of young South Africans do not have the opportunity to study Visual Arts at all. In creative fields, education at most schools reproduces domination, effectively excluding young working class students from developing the skills and portfolios of work required to access creative careers. At government schools, digital aspects of the visual arts are

not well established and serve to mark the distinction of those attending schools like the private school documented in the study, or the relatively good circumstances of those able to attend an Arts and Culture Focus School.

Our case studies, though featuring two exceptional individuals, suggest the growing importance of a digital habitus, or general orientation towards an online audience developed through everyday practices. The differences in reach between George and Masibulele suggest the importance of the availability of social, material and digital infrastructures such as family networks, good bandwidth, computer hardware and software.

Creative production with digital media involves the use of varied hardware and software as users digitize, edit, share and organize digital content. Our case study of the private school shows the complex layering of infrastructure and cultural and social capital involved as young people in the elite class acquire the distinctions associated with an education in Visual Arts, and the considerable advantages provided by their home backgrounds.

The state school suggests the challenges and the possibilities which come into play when these technologies are appropriated by teachers and working-class students in poorly resourced school and home environments, particularly in the global South.

George's 'model' e-portfolio reflects his privileged access to the world of art, its discourse and practices. The identity he constructed accommodates the markers of his ethnicity and rewards his cultural capital while being seamlessly accessible to both his everyday and digital networks, who provide him with multiple audiences who can reinforce his access to the discipline.

Masibulele's e-portfolio reveals a great deal about the permissible identities associated with the visual arts at school in South Africa. On the one hand, Masibulele's mobile-centric Facebook network reveals the emergence of a grassroots exhibition space, and his command of marketing discourse suggests the desire to influence this network as an entrepreneur. On the other hand, Masibulele's initial association between the academic discipline of Visual Art and white identity suggests an exclusionary ideology which

teachers need to address explicitly. In this case it only came to light as a result of the in-depth interviews conducted for this research project.

While both George and Masibulele managed their self-presentations strategically, George's cultural capital allowed him a more intimate knowledge of how examiners might evaluate his work. Masibulele's initial self-censorship revealed his sense that he should conceal rather than foreground race and class identities. This crucial difference coexists with severe inequalities in access to infrastructure for digital publication, and we would recommend that these issues of cultural and economic capital need to be addressed together.

PEDAGOGICAL RECOMMENDATIONS

We argue that the relative accessibility of mobile phones in the state school ecology suggests that a recentering of current curricula and software designs around mobile phone use and genres could be an important shift to broadening access. Mobile technology is already playing a crucial role in opening access to certain aspects of digital creativity, notably photography and sharing of photographs and other images. Mobile phones and mobile photography in particular should be a central component of Visual Arts education in South Africa today. At the same time, current mobile technology bars access in other ways, in particular through the tricky interface with PC-based ecologies and peripheral devices, the high cost of mobile data, and, compared to laptops or desktops, the handset's limitations as a media production device. This paper has thus suggested how students creating e-portfolios in such settings must work around the limits of phones as currently designed.

An approach drawing on Bourdieu might aim to use the affordances of mobile phones to extend the advantages of bourgeois culture to all by encouraging the use of free school wifi on students' own devices, and broadening their access to "high culture", such as online galleries.

Masibulele's story in particular suggests that such an approach is incomplete without addressing the cultural politics of Visual Art. Here Freire, for example, might seek an alternative approach which values and cultivates existing

creative practices in a pedagogy starting out from young working class people's lived experience (Burawoy, 2012:104). Infused by this ethos, a Visual Arts curriculum would need to spiral out from the everyday photographic genres already accessible to young people, using them to reflect on local surroundings, and to address internalised oppression as well as to construct fantasy selves.

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MAKING NANO-SATELLITES MORE SUSTAINABLE: INVESTIGATION INTO AN OPTIMAL COMMUNICATIONS PROTOCOL USING A NOVEL SIMULATION TOOL

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ABSTRACT:

Many developing countries lack the tools and knowledge on proper design processes to effectively participate in nano-satellite development and design projects. Nano-satellites are great vehicles for enabling technological development, especially with the development of the CubeSat standard. In this paper we highlight the importance of CubeSat communication system design towards successful and sustainable satellite development. A new open-source discrete event network simulation tool named SatSim is introduced. SatSim is developed in Python to provide a user-friendly environment wherein developers can easily implement and test new and existing communication strategies and protocols. This promotes proper testing which is critical to reduce some of the risk factors associated with satellite development. SatSim is also utilised to simulate and test the performance of the AX.25 and FX.25 protocols. Both these protocols serve in terrestrial and satellite applications, although FX.25 has been used to a lesser extent. Simulations show that an optimal satellite communication strategy can be implemented by using a combination of AX.25 and FX.25. AX.25 with a CubeSat configuration performs well when the transmitter and receiver are in close proximity, but struggles over noisy channels. FX.25 on the other hand performs more reliably, but at a lower throughput compared to AX.25. By intelligently switching between the two protocols a more reliable and efficient strategy is proposed for CubeSat communication systems.

Keywords: CubeSat, AX.25, FX.25, Network Simulation, SimPy

INTRODUCTION

Developing countries face numerous obstacles with entering the space segment research and development sector. Major obstacles include a lack of knowledge, the importance of proper design processes, economic factors and limited access to tools and facilities. Some of these obstacles have been reduced due to the developments surrounding the CubeSat standard (CubeSat, 2014). This standard set in motion the possibility for any small institution to develop and construct a nano-satellite. CubeSats are ideal vehicles for developing countries to enable space research and development.

One caveat of CubeSats is the limited communication bandwidth between the satellite and ground station, which translates to limited data throughput. This limitation is attributed to multiple factors including the low satellite orbit altitude and the power and weight restrictions associated with the CubeSat standard. A solution to the communication bandwidth problem has been proposed by Stellenbosch University (SU) which is called The Outernet (Kearney, et al., 2012). The basic concept is to use a nano-satellite constellation to relay satellite data to a distributed ground station network. The constellation would consist of 14 satellites in an equatorial circular orbit. A constellation like this can provide a service with much improved communication bandwidth compared to an average CubeSat mission with limited ground support. Even if a solution such as The Outernet is implemented, CubeSat missions are still limited since sub-optimal communication strategies are implemented.

Network simulation tools and results are required to assist with the research and development of communication strategies. Although both commercial and open source simulation tools are available, there are various drawbacks limiting their full utilisation. The most prominent factors are cost, complexity and lack of satellite orbit support. SatSim, a network simulation tool based on Python, was developed to assist with the investigation of an optimal strategy. It also provides a low cost, royalty free, easy to learn, extended feature, open source development tool available to developing countries. The simulator was validated by comparing simulation results to results from other simulators as well as theoretical calculations. SatSim was used to simulate AX.25 and

FX.25, the latter being an extension to AX.25 which adds forward error correction (FEC). By simulating these two protocols under the same conditions, it was possible to identify an optimal case to maximise throughput for a satellite pass over a ground station. The optimal strategy proposed is to use a combination of AX.25 and FX.25 and to optimally switch between the protocols. This novel approach re-uses existing protocols and can drastically improve communication throughput and reliability of communication channels traditionally used for CubeSat missions.

BACKGROUND

CubeSats are ideal platforms for developing countries to enter the space research and development environment. Compared to conventional satellite development programs, CubeSat programs are much more affordable, features reduced risk profiles and have much shorter development and deployment time frames. These characteristics allows for institutions from developing countries to become involved in satellite development and research.

The first CubeSat project began in 1999 as a collaborative effort between the California Polytechnic State University and Stanford University's Space Systems Development Laboratory. The purpose of the project was to provide a standard for the design of pico-satellites to reduce cost and development time, increase accessibility to space, and sustain frequent launches (Munakata, 2014). This concept has been a massive success as it facilitates a platform for regular new developments and has made satellite design and launching much more accessible to a lot of institutions including universities, high schools and private firms.

A CubeSat is a 10 cm cube with a maximum weight of 1.33 kg (Munakata, 2014). This specification was designed to allow for the development of specific launch vehicles and launch adapters, purpose built for CubeSats. Launch safety is also improved through this approach as all the CubeSats will have similar shapes and weights. CubeSat developers benefit from sharing their findings within the community further facilitating the rapid advances in

the field which leads to regular technological discoveries. The movement has even spawned CubeSat hardware developers and manufacturers creating a nano-satellite industry. Some of these developers are breakaway groups from academic institutions who did research for CubeSat missions. Typically the approach in CubeSat projects is to rather make use of commercial off the shelf (COTS) components rather than building custom satellite components, as this approach reduces cost and development time. However, custom hardware is regularly built for research purposes. For the same reason propriety network protocols and experimental transmission frequencies are also used. With the rapid development of the CubeSat environment, companies have started to produce purpose built CubeSat hardware which can be acquired as a single functional unit. Entire 10x10 cm units in the form of radio transceivers, attitude determination and control (ADCS) units, on-board computers, power supply units and others can be purchased. By procuring standardised CubeSat sub-systems, development time is reduced and enables resources to be focussed more on the experimental or research payloads.

CubeSat communication systems

It is necessary to establish a baseline against which any newly proposed communications strategy can be compared. For this purpose the current trends in CubeSat communication systems is investigated. A detailed and periodically updated record of CubeSat missions is available through the efforts of B. Klofas (Klofas, 2014). The summary of CubeSat missions shows an overall trend towards 1 Watt (W) of transmission power. The most common modulation schemes are variations of Frequency Shift Keying (FSK). Data transmission rates tend to be very low with 1200 bits per second (bps), but many satellites have used 9600 bps for increased throughput. Communication antennas vary between monopole and dipole antennas with a few missions opting for patch antennas when transmission frequencies reach beyond 1 GHz. With these kinds of configurations it is important to have a clear indication of expected data throughput as some space missions can generate large quantities of data.

Another significant factor in CubeSat communications is the effect of orbit altitude. Most CubeSat missions are launched into lower earth orbit (LEO) which is at an altitude from 400 to 2000 km above the earth's surface. Satellites orbit the earth very fast at LEO altitude which leads to short periods of communication with ground stations. With these limited communication resources arises the need to use the communication channel as optimally and efficiently as possible.

The need for network simulation

There are many advantages in being able to simulate a satellite network's communication paths in its entirety. Firstly, it reduces the risk of a satellite mission by being able to fully understand and analyse the potential communication problems during a satellite's orbit. It also allows communication engineers to develop and test new and innovative protocols before it is implemented and deployed. Communication systems are inherently complex due to the influence of the many variables in such a system and it is difficult to factor in all these influences without some form of simulation.

Current state of simulators

There is a wide variety of communication simulation tools available, ranging from fully fledged network simulators to programming frameworks for discrete event simulation. A network simulator is software that is purpose built for simulating networks. It will most likely contain pre-developed packages that can be used to simulate a wide variety of topologies and protocols. Current well known network simulation tools include ns2, ns3, OPNet and OMNet++.

ns2 and ns3 are open source network simulation platforms. ns2 is widely used in academic research, but have some drawbacks. A significant drawback is the complexity and difficulty of implementing new models. This complexity makes defining new simulation scenarios tedious and imposes a significant learning curve on new users. The simulator consists of an OTCL scripting front-end, wherein the simulation is configured, while the simulation and modules are all implemented in C++. Very specific C++ file structures are

required to implement new modules and various header files requires modification to add new modules successfully. Recompilation of the ns2 simulator is required after changes to source files. A deep understanding of the ns2 simulator structures is required to successfully operate it. This is a drawback for novice users as the daunting learning curve encourages them to look for alternatives. ns3 is the replacement for ns2 and is still under development. It is a usable simulator, but the application focus has shifted towards internet applications.

OPNet Modeller is a commercial network simulator software package (Riverbed Technology, 2014). An academic edition is available for certain institutions on a 6 month renewable license agreement, but it is severely limited in functionality. The set of protocols and devices are fixed and a user cannot create new protocols nor modify the behaviour of existing ones, although some configuration parameters can be modified. The Academic Edition is limited to simulating 50 million events (events actions in the network, for example receiving a packet or the occurrence of a timeout). To put this amount of events in context: a wireless LAN with 10 devices all generating a high load will reach 50 million events in about 5 minutes of simulation time. OPNet is not a preferred solution unless funds are available to purchase a commercial licence. This will rarely be the case for developing countries.

OMNeT++ is a discrete event simulation environment for the C++ programming language (OMNeT++, 2014). Its primary application area is the simulation of communication networks, but due to its generic and flexible architecture, it is successfully used in other areas. Although OMNeT++ is not a network simulator in itself, it is currently gaining widespread popularity as a network simulation platform in the scientific community. Research or testing done in OMNeT++ can take some time due to it not being a dedicated network simulator. It also houses some complexity to overcome for less experienced developers.

There is clearly a need for network simulation and there are plenty of tools available, but not one tool is an obvious choice when it comes to introducing

new developers to satellite network simulations. This encouraged the development and design of a new tool for this purpose.

SATSIM DESIGN AND DEVELOPMENT

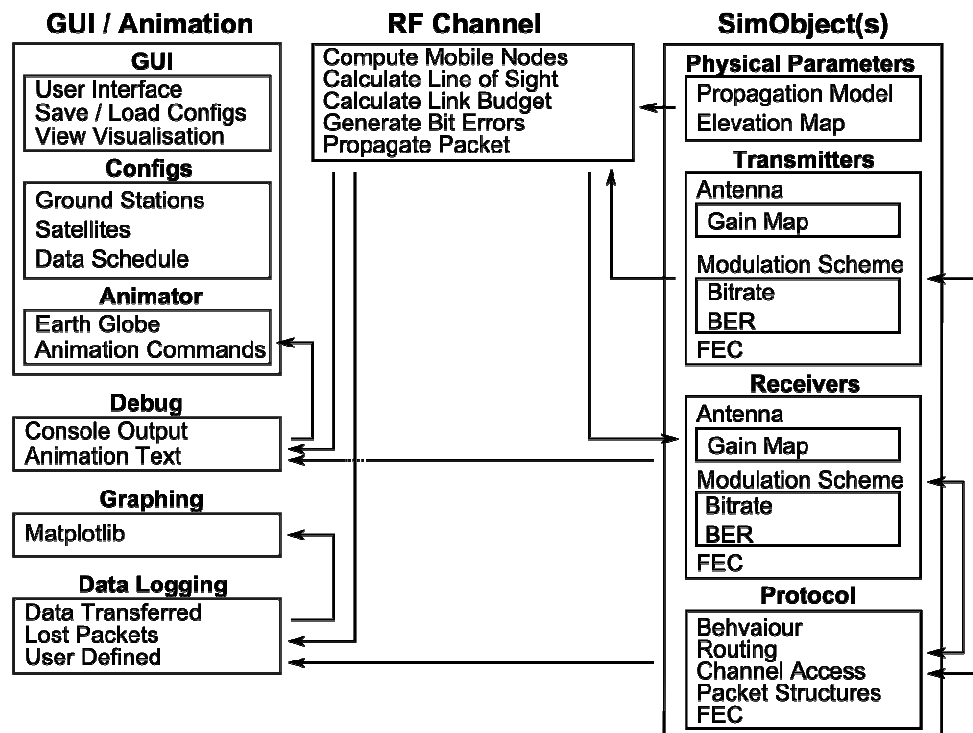
At the start of any software project it is important to identify the most important factors that will drive the software design effort. After investigating the current state of network simulators in the previous section, it was possible to identify a few key aspects that have to be addressed. The primary design drivers for SatSim are user friendliness (complexity to learn the tool), cost, modularity (complexity to add features to the tool) and reusability (complexity to adapt the tool to fit your project). Providing an open-source solution makes the simulator available to any interested party, as well as fully addressing the issue of cost. User friendliness, modularity and reusability are strongly tied together with the choice of programming language, the programming framework and the data structures used by the simulator.

Design of SatSim software framework

SatSim was developed using the Python programming language. There are a few reasons for this design choice. A key point is that Python is an interpreted programming language. This makes it easy for users with limited programming experience to learn and understand it. There is also no compiling required for Python which also decreases the time required to modify and test simulation code. Another reason is the plethora of available Python packages which can assist with different elements of simulator and protocol development. A critical package integrated into SatSim for the simulation engine is SimPy (Team SimPy, 2014). SimPy provides a framework for discrete event simulation within Python and it is the back bone of the SatSim framework. Another Python package named PyEphem (Rhodes, 2014) was integrated to provide propagation models for satellites. PyEphem makes use of the XEphem software routines which ensures that all underlying code is executed in C which greatly speeds up simulation execution time while keeping complexity low.

An object orientated software design approach is used for SatSim. This approach assists greatly with understanding the simulation environment. Each of the communication system functions, as well as visualisation and data management elements, are implemented as objects interacting with the other objects in the system, as shown in Figure 4. The user can alter a simulation by either replacing an object or by modifying its parameters. This allows for a highly modular simulation environment where code is reusable due to clearly defined interfaces within the simulator framework. This greatly reduces development time when adapting the simulator to fit one's own project.

Figure 4: SatSim framework



An issue identified during previous research done at SU was the execution time of simulations (Bezuidenhout, 2012). Python is an interpreted language and it may execute slowly under certain conditions, especially when compared to C. This is the only potential drawback with using Python. However, there are multiple solutions to combat slow simulations including executing computationally expensive code in C or exploiting multi-core processors to execute multiple simulations in parallel. Both of these techniques are relatively easy to implement in Python.

SatSim also provides the ability to visualise simulation results. Visualisation assists greatly to verify the physical aspects of a satellite simulation. The visualisation is optional and can be disabled by the user. SatSim also has a modular general user interface (GUI) constructed in Qt, which can be used to assist in loading or configuring a simulation. Advanced users can also perform simulations through custom Python scripts. The scripting approach also supports running multiple simulations in parallel and the gathering of statistic data relevant to the user's study.

VALIDATION OF SATSIM RESULTS

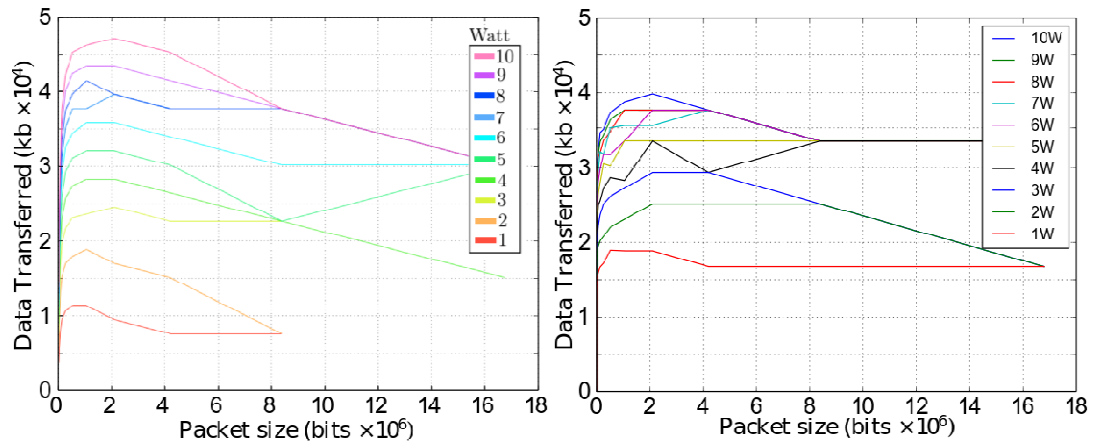
When introducing a new software tool into an established community, validating the results produced by the tool is critical. Showing that the tool provides accurate results greatly aids adoption of the tool by the engineering community. Validation of SatSim results was done in two ways. The first approach was to recreate simulation scenarios of previous research that used a different simulator and validate that similar results are generated. The second approach was to use SatSim to generate simulation results of protocols that can be compared with theoretical calculations. This part of the validation served two purposes: verifying the simulator up to protocol layer and verifying the AX.25 implementation.

Validation of SatSim results against OPNet simulator

Previous satellite communication strategy research was conducted at SU using OPNet (Bezuidenhout, 2012). The research involved the investigation and development of a satellite communication strategy. The custom protocol used for Bezuidenhout's study was duplicated as closely as possible and then implemented in SatSim. A comparison of the results from each simulator is shown in Figure 5. The simulation configuration and protocol used by Bezuidenhout was not well documented and certain assumptions had to be made during its reimplementing in SatSim which explains why the results in Figure 5 are not identical. Of more importance is the similar behaviour of SatSim results to the OPNet results. This illustrates that SatSim has the same

dynamic response within the simulation, given that the same satellite orbit and link budget constraints are applied.

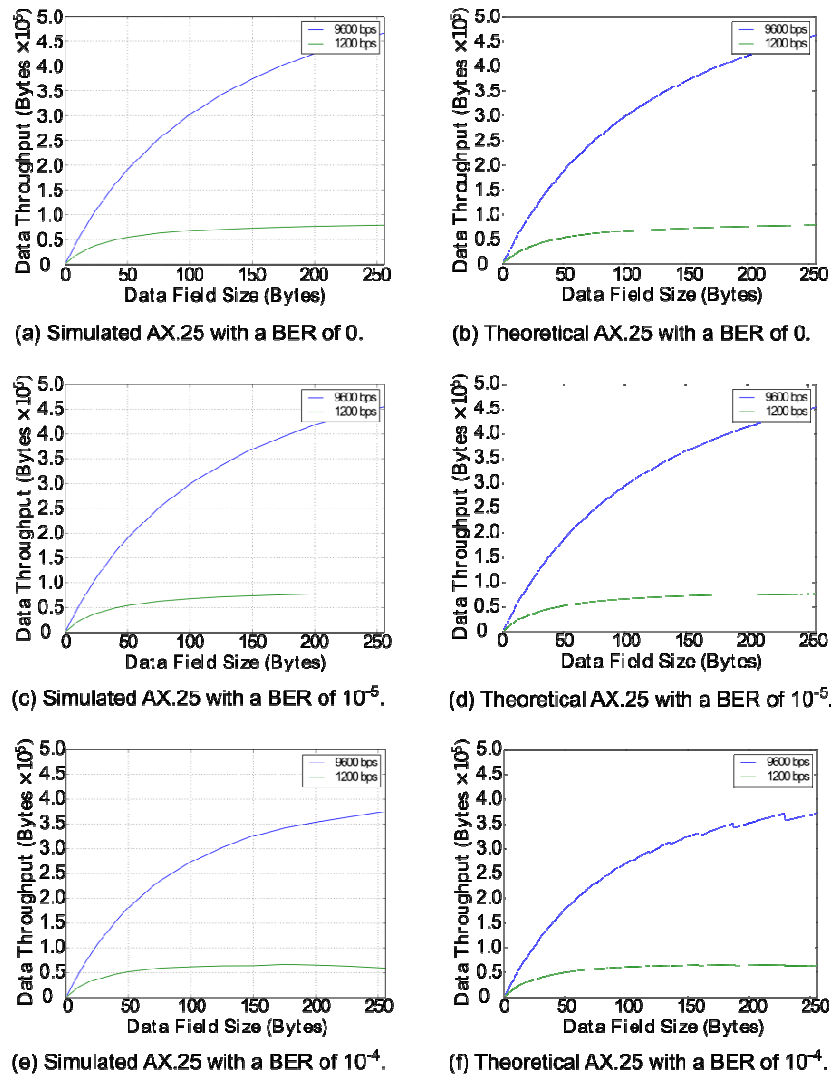
Figure 5: OpNet (Bezuidenhout, 2012) and SatSim (right) comparative simulations



Validation of SatSim results against theoretical calculations

The second approach of validating SatSim results was to compare results from implementing a protocol with theoretical calculated results. Firstly, a well-documented theoretical analysis of a communication protocol was required for comparison. For this purpose the analysis by Grønstad (Grønstad, 2010) was used. The results achieved and comparison with Grønstad's theoretical results is shown in Figure 6(a-f). Due to AX.25 being well-documented and its highly structured nature it was possible to implement it accurately and to achieve simulation results that are near identical to the theoretical results.

Figure 6: SatSim simulations (left) and theoretical calculations (Grønstad, 2010)



DESIGN OF A NOVEL CUBESAT COMMUNICATION PROTOCOL

The protocol investigation revolves around using and improving existing communication protocols, and applying them to the CubeSat environment. AX.25 was identified as the prime candidate for further investigation and possible optimisation for three reasons. Firstly, it is known that AX.25 is the most commonly used protocol for CubeSat missions (Klofas, 2014), which might be due to its simplistic nature and widespread use by the Amateur Radio Satellite (AMSAT) community. Secondly, the AX.25 protocol is well-documented and various software implementations are available. Thirdly, there is little to no simulation data available on AX.25 as part of a satellite

communication system, which provides an opportunity for generating new research data.

In relation to the improvement of AX.25, past research and development has been conducted by the StenSat group (McGuire, et al., 2006). This group developed the FX.25 protocol which adds Forward Error Correction (FEC) coding to the AX.25 frame. By adding an error correcting code the reliability and throughput of the protocol is increased under noisy channel conditions. Since there is no simulation data available for FX.25 it is an ideal alternative candidate to further investigate and compare with the AX.25 protocol.

The AX.25 protocol

AX.25 (Beech, et al., 1993) is a protocol that was developed for amateur radio applications, but due to its simplicity and robustness it was also employed for nano-satellite applications in connectionless mode. Connectionless mode has reduced functionality in terms of link configuration and management and serves only as a framing protocol. Connectionless mode encapsulates data in unnumbered information (UI) frames which provides addressing and error checking.

Figure 7: AX.25 unnumbered information frame

Flag	Address	Control	PID	Info	FCS	Flag
01111110	112/224bits	00000011	11110000	N*8 bits	16 bits	01111110

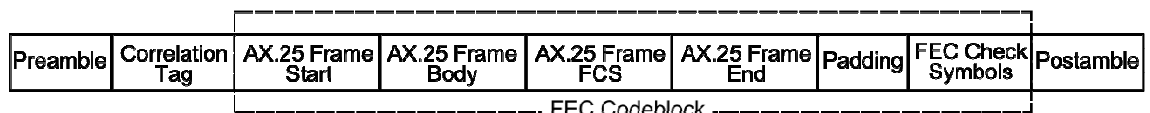
The structure of a UI frame is shown in Figure 7. A frame is delimited by the flag sequences on each end of the frame. This assists with identifying the contents of each frame. Bit stuffing is performed on the frame to remove any other occurrences of the flag bit pattern; otherwise the frame will be delimited incorrectly. Payload data is stored in the Info field whose size defaults to 256 bytes. All fields in an AX.25 frame must consist of multiples of 8 bits. The Frame Check Sequence (FCS) is calculated by the transmitter and receiver. It serves as an indication of whether a frame has been corrupted during transmission.

The FX.25 protocol

FX.25 encodes an AX.25 frame by wrapping additional data around the frame as shown in Figure 8. Of specific importance is the correlation tag. The correlation tag is a 64-bit sequence designed to indicate the start of the frame and identify which FEC algorithm is applied. The tag is located outside the FEC code-block as it is designed to provide good correlation even in the presence of bit errors.

Reed Solomon (RS) FEC coding is used in FX.25 as it has been used successfully in terrestrial and space radio applications. The FEC code block is the data to which the FEC algorithm is applied. The size of the FEC code block is dependent on the specific FEC scheme implementation. The padding field is required to pad out the code block to the appropriate amount of bits for the FEC scheme. The size of the padding field will be different for every frame. The pad field does not carry any data and will be discarded after reception. Thus, it is important to choose the correct variation of the RS code to minimise the amount of redundant data in the pad field.

Figure 8: FX.25 frame structure



Simulation results of AX.25 versus FX.25

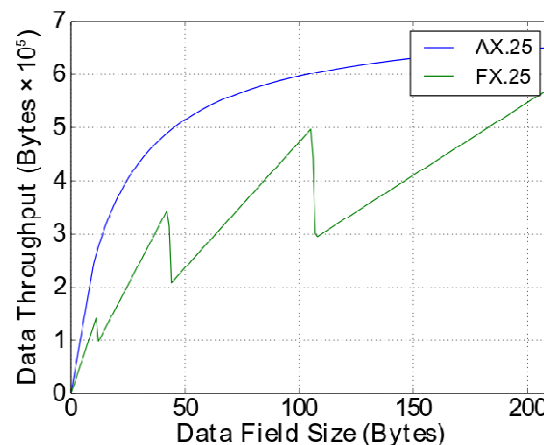
Initial simulations were done to compare the best possible throughput that AX.25 and FX.25 can achieve. The simulation configuration was as follows:

- Two ground transmitters with one sending AX.25 frames and the other FX.25 frames on different frequencies (437.3 and 437.5 MHz) at 9600 bps with Binary Frequency Shift Keying (BFSK) modulation.
- Two satellite receivers (one receiving AX.25 and the other FX.25) in a 600 km circular polar orbit passing over the ground transmitters.

- The FX.25 protocol uses an FEC symbol size of 8 bits and can correct up to 8 symbols.
- A single pass lasts for roughly 600 seconds.
- The throughput is the measurement of the actual amount of payload data that is received by the satellites.
- The data field size of both protocol frames are varied as this varies the total frame size.

The first simulation was done for a 0 Bit Error Rate (BER) channel in Figure 9 as this indicates the maximum amount of data than can be transmitted in a single satellite pass. The jagged edges on the FX.25 throughput are caused by the automated choice of FEC. The FEC requires a set block size for the algorithm to work and pads the data to fill up the block if required. As the size of the info field in the AX.25 frames increases, it will approach the information block size limits and will move to a larger block size. At this point the throughput will drop dramatically as the frame contains many redundant padding bits. The throughput for FX.25 is considerably less than that of AX.25 with a 0 BER channel, but this is to be expected as the FEC bits can be seen as redundant bits if no bit errors are present.

Figure 9: Protocol comparison on a 0 BER channel



The next phase of simulation involves slowly introducing bit errors into the channel and comparing the performance of the two protocols. The results can be viewed in Figure 10(a-d). It is clear that AX.25 has greater throughput up to a BER of 10^{-4} . This response is to be expected as bit errors are relatively low.

The response drastically changes when a BER of 10^{-3} is reached. At this point the channel is very noisy and the advantages of the FEC algorithms start to become clear, especially with larger frame sizes. AX.25 is barely operating at the larger frame sizes as the frame loss is substantial. The throughput of FX.25 stays fairly consistent, only dropping off at a BER of 10^{-2} , where it struggles to sustain a reasonable throughput.

The data throughput for the entire satellite pass is a good metric to analyse the overall performance, but detailed observations are lost especially considering the dynamics involved with satellite movement. Two parameters which will influence signal strength considerably are the propagation distance and the antenna gain. Both these parameters change due to the relative position between the transmitter and receiver. An antenna will also rarely have a constant gain pattern. It is expected that the throughput should increase as the satellite approaches the ground stations and decrease as it moves further away again. This dynamic behaviour of the link needs to be studied before an optimal strategy can be developed.

Figure 10: Throughput comparison for various channel BER

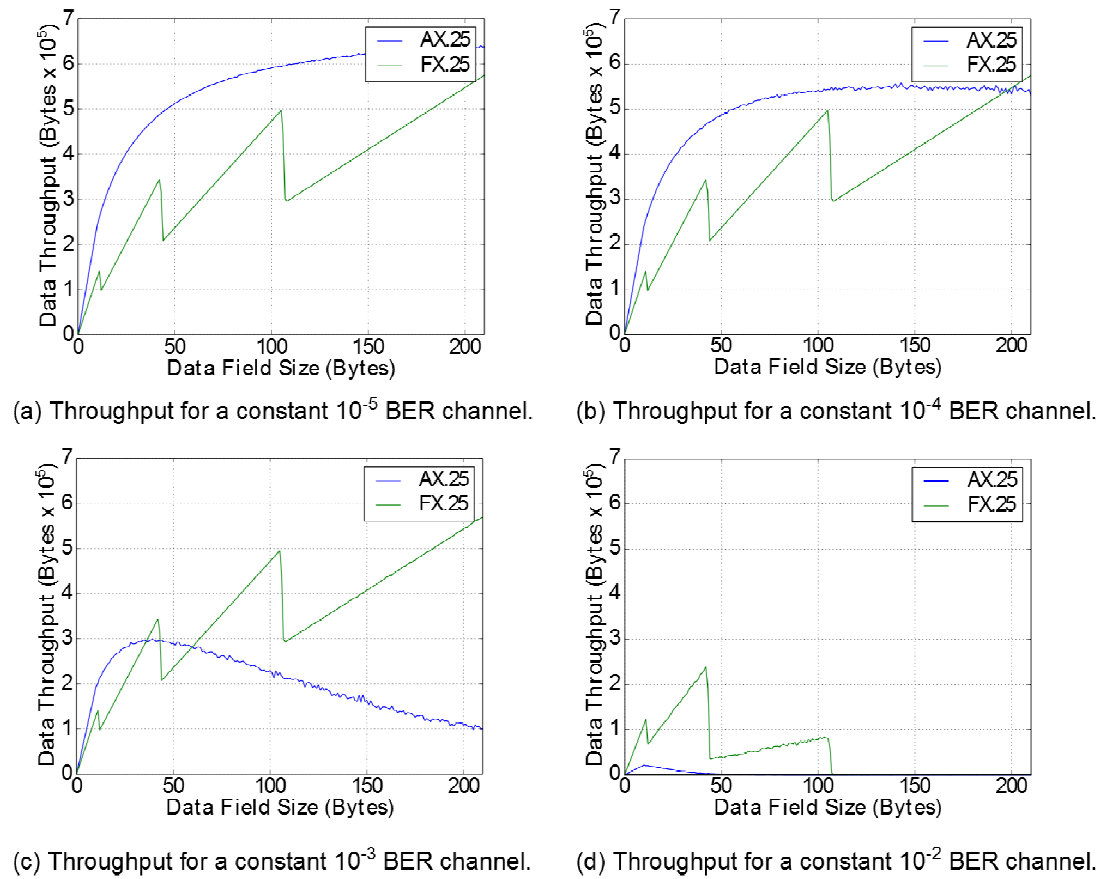
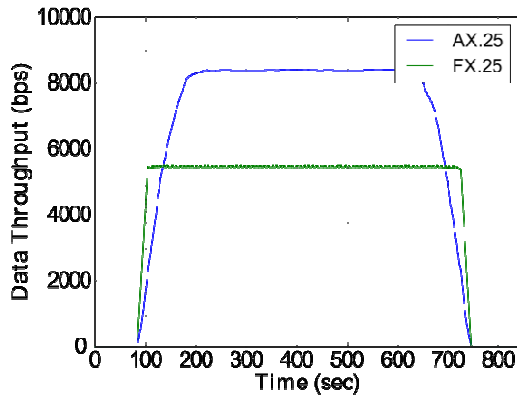
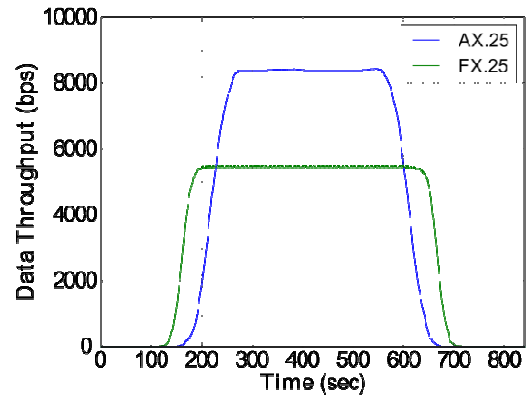


Figure 11(a-d) shows the simulation results (averaged over 10 iterations) where the time related dynamics of the satellite link during a pass is visible. The antenna gain is lowered for each simulation, but the lowered antenna gain can also be viewed as increased signal attenuation in the communication link. This attenuation can occur due to varying weather conditions, degradation of communication components and other effects. The data throughput is calculated using the simulation results averaged over a rolling window of 20 seconds.

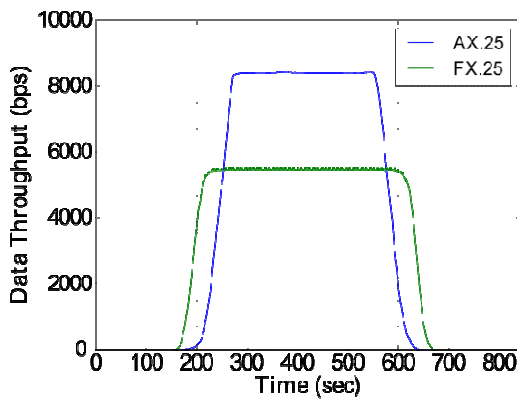
AX.25 shows much better throughput when the channel conditions are perfect, but FX.25 is able to transmit data much earlier than AX.25. This is a very relevant observation as CubeSats pass over a dedicated ground station roughly twice a day for only a few hundred seconds. It would be ideal to maximise the possible data throughput during this time.

Figure 11: Time related throughput for various channel BER

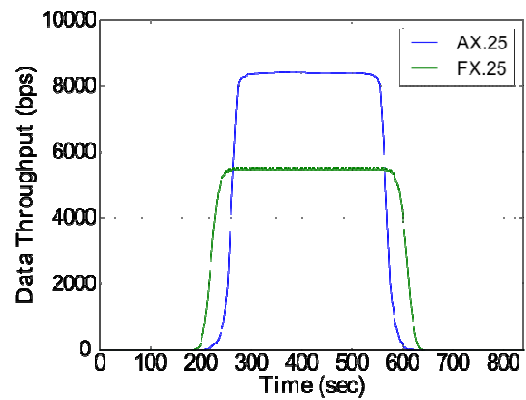
(a) Payload throughput for 0dB antenna gain.



(b) Payload throughput for -3dB antenna gain.



(c) Payload throughput for -4dB antenna gain.



(d) Payload throughput for -5dB antenna gain.

Combining AX.25 and FX.25

Using the two existing protocols it is possible to optimise the throughput by following the envelope of highest throughput. To achieve this, a configuration is required that can utilise both AX.25 and FX.25. On the transmission side of the link this involves switching between adding FX.25 encoding to the AX.25 frame or not while on the receiving side it involves switching between two decoders or decoding in parallel. The initial connection can be established with FX.25, which makes it possible for the satellite to communicate earlier during the pass than using only AX.25. When the amount of bit errors reduce below a certain threshold the communication channel can switch over to AX.25, thus reducing unnecessary overhead and increasing data throughput.

An important feature of FX.25 is that AX.25 can decode FX.25 frames, since the additions made by FX.25 only wraps around an AX.25 frame. FX.25 on the other hand cannot decode AX.25 frames as FX.25 frames are identified by

the 64-bit correlation tag values and not the frame delimiters. There are multiple solutions to implement a hybrid AX/FX.25 decoder.

One approach is illustrated in Figure 12. This implementation relies on sharing the demodulated bit stream between an AX.25 and FX.25 decoder while feeding both outputs to a processor. The processor can then choose which stream to use.

Figure 12: Hybrid AX/FX.25 demodulation

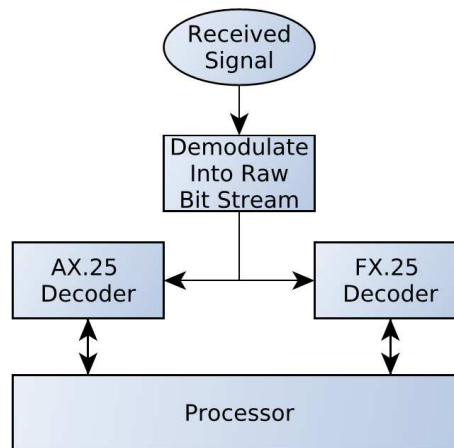


Figure 12 provides a potential solution, but it is not ideal for CubeSat deployment. An excessive amount of processing, and therefore power, will be required for such an implementation as two decoding processors will be running concurrently. Multiple I/O ports are also required on the processor with additional processing load to interpret the two decoded data streams. Investigating different optimisation options for implementing this decoding process in hardware will form part of future work. This work will first design this scheme for software simulation in SatSim and will be followed by the development of a Field Programmable Gate Array (FPGA) solution.

CONCLUSION AND IMPACT ON CUBESAT COMMUNITY

This research has yielded multiple contributions. Firstly it provided an open-source tool to assist with the research, development and design of satellite networking functionality. SatSim is designed to be easy to use which allows developing countries and institutions with limited exposure to satellite communication to easily learn and understand the environment.

There is a lack of simulation research surrounding the AX.25 and FX.25 protocols. This work contributes to the field by showing verifiable simulation results for both of these protocols under various user specified conditions.

This work also proposes a novel approach to drastically improve CubeSat communication throughput and reliability through a hybrid AX/FX.25 protocol. A structured approach to research and analysis was followed to arrive at the conclusion of a hybrid AX/FX.25 protocol. This protocol has the potential to dramatically improve communication reliability and throughput for the CubeSat community. One of the factors that limited the sustainable utilisation of CubeSats is the limited throughput of their communication systems. This technology can address this limitation and enable missions that require the reliable transmission of large quantities of data. Thus CubeSats, and nano-satellites in general, can become sustainable platforms for research institutions and governments of developing countries.

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ELECTRICAL POWER SUBSYSTEM DESIGN PROPOSED FOR THE ZACUBE-2 3U CUBESAT NANOSATELLITE MISSION

J. le Roux, A. Barnard, R. Wolhuter

ABSTRACT:

The French South African Institute of Technology (F'SATI) at the Cape Peninsula University of Technology (CPUT) offers a postgraduate programme in nanosatellite systems engineering where students are given the opportunity to be involved in the development of CubeSats. The first mission, a 1U CubeSat codenamed ZACUBE-1, has been completed and was launched on November 21, 2013. The second mission, a 3U CubeSat codenamed ZACUBE-2, is currently under development by F'SATI students. An EPS (electrical power subsystem) design is proposed herein, with the aim to implement the design for ZACUBE-2 EPS development. A comparative literature study of available EPS systems for CubeSat applications is presented. The study dwells on the topology used in different subsections which form part of a complete EPS, namely the energy extractor, power conversion, power regulation, power distribution and housekeeping. Careful design consideration is given to different ways of designing a fault tolerant system by coordinating existing EPS related research projects previously completed by postgraduates within the F'SATI nanosatellite systems programme. The EPS design incorporates three inputs to connect solar panels for energy extraction. A P&O (perturb and observe) MPPT (maximum power point tracking) algorithm is used to control a SEPIC DC-DC converter. The converter is driven by a high speed low- side MOSFET driver, which is controlled by a selectable digital or redundant analogue PWM (pulse width modulator) signal. Off the shelf voltage regulators are used for power regulation, and a reliable power distribution topology is included in the design for overcurrent protection.

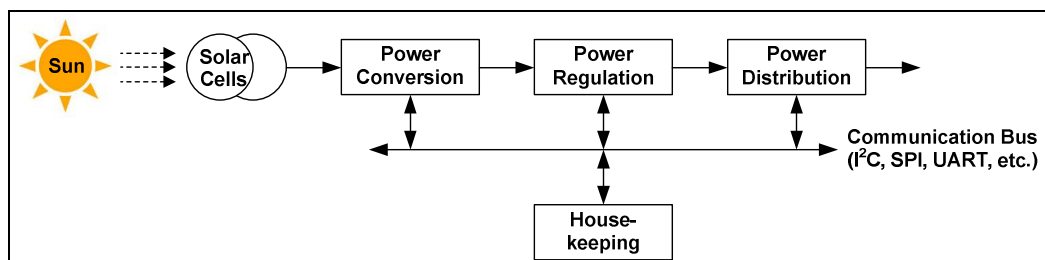
Keywords: *Energy, DC-DC converter, regulation, conditioning, distribution, housekeeping.*

INTRODUCTION

The basic operation of a typical power subsystem for satellites is best described with a block diagram depicted in Figure 1. Solar energy from the Sun illuminates the solar cells which convert it into electrical energy on the

basis of a photovoltaic effect (Maini & Agrawal, 2007:134-140). A DC-DC converter, controlled by a MPPT (maximum power point tracking) algorithm, converts the fluctuating solar cell's voltage to a usable smooth DC voltage source. A PCC (power conditioning circuit) regulates the DC voltage source to the required voltage level at the power regulation stage. A PDM (power distribution module) reliably distributes power outputs to other subsystems loads within the satellite system by monitoring and controlling faulty overcurrent and latchup conditions.

Figure 13: Block diagram showing sections of a typical satellite EPS



OBJECTIVES

Four EPS related master's thesis projects completed within the F'SATI programme are collectively considered in comparison to the current off-the shelf EPS systems from Clyde Space and GomSpace, with the aim to propose an optimised EPS design for the current ZACUBE-2 nanosatellite mission under development at F'SATI.

DELINEATION OF DESIGN PROPOSAL

The proposed design shall not incorporate the characteristics of the solar cells to be used on ZACUBE-2. These will be determined by the mission power budget, which depends on the overall sum of each subsystem's power requirements. However, the design proposes solar panel input channels with power ratings comparable to the current off-the-shelf EPS systems, typically 30 W maximum ratings (GomSpace, 2014:2).

COMPARATIVE STUDY OF ELECTRICAL POWER SUBSYSTEMS

The Clyde Space and GomSpace EPSs are studied at block diagram level because circuit component level designs are not available to customers. However, EPSs completed at F'SATI are studied at circuit component level to coordinate the projects designs into a solid combined design for ZACUBE-2 EPS.

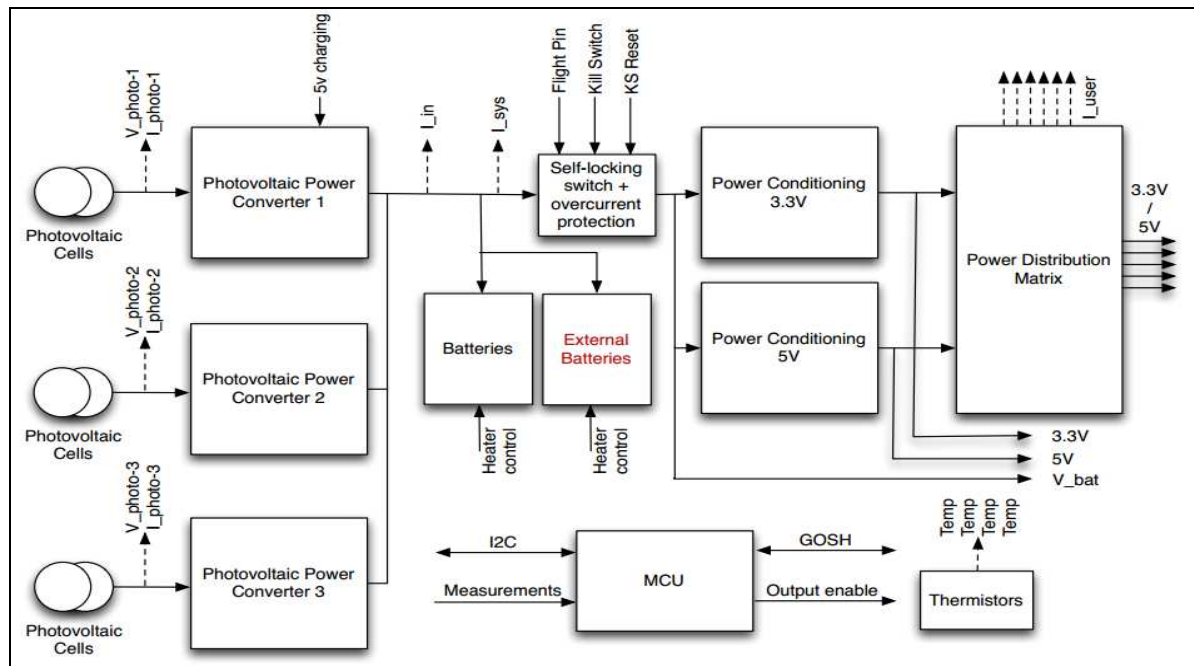
Off-the-shelf EPSs

Clyde Space and GomSpace are competitive suppliers of nanosatellite subsystems. Herein, EPSs from both suppliers are studied. The study aims to give a basic background of currently available CubeSat EPS systems and also to provide guidance towards a preliminary design proposal for ZACUBE-2 EPS. In particular, the study dwells on the topology used in each subsection of the EPSs.

GomSpace EPS

The GomSpace NanoPower P31us EPS is applied on a 3U CubeSat. The EPS offers a maximum voltage output of 14.8 V with 3 solar cell inputs that can handle up to 2A input current, thereby qualifying the EPS to have an output power budget of up to 30 W (GomSpace, 2014: 2-4). The EPS system block diagram is shown in Figure 2.

Figure 14: GomSpace NanoPower P31us EPS

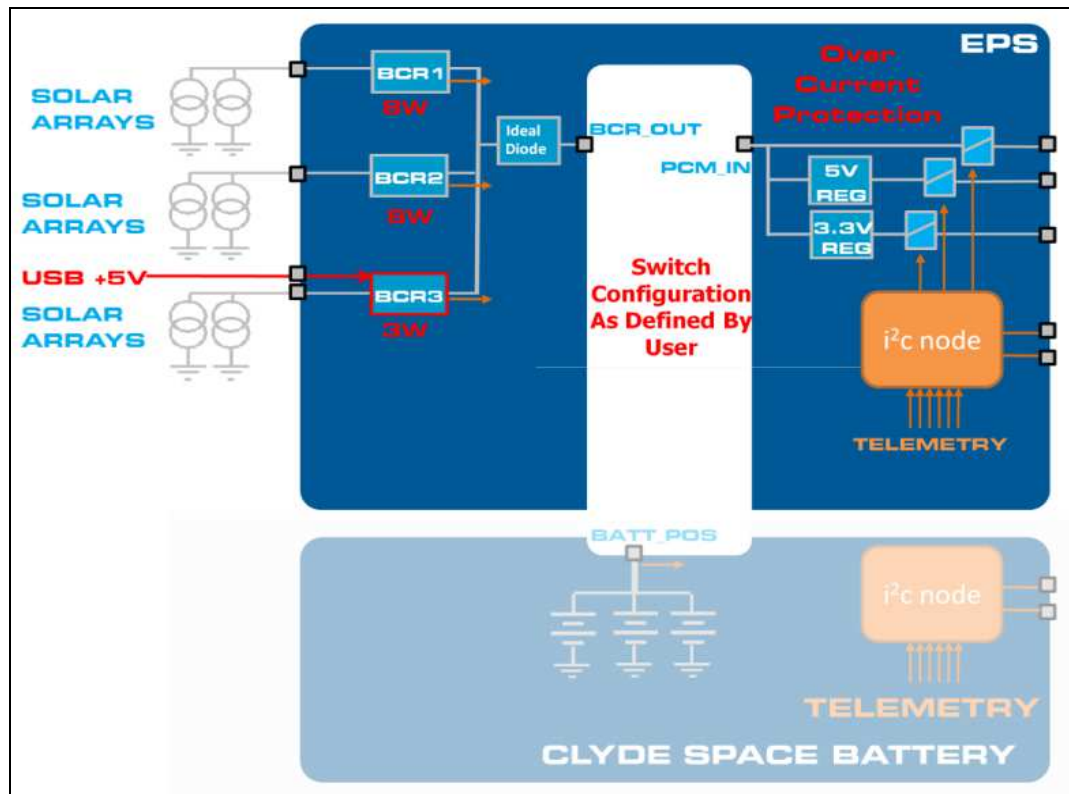


ZACUBE-2 EPS's distribution typology is proposed in Figure 2. The distribution system offers latchup protected power outputs from the power distribution matrix, and, at the same power rating, offers unlatched power outputs as shown by 3.3 V and 5 V outputs from the distribution matrix in Figure 2 (GomSpace, 2014: 4). It is proposed that ZACUBE-2 EPS should have a primary power source of power (solar cells) as well as a secondary source of power (battery pack in Figure 2). A secondary power source may be purchased from Clyde Space or GomSpace and can be interfaced to the ZACUBE-2 EPS.

Clyde Space EPS

The Clyde Space 3U EPS, codename CS-3UEPS2-NB, was developed for a 3U CubeSat application. The EPS provides up to a maximum of 8.26 V battery bus with a maximum current rating of 6 A. Similar to GomSpace NanoPower P31us EPS, the Clyde Space EPS has connection ports available for a secondary power source (BATT POS in Figure 3). It should be noted that Clyde Space's EPS is configurable to an external Clyde Space PDM which is available for online purchase from the Clyde Space website (Clyde Space, 2014)

Figure 15: Clyde Space 3U EPS



F'SATI's power systems masters research projects

F'SATI postgraduates have developed a series of EPS related thesis projects for CubeSat applications. In particular, the project titles are:

- **EPS 1** – Augmentation of a nanosatellite electronic power system using a Field-Programmable-Gate-Array, by Stephen Cupido;
- **EPS 2** – Electrical power system for a CubeSat Nanosatellite, by Jean Bester;
- **EPS 3** – An analogue controlled switch-mode power system for a CubeSat, by Gavin Mutch;
- **PDM** – Development of a power distribution module for a nanosatellite, by Motlokwe Maleka.

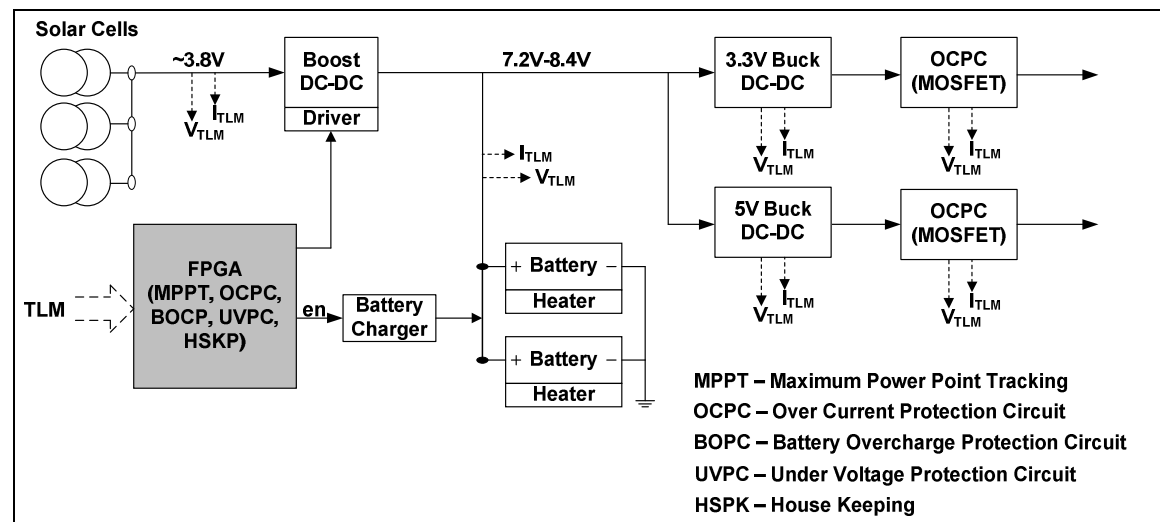
EPS-1

EPS-1 uses the Actel SmartFusion A2F200 which integrates an FPGA hard ARM®, a Cortex™-M3-based microcontroller subsystem (MSS) and programmable analog I/Os. The analogue section of the SmartFusion is not

radiation tolerant; only the FPGA matrix is radiation tolerant. The A2F200 features (Microsemi, 2011:4) are:

- Total of 135 I/Os,
- 78 FPGA I/Os (input/outputs);
- 31 MSS I/Os;
- 24 analogue inputs and 2 analogue outputs;
- Two configurable resolution ADCs: 8-bit, 10-bit, and 12-bit mode
- SPI, I²C and UART peripherals.

Figure 16: FPGA controllable F'SATI EPS



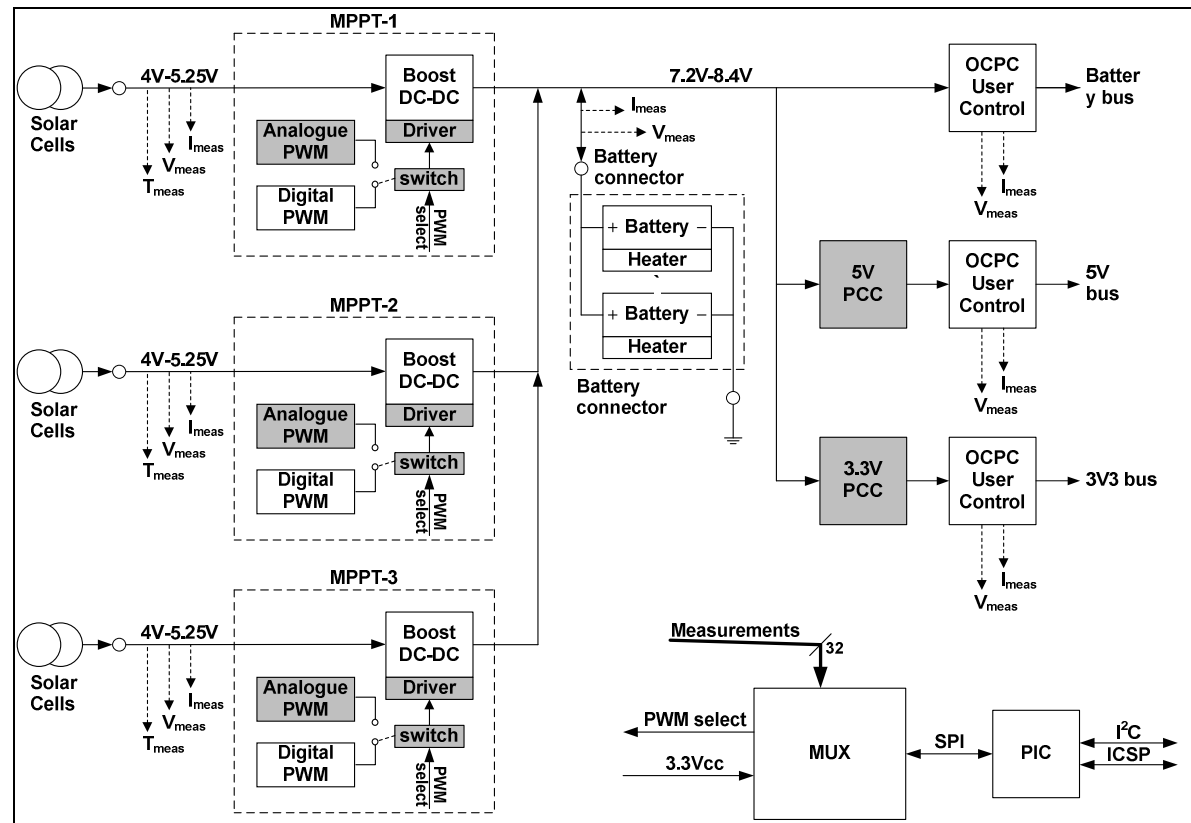
The Actel SmartFusion FPGA is proposed for the design for the following reasons:

- The MSS will perform the functional requirements listed within the shaded FPGA block of Figure 4, hence, no additional microcontroller will be required on-board of the EPS.
- The radiation hardened FPGA matrix of the SmartFusion A2F200 can be used to execute mission critical housekeeping commands, like system reset, UVPC and BOPC in Figure 4, when the EPS is exposed to space radiation environments.

EPS-2

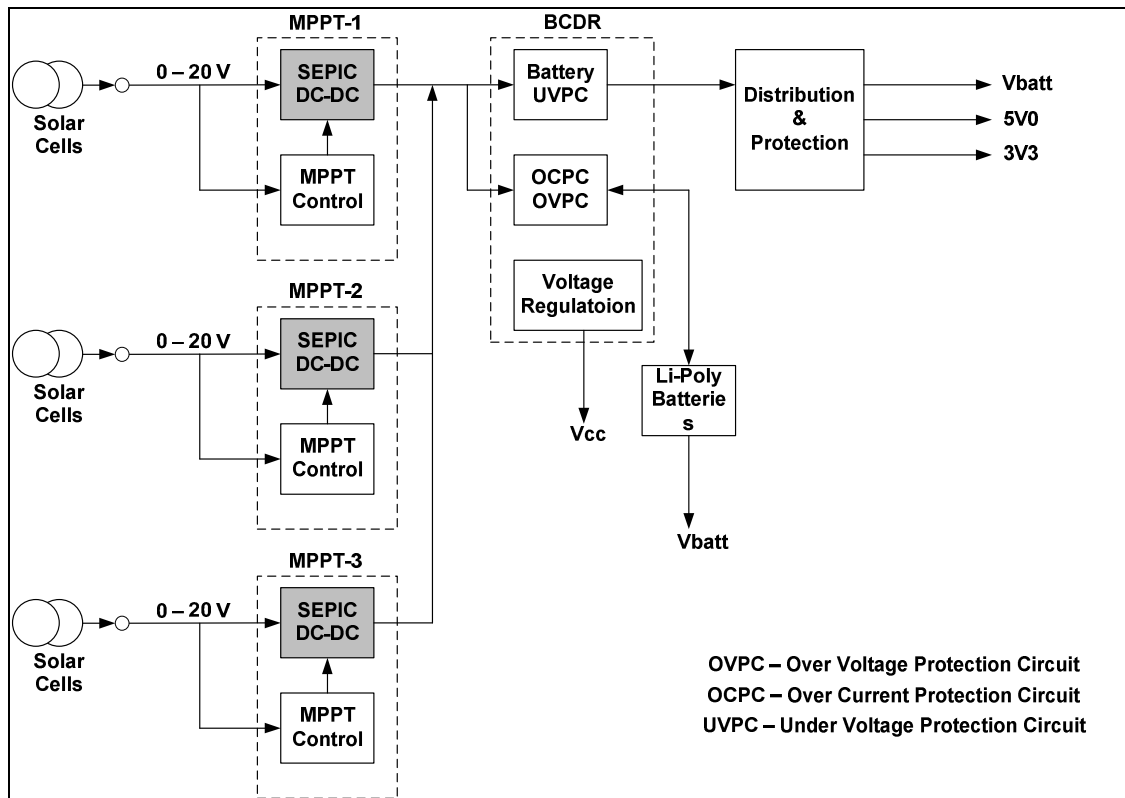
EPS-2 features a redundant MPPT algorithm circuit built using discrete components instead of implementing the algorithm in a microcontroller. The circuit provides a PWM signal to a SN74LVC1G3157 single-pole double-throw analog switch shown in Figure 5 (Texas Instruments, 2003). The switch accepts a logic PWM select signal, which will be from the proposed Actel SmartFusion A2F200 FPGA, to drive the converter. The default PWM source will be the digital PWM from the FPGA, activated by a logic HIGH signal from the FPGA. The analogue redundant PWM is activated by a logic LOW signal in case the MSS section of the FPGA fails to execute the MPPT algorithm due to radiation induced single event upsets (SEUs). The analogue PWM circuit, the PWM select switch and the DC-DC driver is proposed for ZACUBE-2 as shown by the shaded blocks in Figure 5. EPS-2 also uses the LP2981-33 and the LP2981-50 LDOs from Texas Instruments to regulate the 3.3 V and 5 V voltage buses, respectively. These are also considered for the proposed design.

Figure 17: Redundant analogue controllable MPPT EPS

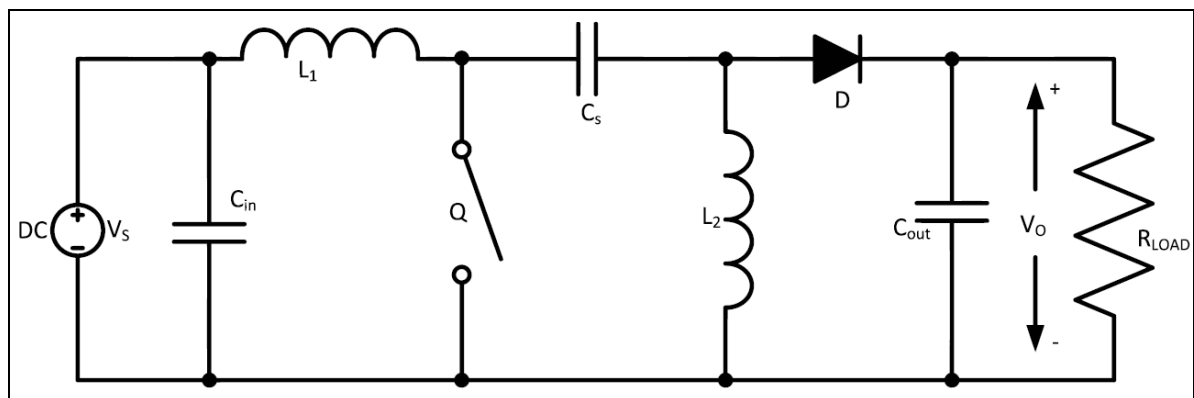


EPS-3

EPS-3, shown in Figure 6, is a fully analogue controlled EPS. It is differentiated by the use of a switch-mode DC-DC SEPIC converter instead of a boost converter, which is proposed for the design as shaded in Figure 6.

Figure 18: Completely analogue controlled EPS using a SEPIC converter

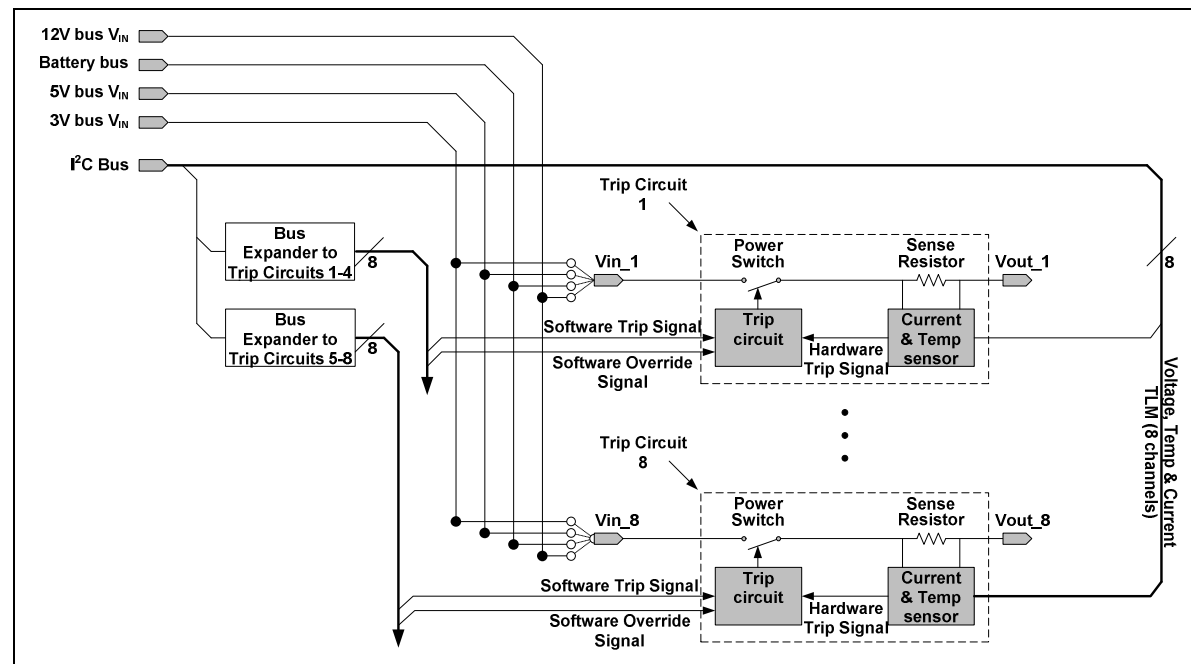
A circuit diagram of a DC-DC SEPIC converter is shown in Figure 7. It uses coupled inductors and a low-side DC-DC drive switch. Its major advantage over its counterpart, DC-DC boost converter, is that it can operate with the input voltage from the solar cells being less than or greater than the output voltage, whereas the DC-DC Boost converter only provides an average output voltage greater than its input voltage (Mutch, 2013:48-49):

Figure 19: Operational circuit diagram of a DC-DC SEPIC converter

PDM

The PDM (power distribution module) from F'SATI features power monitoring, control and switching capabilities. The module does not include power conversion nor does it include power regulation. The module is based on a reliable power distribution topology with an I²C bus to interface housekeeping commands to an on-board computer (OBC) in a typical CubeSat. The PDM distributes eight identical output power channels from four input voltage buses. Each power channel features voltage, current and temperature monitoring. In addition, each power channel features autonomous overcurrent (and latchup) tripping. The module accepts logic software trip and software override commands via the I²C bus. The functionality of each power distribution channel is illustrated by Figure 8, showing identical distribution channels 1 to 8. The distribution methodology (V_{in_1} and V_{out_1} in Figure 8), the p-channel MOSFET as the power switch and the MAX9611 I²C configurable current sensors are proposed.

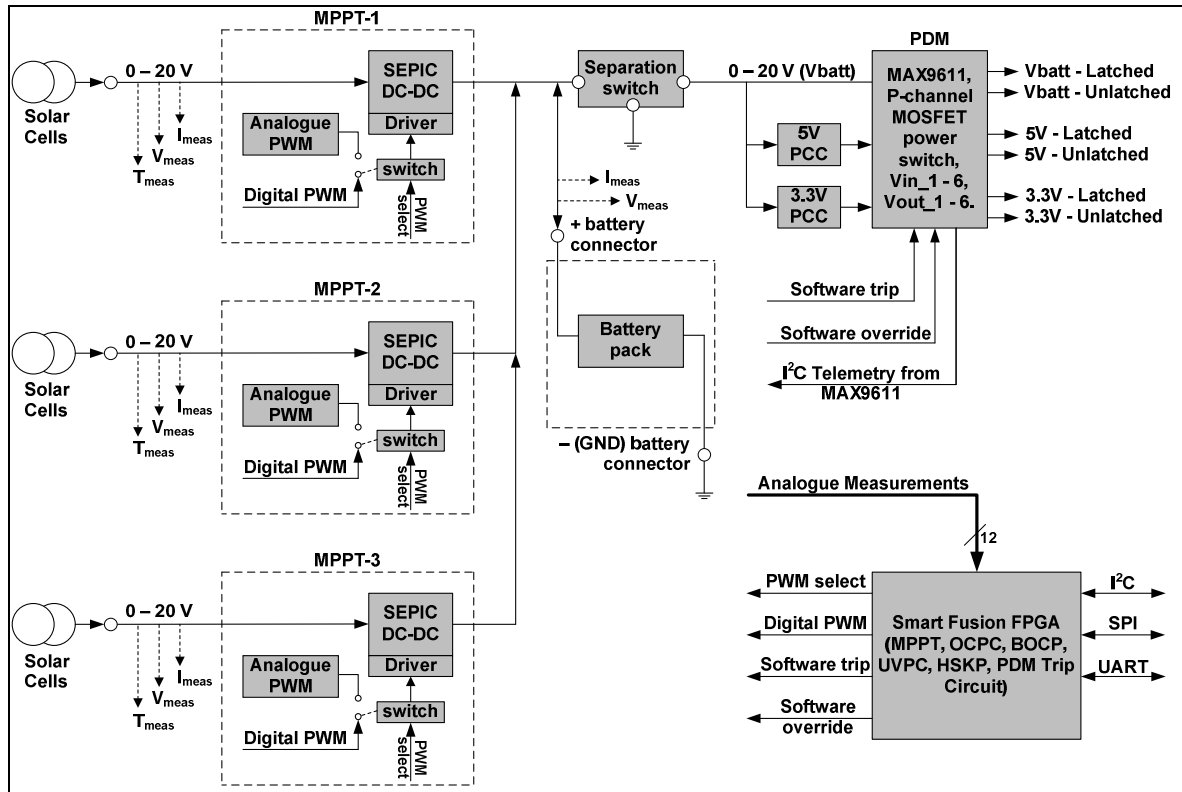
Figure 20: F'SATI power distribution module



PROPOSED EPS DESIGN FOR ZACUBE-2

The proposed ZACUBE-2 EPS design is depicted in block diagram format in Figure 9. Each section of the design is extracted from one of the four F'SATI EPS related master's projects, and will briefly be discussed at component level.

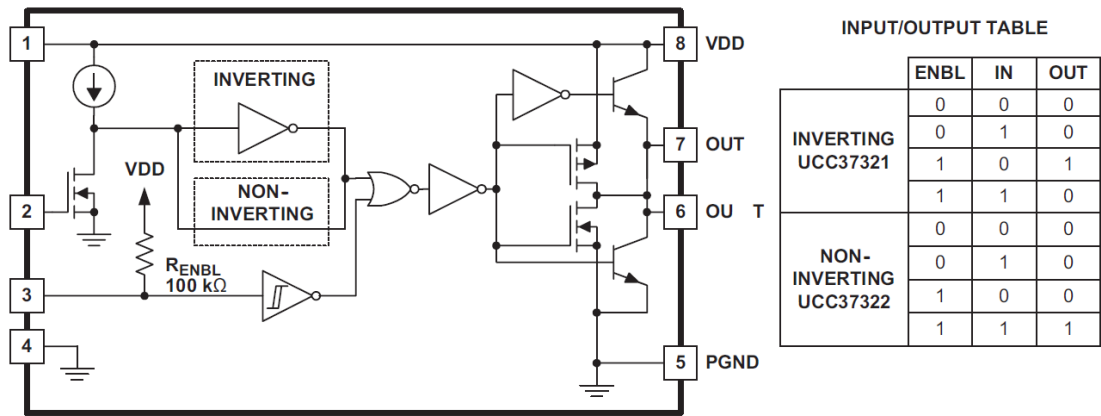
Figure 21: Proposed EPS design for ZACUBE-2 3U nanosatellite mission



SEPIC converter MOSFET driver

The UCC27332 is a 9 A single high speed low-side MOSFET driver (shown in Figure 10) with enable that will be used to drive the DC-DC SEPIC converter. It features a switching speed of up to 20 ns. The EN input will always be connected to logic HIGH for a non-inverting PWM signal output.

Figure 22: MOSFET driver for the SEPIC converter switch



PWM select switch

A switch will be used to select the PWM signal source. The default PWM source will be the digital PWM from the FPGA. The switch works according to the following logic; when PWM select input is logic LOW, the analogue PWM circuit is used to obtain maximum power point (MPP) and when the input is logic HIGH, the digital PWM implemented inside the FPGA is used to obtain MPP.

Analogue PWM

The analogue PWM circuit works by measuring the output current of the SEPIC converter. The duty cycle of the PWM signal fluctuates directly proportional according to the change in the measured output current from the SEPIC converter, thus the PWM signal is a function of the output current from the SEPIC converter as well as the duty cycle.

Batteries

An 8.4 V battery, made of two 4.2 V cells in series is adequate enough to power other subsystems within the 3U CubeSat with the battery voltage. A secondary power source in the form of a battery-pack can be interfaced to the EPS board as a separate module.

PCC

The LP2981-33 and the LP2981-50 LDOs from Texas Instruments with a peak output current of 400 mA shall be used to regulate the 3.3 V and 5 V voltage busses, respectively.

PDM

The EPS shall include the existing F'SATI power distribution module (PDM) design on-board, shown in Figure 8. However, the I²C expanders shall be replaced by I/O ports on the SmartFusion FPGA.

CONCLUSIONS

The proposed EPS design includes all the previous research that has been done by CPUT/FSATI graduates specializing in satellite power systems. The most attractive attributes of the student research was taken into consideration and incorporated into the design. The proposed design includes the innovative use of an FPGA, analogue redundancy, a SEPIC DC-DC converter as well as an integrated PDM. These features will allow ZACUBE-2 to have reliable and efficient uninterrupted source of power.

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AN EVALUATION OF LOW NOISE AMPLIFIER PERFORMANCE AT L-BAND FOR CUBESAT APPLICATIONS

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ABSTRACT

Optimum communication can only be achieved with a very sensitive front-end section in the receiver on a satellite because the transmitted signal from the ground station must travel hundreds of kilometres through the earth's atmosphere to a low earth orbit (LEO) satellite. The design of a low noise amplifier (LNA) may appear to be a relatively simple exercise using modern EDA software, but finding the delicate balance between performance parameters with conflicting requirements presents a greater challenge. The decisions and performance parameter trade-offs pose various difficulties to the LNA designer such as simultaneously achieving good noise performance and high gain. This paper reviews the design and simulation of four LNAs, each of which uses a different active device technology for an L-band receiver operating at 1.265 GHz. The main objective of the LNA is to add as little noise possible to the received signal with minimum power consumption as well as provide sufficient power gain. Simulated results using Agilent Technologies' ADS for the HBT, GaAs pHEMT, e-pHEMT and BJT LNAs show noise figures of 0.66 dB, 0.47 dB, 0.7 dB and 1.7 dB respectively. For all the amplifiers the associated power gains exceeded the minimum requirement of 13 dB. The HBT amplifier performed best based on its low noise figure and superior power gain performance.

Keywords: low-noise amplifier (LNA), radio frequency (RF), return loss (RL), noise figure (NF), power gain, satellite

INTRODUCTION

Optimum communication can only be achieved with a very sensitive front-end section in the receiver on board a satellite. The transmitted signal from the ground station must travel hundreds of kilometres through the earth's atmosphere to reach the satellite which is in low earth orbit (LEO). This process causes the transmitted signal to be severely attenuated in addition to being corrupted by high levels of before it is received by the satellite (Ippolito,

2008:61). It is therefore understandable why the radio frequency (RF) front end forms the most important part of any radio receiver system as it must be able to amplify extremely small signals, add as little amount of noise as possible and recover the original data from them (MacPherson & Whaits, 2002, (5):1).

Selecting the correct active device technology for a given application together with the optimum architecture is a crucial process. To simplify the process and ultimately make an educated decision as to which active device to select, an evaluation of the performance parameters of multiple LNAs, each utilizing a different active device is very useful. Comparing the performance parameters of each LNA will assist the designer in selecting the best performing active device technology. This performance analysis is achieved when the active device is terminated in the appropriate input and output matching network and is operating at its optimum biasing point. To realise this comparison, the four LNAs were designed according to the requirements of the link budget analysis of the system and performance parameters were optimised to meet these requirements.

LNA DESCRIPTION

The LNAs were designed for the front end of a QPSK communications system operating in the L-Band frequency range (1.26 GHz - 1.27 GHz) for a Cubesat application. Very limited power is available for each subsystem on the satellite, therefore the front end must use as little power as possible. To satisfy the link budget calculation a low noise figure for the front end was required. The LNA is the first component in the receiver system as illustrated in Figure 1.

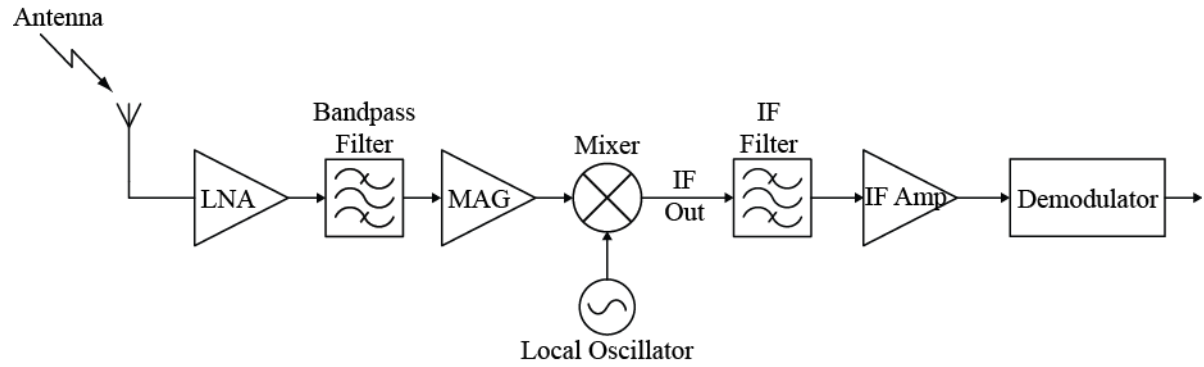


Figure 23: Block Diagram of Receiver System

One option in a receiver is for the band-pass filter (BPF) to precede the LNA, thereby rejecting any large out-of-band signals that could potentially damage the receiver front end. However, since the specifications require the lowest possible NF achievable, the other option of inter-changing the positions of the BPF and the LNA was implemented. To protect the receiver from large out-of-band signals the LNA must provide as high a third order intercept point (OIP_3) as possible. The complete list of generated specifications for the LNAs is listed in Table 1.

Table 1: Generated Specifications for the LNA

Parameter	Symbol	Specification
Frequency band	f	1.26 - 1.27 GHz
Supply voltage	V_{cc}/V_{dd}	5 V
Noise figure	NF	< 1 dB
Power gain	G_A	> 13 dB
Power consumption	P_D	≤ 50 mW
Input return loss	S_{11}	< -5 dB
Output return loss	S_{22}	< -15 dB
Third order intercept	OIP_3	< 0 dBm

From the latest active device technology available, a silicon bipolar transistor (BJT), a gallium arsenide pseudomorphic high electron mobility transistor (GaAs pHEMT), an enhancement mode pHEMT (e-pHEMT) and a silicon germanium carbon (SiGe:C) heterojunction transistor (HBT) were selected. A study of the device data sheets confirmed that all of the transistors should be capable of satisfying the performance requirements as indicated in Table 2.

Table 2: Performance Parameters of Selected Transistors

Name	Manufacturer	Type	Frequency (GHz)	Voltage (V)	Current (mA)	NF (dB)	Gain (dB)
AT-32032	Avago	Silicon bipolar	0.9 - 2.4	2.7	5	1.0	13
ATF-36163	Avago	GaAs pHEMT	1.5 - 18	1.5	10	0.5	17
ATF-55143	Avago	E-pHEMT	0.45 - 6	2.7	10	0.5	17.7
BFP-740	Infineon	SiGe:C	0.9 - 6	2.5	6	0.5	22
ATF-36077	Avago	GaAs pHEMT	2 - 18	1.5	10	0.3	17

LNA

Following the active device selection the design procedure of a LNA is as follows:

- Stabilise the active device
- Select the appropriate matching topology
- Design the input and output matching networks
- Select a DC bias circuit
- Optimise the circuit for minimum component count and perform computer simulations
- Printed circuit board design
- Construct and test the amplifier to verify that the design meets the specifications

Stability of an active device

The active device must be unconditionally stable within and outside the operating frequency band. Achieving this unconditionally stable state is vital in RF amplifier design. Unconditional stability means that the active device can be terminated in any load or source impedance and it will not oscillate (MacPherson & Whaits, 2002, (4):3). To make the active device unconditionally stable equation 1 must be satisfied:

$$K > 1 \quad \text{and} \quad |\Delta| < 1 \quad (1)$$

where the Rollet stability factor (K) of a 2 port network is defined as:

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2 |S_{21}S_{12}|} \quad (2)$$

and the magnitude of the determinant of the device S-parameters ($|\Delta|$) is:

$$|\Delta| = |S_{11}S_{22} - S_{12}S_{21}| \quad (3)$$

Initial S-parameter simulations of the active devices by themselves reveal that they are all unstable at the frequency of operation. In the case of the BJT and HBT, unconditional stability was achieved by resistively loading the collector of the active device. The GaAs-pHEMTs and E-pHEMTs were made unconditionally stable using shunt resistor loading and by adding a small amount of source lead inductance. This was implemented by increasing the track lengths connected to the source leads of the device.

Design of matching networks

The process of matching enables the operation of the active device in a 50 Ω system. This process matches the impedances presented by the input and output ports of the transistor to the impedances presented by the generator and the load respectively, as illustrated in Figure 2.

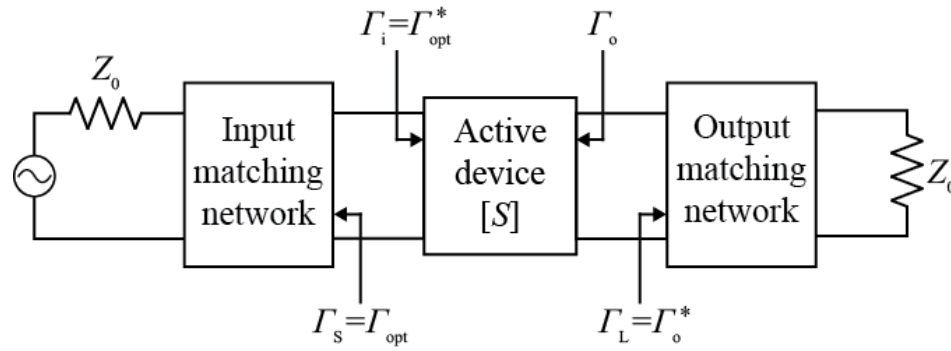


Figure 24: Active Device with Input and Output Matching Networks for Minimum NF

The optimal input return loss (IRL) can only be achieved when the impedance presented by the output port of the input matching network is the complex conjugate of the impedance presented by the input port of the active device. That is, $\Gamma_s = \Gamma_i^*$. For optimum noise performance the input port of the active device must be loaded with a specific value of impedance which seriously compromises the IRL and reduces the gain of the amplifier significantly. That is, $\Gamma_s = \Gamma_{opt}$ and $\Gamma_i = \Gamma_{opt}^*$. To maximise the gain, the output port of the active device is complex conjugately matched to Γ_o , the value of which is determined by Γ_s (Gilmore & Besser, 2003:107).

DC biasing

The same DC bias network was used for the BJT and HBT active devices. The network selected was a voltage feedback constant current source configuration and is illustrated in Figure 3. It provided the best temperature stability and maintains the amplifier quiescent state over large temperature changes. Gonzalez (1997:273)

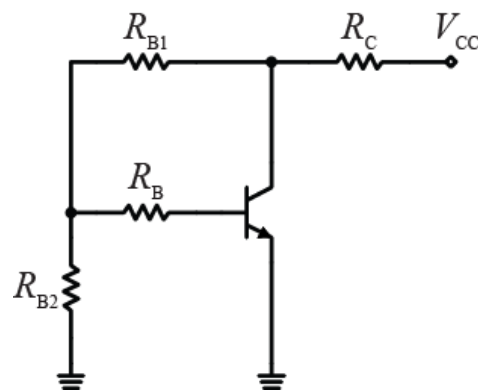
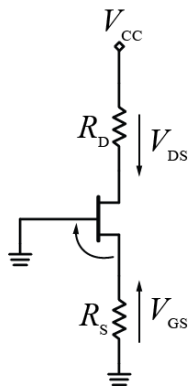


Figure 25: Voltage Feedback Constant Current Bias Configuration

Typically GaAs pHEMT devices need more than one power supply because a negative gate-source voltage is required to turn the device on. Alternative solutions were therefore considered and Figure 4 illustrates the configuration of a suitable passive self-bias circuit for FET operation.

**Figure 26: Passive Self Biasing Network for FET Devices**

This bias technique uses the active device itself to provide DC regulation. Although the technique slightly degrades the performance of the device it enables the device to be used in an environment where only a single DC supply is available. A small value resistor (R_S) is placed between the source and ground, resulting in a small amount of current flowing through R_S . This makes the source voltage more positive than ground potential, effectively creating a negative voltage being applied across the gate-source junction and turning the device on. Thus the ATF-55143 e-pHEMPT device can be biased using a single power supply and a biasing network similar to that for the BJT devices.

Final design

For the final LNA design the matching networks were connected to the already biased active device.

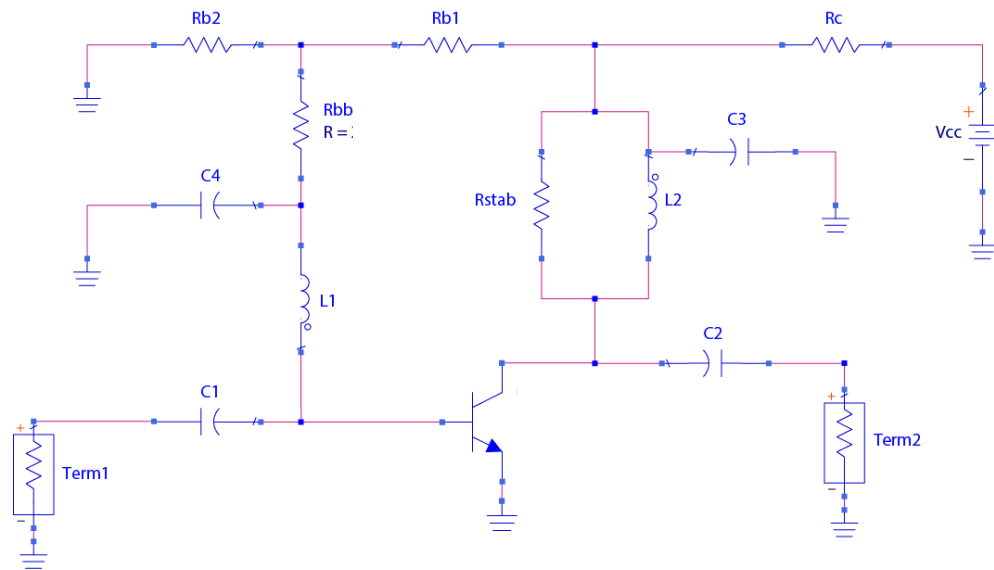


Figure 27: Overall Schematic of BJT Amplifier

Figure 5 shows a typical LNA topology for BJT devices where. the circuit was optimised for a minimum component count. The resistor R_{stab} ensures that the active device is unconditionally stable and inductor L_1 acts as an input matching element together with C_1 but also as a radio frequency choke (RFC). Inductor L_2 forms part of the output matching network and also feeds the DC voltage to the active device while simultaneously acting as a RFC. Capacitors C_4 and C_3 are bypass capacitors. The bias circuitry is made up of R_c , R_{b1} , R_{b2} and R_{bb}

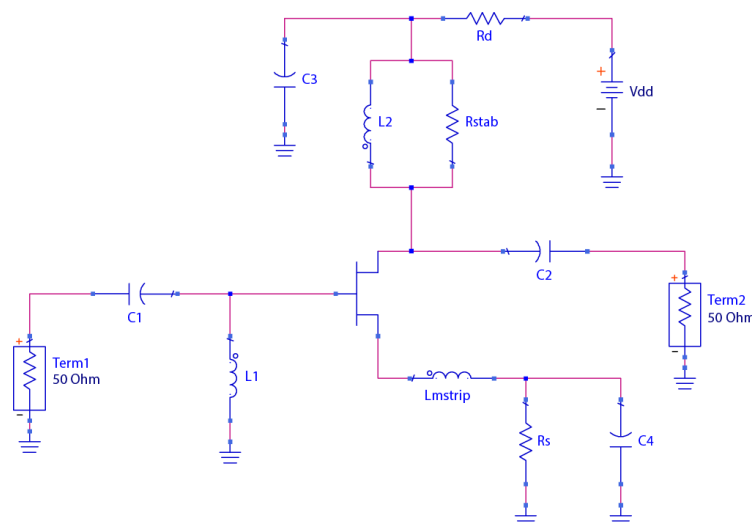
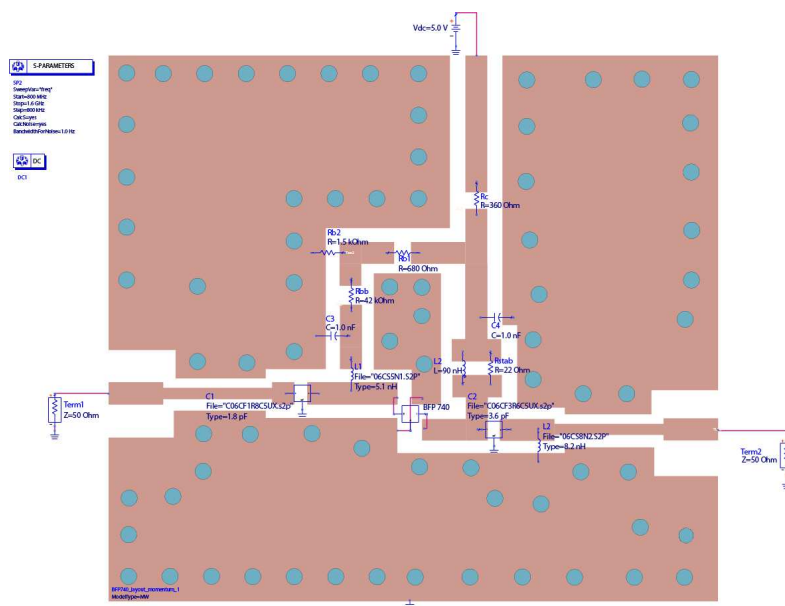


Figure 28: Overall Schematic of FET Amplifier

Figure 6 shows a typical LNA topology for FET or pHEMT active devices. The input matching network consists of C_1 and L_1 and the output matching network consists of C_2 and L_2 . Inductor L_2 again feeds DC as well as acting as a RFC. Capacitors C_3 and C_4 are bypass capacitors and the biasing network is comprised of R_d and R_s .

SIMULATED PERFORMANCE PARAMETERS

All of the circuits were simulated using *Agilent Technologies' Advanced Design System (ADS)* software package. To ensure accurate simulated results an electromagnetic (EM) simulation was performed on the final circuit designs. The EM simulation is a method of moments program called Momentum and generates a model of the PCB takes into account any signal coupling and parasitic components which exist on the PCB. An example of the simulation setup is illustrated in Figure 7.

**Figure 29: ADS Momentum EM Simulation Setup**

The simulated performance parameters of all the designed circuits are grouped together and plotted in Figures 8 to 10 for comparison purposes.

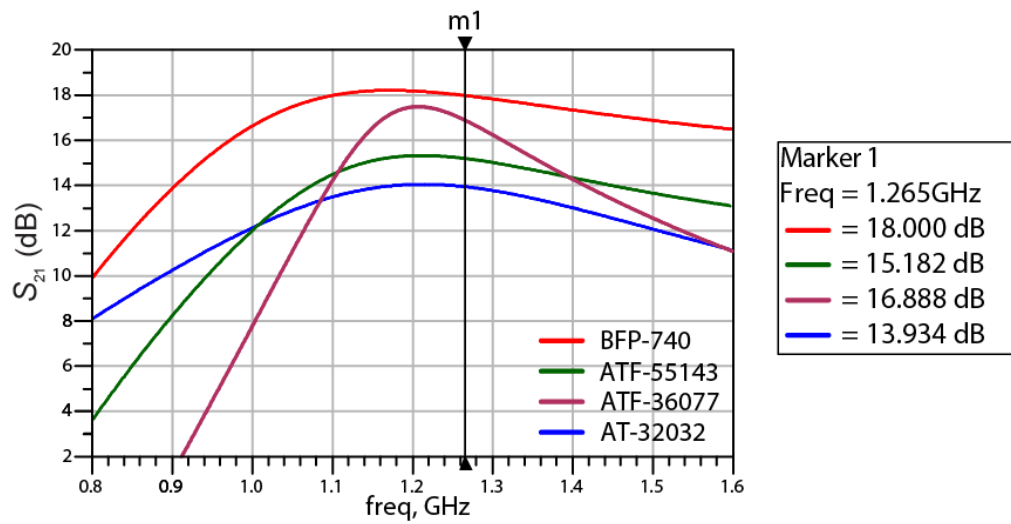


Figure 30: Simulated Results for the Power Gains (S_{21}) of Each Circuit

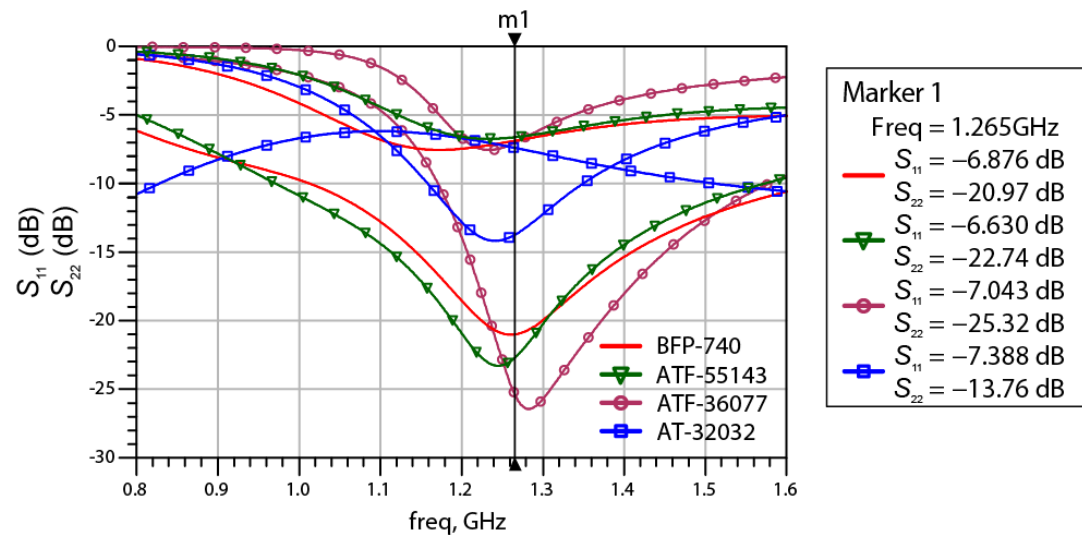


Figure 31: Simulated Results for the Input (S_{11}) and Output (S_{22}) Reflection Coefficients of Each circuit

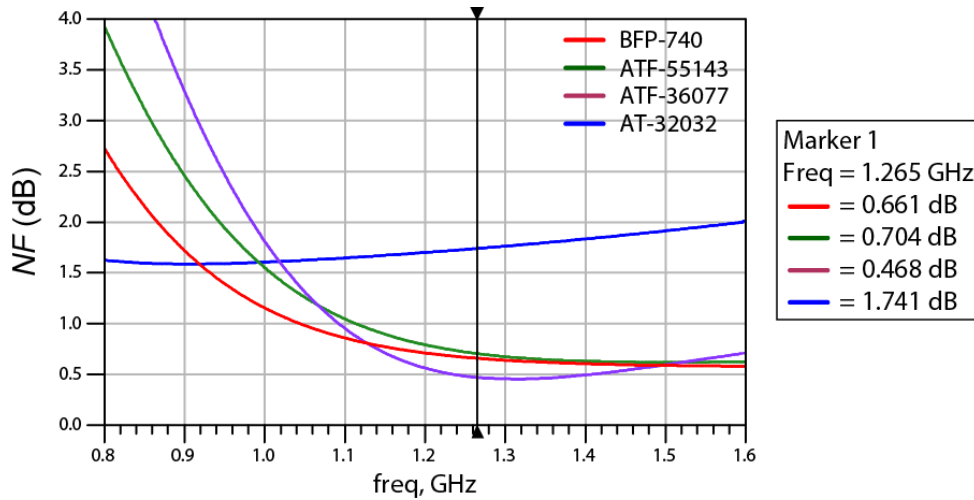


Figure 32: Simulated Results for the NF of Each Circuit

SUMMARY OF PERFORMANCE PARAMETERS

The simulated performance parameters of each circuit are summarised in Table 2 followed by a brief explanation of the calculation of some of the performance parameters.

	BFP-740	ATF-55143	ATF-36077	AT-32032
S_{21} (dB)	18.000	15.182	16.888	13.934
NF (dB)	0.661	0.704	0.468	1.741
S_{11} (dB)	-6.876	-6.630	-7.043	-7.388
S_{22} (dB)	-20.97	-22.74	-25.32	-13.76
IP_{1dB} (dBm)	-30.74	-22.02	13.498	-9.57
OP_{1dB} (dBm)	-13.54	-3.75	-3.086	4.214
OIP_3 (dBm)	0.630	11.582	16.824	17.664

Equation 4 was used for calculating the OP_{1dB} value.

$$OP_{1dB} = IP_{1dB} + G_A \quad \text{dBm} \quad (4)$$

The OIP_3 is a performance parameter indicating the linearity of the amplifier, and is determined using Equation 5. The OIP_3 is usually about 10 to 15 dB higher than the output 1 dB compression point.

$$OIP_3 = P_{out} + \frac{\Delta P}{2} \quad \text{dBm} \quad (5)$$

CONCLUSIONS AND RECOMMENDATIONS

Four types of active device technologies were selected based on the specifications published in the manufacturers data sheets and then used to design the four LNAs. The simulated results in Table 3 show that all of the amplifiers performed relatively well with no particular LNA out-performing the other.

Even though the manufacturers datasheet for the AT-32032 BJT active device specified an achievable noise figure of 0.9 dB, the lowest noise figure attainable was 1.7 dB. A possible reason for the difference in the specified and achieved noise figure is an inaccurate non-linear model of the active device provided by the manufacturers.

The LNA which used the GaAs pHEMT proved difficult to optimise. Rigorous amounts of component adjustment (tweeking) failed to achieve the maximum gain point to correspond to the minima of the input and output return losses.

The LNA which used the AT-55143 active device delivered excellent results and the fact that this e-pHEMT can be biased in a similar fashion to a BJT, simplified the design procedure. The performance results obtained from the simulations made it a strong contender for use in the final product.

The LNA with the BFP-740 active device provided the highest power gain of 18 dB and a NF of only 0.661. This relatively high gain and low NF provided by the BFP-740 active device made it the active device technology of choice for the LNA to be constructed and implemented in the Cubesat receiver.

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NANO-SATELLITE IN-SITU MONITORING: AN ADAPTABLE APPROACH TO COMMUNICATION SCHEMES THROUGH SDR-BASED TECHNOLOGY

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ABSTRACT

Traditionally, communication systems are designed with Application-Specific Integrated Circuit (ASIC) technology. Such designs are inherently restricted by their very nature of not being reconfigurable. The deployment of new algorithms or system level protocols require new hardware development. Field-Programmable Gate Arrays (FPGAs) allows for reconfigurable hardware within limits and can therefore form the basis on which multiple communication schemes can operate from or have the ability of updating to accommodate new protocols. Reconfigurability relieves conventional constraints on such systems and allows dynamic change in systems that are difficult to access without performing physical changes.

This paper highlights an adaptable communication channel with a focus on in-situ monitoring of vessel and aircraft objects. The proposed system will be capable of interacting with multiple protocols through Software Define Radio (SDR) technology for nano-satellites. Such a communication platform would enable more efficient development with the ability to incorporate changes and reconfigurations for post-launch application.

Keywords: Software Defined Radio, AIS, ADS-B, in-situ monitoring, nano-satellite

INTRODUCTION

Every subsystem in a satellite can arguably be the most important system as it forms an integral part in the fulfilment of the overall purpose and designed application. However, all data gathered by the satellite can be rendered futile if not able to communicate such information back to Earth. With the focus on environmental monitoring and tracking, this is especially evident as the communication subsystem plays a crucial part in being the gateway between

useful collected information and relaying that either to other satellites or ground stations for post processing and analysis.

The importance of a communication subsystem can thus not be understated. An ideal approach would be a flexible system that can communicate and cater for various communication protocols, switch between modulation schemes and other existing industry standards with the ability to be reconfigured on the fly as new protocols are developed.

Such an adaptable system is possible through SDR technology on FPGAs. SDR in itself is not a new technology but has received a lot of interest lately with the advancement in embedded computation power making this a feasible technology for nano-satellite applications.

BACKGROUND

The concept behind SDR is to replace components within a radio communication system that are traditionally hardware-based such as mixers, filters, modulators and demodulators and replace them with software modules. The principle of implementing an SDR system is not novel. A team from E-Systems Inc. developed a digital baseband receiver in 1984 and referred to it as a “software radio” (Johnson, P. 1985:6-7). With the advancement in embedded computation power and Moore’s Law stating exponential growth in the number of transistors inside integrated circuits, it enabled smaller and more feasible SDR platforms to be developed. Complex coding and modulation schemes can now be calculated within software algorithms allowing for a much more flexible system that grants an alternative to conventional Radio Frequency (RF) systems (Olivieri, S.J. 2011:7).

Nano-satellite in-situ monitoring can assist and aid a number of applications in the maritime and aerospace industries ranging from vessel and aircraft tracking and monitoring to disaster management. Two such industry platforms are Automatic Identification System (AIS) for maritime fleet tracking and Automatic Dependent Surveillance - Broadcast (ADS-B) for aircraft monitoring.

AIS is an RF communication protocol originally designed for vessel-to-vessel communication. AIS transponders automatically send and receive information such as their identity, location, speed and course to surrounding ships to ensure they safely navigate and avoid collisions (Ball, H. 2013:5-22). Although AIS was originally designed for ship-to-ship and ship-to-land communication, companies such as ExactEarth (ExactEarth, 2014) and Spire (Spire, 2014) have exploited this technology by implementing low-earth orbit satellites that can pick up signals from AIS transponders, commonly referred to as Satellite-AIS (S-AIS). The AIS protocol broadcasts on VHF maritime channels 87B (161.975 MHz) and 88B (162.025 MHz) and uses a Self-Organising Time Division Multiple Access (SOTDMA) scheme to allocate time slots for each ship.

ADS-B is a protocol used for aircraft situational awareness by periodically broadcasting data from the aircraft's navigation system such as identity, altitude and velocity to overhead satellites from where the information are fed to traffic control towers and surrounding aircraft (Airservices Australia, 2012). ADS-B data is broadcast every 500ms on a carrier of 1090MHz from the aircraft.

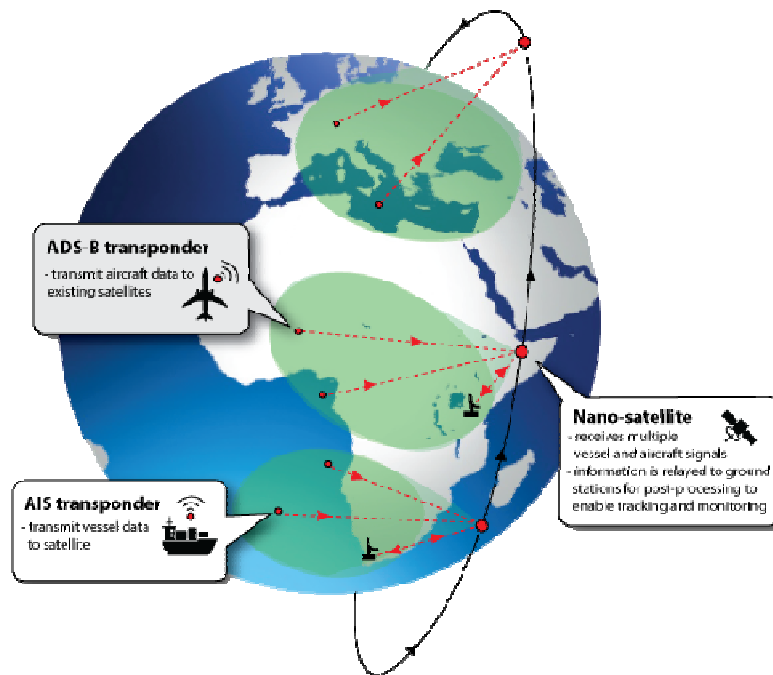
PROPOSED SYSTEM

Figure 1 details the overview of the proposed application and will allow nano-satellites to receive both AIS and ADS-B signals, store it and forward the relevant information to ground stations. The proposed system is especially beneficial for vessel and aircraft tracking in remote locations where receiving ground stations are not in line-of-sight but still within the footprint of one of the nano-satellites.

One advantage of the proposed application is the incorporation of established technologies with existing infrastructure. The International Maritime Organisation (IMO) has required the installation of AIS transponders on all ships exceeding 300 gross tonnage and cargo vessels exceeding 500 gross tonnage on international voyages as well as all passenger ships. The adoption of AIS systems have been very successful with an estimated 250

000 vessels equipped with AIS since 2012 (ExactEarth, 2012). Comparably, the ADS-B standard is implemented across the globe in a similar fashion with existing aircraft transponders already installed.

Figure 1: Nano-satellite in-situ vessel and aircraft monitoring



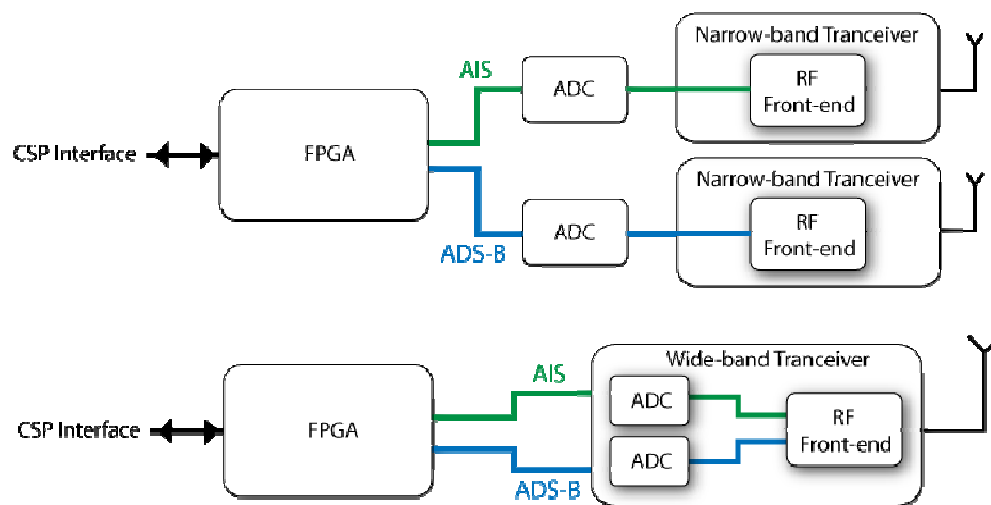
In order to realise such an application the communication channels between the transponders, satellites and the ground are of vital importance. Implementing an SDR-based architecture will cater for the various transmitted frequencies together with their network and data protocols of the transponders.

High-level block diagrams of two suggested systems are detailed in Figure 2 showing the AIS and ADS-B signal paths as received by the satellite. The top section of Figure 2 suggests a more discrete solution with both signals being down-converted with optimised narrow-band RF front-ends. The base-band signals would be sampled from where digital demodulation would happen inside the FPGA as an SDR solution. The FPGA will interface to a CubeSat Space Protocol (CSP) - a network protocol implemented between all the subsystems on the nano-satellite (CSP, 2014).

A more integrated approach can be used by implementing a dual-channel wide-band transceiver such as the AD9361, capable of receiving and

transmitting with a frequency range of 70MHz - 6 GHz. This component will serve as the RF front-end with integrated ADCs to receive both the AIS signals at 161MHz and the ADS-B signals at 1090MHz. As proof of concept and to accelerate development time the integrated option promises to be a good fit, although performance comparisons would need to be made against a more discrete approach as mentioned above.

Figure 2: High-level implementation of AIS and ADS-B signal capture



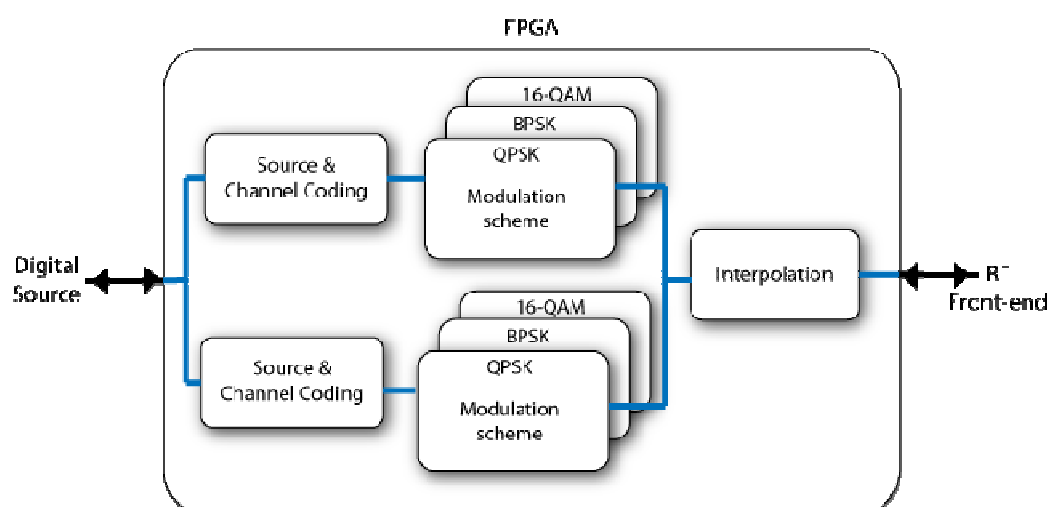
BENEFITS

As detailed in Figure 2, the architecture allows for a scalable design in that multiple RF front-ends coupled with ADCs can be layered to cater for specific RF requirements. Alternatively, by introducing a wide-band transceiver, the need to operate at specific frequencies together with their protocol layers can be achieved by switching and controlling such requirements completely in software. The disadvantage is that the wider receiver bandwidth will result in a poorer noise figure and greater susceptibility to interference, unless switchable front-end filters are incorporated.

By having a base hardware design of a reconfigurable FPGA coupled to a wide-band transceiver, the system becomes extremely flexible and adaptable. A firm and stable hardware design layer can therefore be used for multiple missions and applications requiring only minor updates with the introduction of new technologies and user requirements.

Dynamic reconfiguration of an FPGA is shown in Figure 3. This allows a system to swap out functional blocks within the FPGA without reprogramming. The system might have been designed to use a BPSK modulation scheme but in the future require QPSK. Additional functional blocks can be developed and interchanged as the need arises. Switching between modulations schemes and/or larger protocols does not require alteration on the physical layer but rather software defined blocks.

Figure 3: Dynamic reconfiguration on FPGAs



Such a system will provide for much faster development cycles and time to market with the added advantage of making post-launch changes to the system. A feature not possible with traditional hardware and ASIC designs.

CHALLENGES

S-AIS poses various challenges of which the biggest one is to manage the large number of AIS messages received by the satellite simultaneously. The TDMA scheme defined by the AIS standard caters for a maximum of 4500 available time slots per minute. However, the satellite will often pick up various AIS cells, therefore resulting in message collisions. New technologies have been developed by companies such as ExactEarth to reliably detect and de-collide such messages.

The desire exists for a generic system that can cater for all protocols on all frequencies. A system that is adaptable and that can handle the introduction of new conventions and schemes. However, in reality this approach is often not possible due to physical constraints imposed by current hardware.

An ideal SDR system would digitise the RF signal as close to the front-end as possible for software manipulation. However, to sample the RF signal directly at the antenna poses various challenges. One such challenge would require having extremely fast ADCs in order to effectively sample the RF signal containing all the relevant information.

RF front-end performance issues needs to be investigated with a trade-off study between application specific narrow-band designs and wide- or multi-band designs highlighting not only performance but flexibility, footprint real-estate, complexity, introduction of human error and reliability.

CONCLUSION

The synthesis of SDRs and FPGAs provide new ways of updating and reconditioning communication systems without physical hardware changes. The proposed design will allow for multiple digital signal processing blocks or software defined functional blocks, such as modulation schemes, to be stored and swapped out on demand. With the possibility of updating the FPGA's firmware remotely, new software blocks can be introduced into the system allowing support for new protocols.

SDR technology has the potential to revolutionise the satellite industry by allowing for a scalable and flexible architecture that is both adaptable and able to cater for new communication protocols without the need for hardware alterations.

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THE PERFORMANCE EVALUATION OF DISTRIBUTED INTER-SATELLITE COMMUNICATION PROTOCOLS FOR CUBE SATELLITE SYSTEMS

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ABSTRACT

The usage of small satellite systems is of great importance to the space community due to the reduced cost of space missions without a great compromise in performance. Small satellites flying in formation help to provide better spatial and temporal resolutions of the target and thus could be useful in many science and environmental applications like gravity mapping, tracking of forest fires, finding water resources, and space weather. Inter-satellite communication is a key aspect when satellites fly in formation. This paper focuses on designing and simulating suitable MAC and routing layer protocols for distributed small satellite network. Given that we use the Open System Interconnection (OSI) as a framework, this work represents a focus on layer 2. To validate our proposed system model, extensive simulations are executed. Performance of the proposed work is evaluated using three different parameters: throughput, average access delay and average end-to-end delay. These findings indicate that the Leader-Follower and Constellation formation flying patterns have the maximum throughput and minimum delay thus ensuring reliable communication and higher data rate with low cost.

Index Terms— *Small satellites, Formation flying of small satellites, Distributed systems in space, Inter-satellite communications, MAC and Routing layer protocols, CSMA/CA/RTS/CTS Protocol.*

INTRODUCTION

Future space missions are envisioned having low cost, autonomous, and distributed space networks using small satellites. Small satellites are artificial satellites with lower mass and smaller sizes (mass less than 180 kg [1]). A group of small satellites offers numerous capabilities that cannot be achieved by a single large satellite. The concept of multiple satellite mission is becoming attractive because of their potential to perform coordinated

measurements of remote space. A large number of government organizations and universities are developing Earth observations and interplanetary space mission concepts using multiple small satellites [2], [3]. Technical advancements in microelectronics, adaptive and reconfigurable hardware and micro sensors have enabled the design and development of highly integrated multi spacecraft systems using small satellites [4]. Space based wireless sensor networks using small satellites can be useful for many missions like servicing or proximity operations of large mother ships. It provides multi-point coverage, thereby increasing the spatial and temporal resolution and also enables extended communications for low powered surface vehicles around other planets or asteroids [5].

Distributed space missions consist of two or more satellites working cooperatively to achieve an objective [6]. These missions consists of numerous satellites that communicate with each other using Inter-Satellite Links (ISL). The ISL have also been called cross links in literature [7]. A satellite can have several communication links with other satellites. Depending on the mission objective, ISL can carry different types of traffic like voice, data, video, or telemetry data. The cross links can be used for connecting two or more separate satellite networks, thereby expanding the coverage area. It is important for interplanetary or deep space missions where it is difficult to control the system from Earth stations. Inter-satellite links can be used for attitude control and timing synchronization in multiple spacecrafts. The ISL eliminates the need of ground stations around the Earth to control the satellites. However, these systems have limitations both at the transmitting and receiving end, for example, limited power, mass, antenna size, on board resources, computing capabilities etc. Iridium, Orblink, Teledesic [7], Proba3 [8], Edison Demonstration of Smallsat Networks (EDSN) mission [9] and QB-50 mission [10] are some examples of multiple satellite space missions with inter-satellite links.

The Open System Interconnection (OSI) model serves as a reference tool for communication between different computer systems connected in a network which divides the communication process in to seven layers [11]. It is a

conceptual framework that helps to understand complex interactions within a network. Each layer has well defined functions and offer services to the layers above and below it. It can be used as a framework for the network process for inter-satellite communication in small satellite systems. The OSI model has seven layers; physical, data link, network, transport, session, presentation and application. The second layer, i.e., the data link layer is the primary focus of our research. This layer is responsible for physical addressing (Medium Access Control/MAC address) and also ensures error free data transmission. In this paper, we propose the appropriate MAC and routing protocols for the three different formation flying patterns (Leader-Follower, Cluster and Constellation) of small satellite systems.

The performance of the entire system is largely depended on the design of multiple access protocols. The MAC protocol should take into account mission specifications like mission application, network topology, number of satellites etc. Also, it has to consider several system constraints of small satellites, for example, limited on board power and computing resources. There are several researches being conducted on various multiple access methods for inter-satellite communications in small satellite systems [12], [13], [14], [15], [16], [17]. In this paper, we are proposing a modified MAC protocol, i.e., Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) with RequestTo-Send/Clear-To-Send (RTS/CTS) protocol and routing protocols for the three different formation flying patterns. The proposed protocol is suitable for science missions that does not require tight communication links between the satellites and has small number of satellites in the system. The novelty and contribution of this work are that 1) To the best of our knowledge this is the first work to propose and validate a MAC protocol for inter-satellite communication for various formation flying patterns of small satellite system. and 2) The contribution lies in the experimental results that quantifies the performance of the various small satellite configurations. The proposed system models are analyzed using three different parameters: throughput, average access delay and average end-to-end delay respectively.

The rest of this paper is organized as below. Section II briefly describes the various distributed systems in space. A brief description of the proposed system models for the various formation flying patterns are described in section III. A brief outline of the proposed MAC and routing protocols are given in Section IV. The simulation results for all three formation flying patterns are discussed in Section V and the paper is concluded in Section VI.

DISTRIBUTED SYSTEMS IN SPACE (DSS)

Small satellites with distributed computing capabilities can fly in various configurations like formation flying spacecraft, satellite constellation, swarms and fractionated spacecraft [18]. These multi-satellite configurations are new prototypes for inter-planetary explorations and remote sensing. Multi-satellite configurations are subsets of a more general class described as Distributed Space Systems (DSS) [19].

A. Formation Flying Spacecraft

In accordance with the engineering definition, for formation flying of spacecrafts, it is required to maintain relative separation, orientation or position among the spacecrafts [20]. The Leader-Follower (A-Train) is a good example of this pattern. In Leader-Follower pattern, multiple spacecrafts will be orbiting the Earth in the same orbit, separated from each other at a specific distance. The A-Train or Afternoon-Train initially consisted of eight U.S. and international Earth science satellites that fly approximately within seconds to minutes of each other to enable multiple science missions. As of June 2012, there are five active satellites namely, GCOM-W1 (SHIZUKU), Aqua, CloudSat, CALIPSO and Aura [21]. The Orbiting Carbon Observatory-2 (OCO-2) is scheduled to join the configuration in 2014. The joint measurements provide an excellent sensor system for Earth observations. Figure 1 shows the Leader-Follower formation flying pattern.

Figure 1: Leader-Follower formation flying pattern

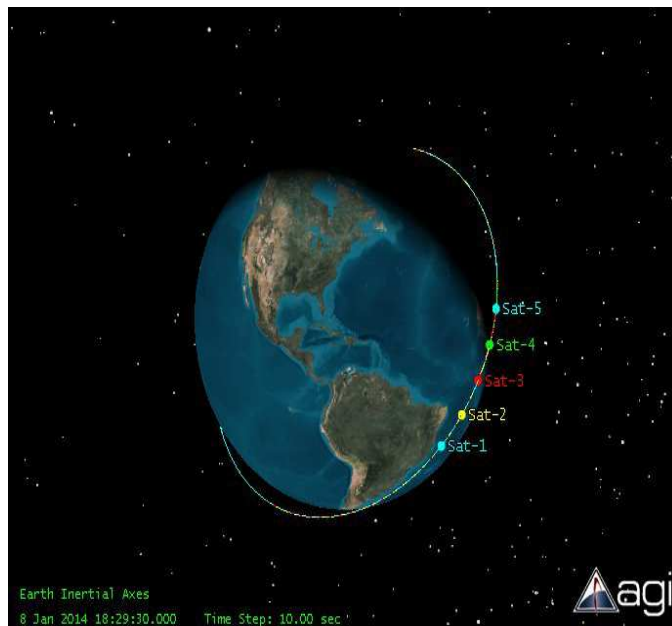
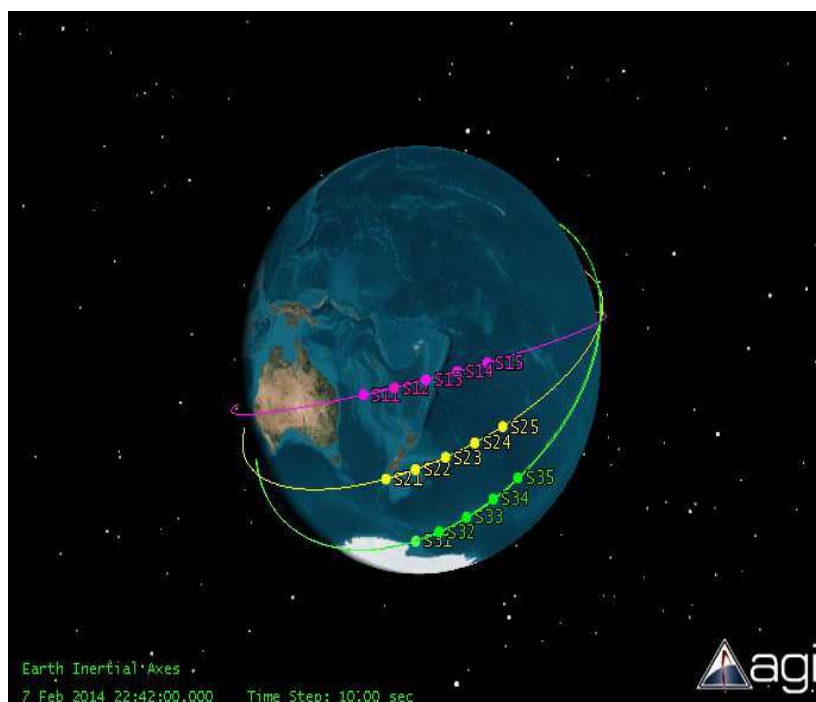


Figure 2: Cluster formation flying pattern

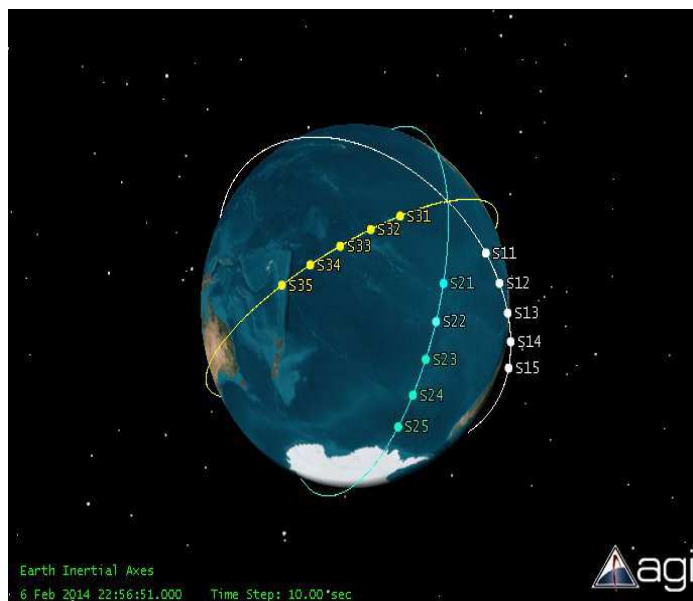


B. Satellite Constellation

A satellite constellation is a set of similar or dissimilar satellites distributed in space so that they overlap well within the coverage area to accomplish mission objectives [22]. A Cluster configuration is a subgroup of Constellation

as it covers a smaller portion of the Earth. A Cluster consists of a number of satellites distributed in different orbital planes that operate cooperatively. The Flower constellation [23] and TECHSAT21 [24] are examples of Cluster configuration. A satellite constellation is a more generalized configuration covering a larger portion of the Earth surface. There is no governing rules for inter-dependency for the satellites in a Constellation. The Global Positioning System (GPS) and IRIDIUM are examples of Constellation configuration. The IRIDIUM consists of 66 Low Earth Orbiting (LEO) satellites arranged in 6 orbital planes, with 11 satellites per plane, at an altitude of 780 km above the Earth surface [25]. Figures 2 and 3 show the Cluster and Constellation configuration pattern for small satellites.

Figure 3: Constellation formation flying pattern



C. Swarms

A satellite swarm is defined as a self-organized, self-functioning satellites that communicate directly or indirectly that enables to achieve a common mission. It can be considered as a set of agents that take decisions independently without ground station intervention. It is highly autonomous with very high possibilities of reconfiguration or extension. The whole system is very complex and also requires precise navigational accuracy [18].

D. Fractionated Spacecraft

A fractionated spacecraft is a new architectural model, whereby the functionalities of a large satellite is distributed across a cluster of small satellites which are wirelessly interconnected. Each small satellite has different functionalities making the whole system heterogeneous. This configuration needs higher position and orbital control of the individual satellite with a moderate system design complexity [18]. Such a system enhances robustness and flexibility in the architecture, while shortening development time and launch constraints.

PROPOSED WORK

A. System Model

This paper mainly concentrates on Leader-Follower, Cluster and Constellation formation flying patterns of small satellites. In our research, we consider closely 1 U cube-satellites with a mass less than 1.33 kg (10 cm cube). The transmission power of 1 U cube-satellite ranges from 500 mW to 2 W. We assume that the satellites operate at the S-band frequency in the magnetic spectrum, i.e., the frequencies ranging between 2 GHz to 4 GHz. In the proposed system model, we assume that the satellites are deployed in nearly circular Lower Earth Orbits (LEO).

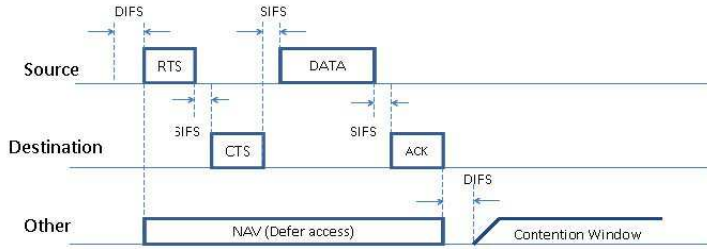
We consider a single orbit for Leader-Follower formation flying pattern and for Cluster, M number of orbits are considered with a separation distance of no wider than y km. For Constellation formation flying pattern, we consider N orbital planes, spaced x degrees apart. In order to avoid collision of small satellites at the poles, it is assumed that the satellites are deployed at different time instants, such that the separation distance between the satellites is greater than the minimum inter-satellite distance, according to the link budget. We can also consider a scenario, where the satellites are deployed at the same time but in different orbital planes that are not at the same altitude, thus avoiding the spacecrafts colliding with each other at the poles. For the three configurations, it is assumed that the satellites in all orbital planes share the same transmission frequency band.

B. The CSMA/CA/RTS/CTS Protocol

The MAC layer provides channel accessing schemes for several terminals within a multiple access network that uses a shared medium. IEEE 802.11 standards specifies both physical and MAC layer. It offers two services i.e, contention based, implemented by Distributed Co-ordination Function (DCF) and contention-free services, employed by Point Co-ordination Function (PCF). The DCF is based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). The CSMA/CA/RTS/CTS (Request-To-Send/Clear-To-Send) multiple access is a good choice for a distributed network of small satellites compared to other traditional MAC protocols, because it can solve the hidden and exposed terminal problems [26].

The carrier sense multiple access scheme is based on sensing the transmission channel to infer the channel conditions. If the channel is found to be idle for a time slot greater than Distributed Co-ordination Function Inter Frame Space (DIFS), then the sender satellite continues transmission by sending the Request-To-Send (RTS) control frame to the receiver satellite. After an interval of Short Inter Frame Space (SIFS), the receiver satellite sends back the Clear-To-Send (CTS) control frame. Upon receiving the CTS, the sender satellite sends the data packet after waiting for a period of SIFS. The receiver processes the data packet and sends an acknowledgment (ACK) after waiting for another SIFS time frame. The RTS and CTS includes the total time it takes for the current transmission including the ACK. It will be sent to the neighboring satellites too, so that they will refrain accessing the channel and thereby avoiding collisions and loss of data packets. After receiving this information, the neighboring satellites setup the network timer called the Network Allocation Vector (NAV). If the NAV timer is zero, satellite initiates channel access. Figure 4 shows the CSMA/CA/RTS/CTS protocol [27].

Figure 4: CSMA/CA with RTS/CTS [12]



When a satellite senses that the channel is busy, it turns on a random back-off counter or Contention Window (CW) that determines the amount of time the satellite has to refrain accessing the transmission channel. The IEEE 802.11 MAC protocol follows exponential back off, i.e., CW size ranges from 0 to 2^m . Every time the satellite experiences a collision, the CW size is doubled and it is reset to the initial value of 0, whenever the satellite succeeds to get access to the channel. During the back off time period, if there is another data packet transmission in its neighborhood, the back-off counter will be frozen to avoid collision. It will be resumed when the channel is sensed to be idle subsequently.

C. Modified CSMA/CA with RTS/CTS Protocol

The CSMA/CA with RTS/CTS Protocol is originally designed such that the control frames, RTS and CTS are transmitted in an omni-directional way. In this paper, we propose to use smart antennas at the physical layer. For small satellite systems, CSMA/CA/RTS/CTS protocol can be modified by transmitting the control frames, RTS and CTS using directional/omni-directional antenna based on the different configurations. For example, for a Leader-Follower formation flying pattern (A-Train), RTS and CTS can be transmitted directionally using smart antennas, thus saving power [12]. For Cluster formation flying pattern, as there are more number of satellites within the transmission range of each satellite, RTS and CTS can be transmitted using omni-directional antennas. For Constellation pattern, as per our design, the satellites in one orbital planes will not come with in the transmission range of the satellites in another orbital plane. Therefore, communication takes place between the satellites placed in its own orbital plane and hence RTS and CTS can be sent using bi-directional antennas. Data frame can be also

transmitted using directional antennas, thereby ensuring longer battery life of the small satellites.

D. Routing Protocols

There are two possible routing schemes, proactive and reactive routing, respectively. In the proactive scheme, each satellite knows the entire network topology and whenever a satellite needs to send a data packet, it finds the route and establishes the connection. However, when the network becomes more complex, it is difficult to maintain the routing tables and also it consumes more power and bandwidth which are the major constraints for small satellite systems. The reactive scheme is based on on-demand routing, i.e., a satellite tries to find an optimal path to the destination only when there is a need to have a communication. We propose to use reactive routing scheme for our system model.

Transmission power and time are the two network optimization objectives for data packet routing. When the data packet is transmitted to the destination satellite by multi hopping, there is a significant reduction in the power for communication. It is important to determine an optimum route for a data packet that is being transmitted between a sender and a receiver. For A-Train formation flying pattern, we can use Bellman Ford algorithm [12] since it computes the shortest distance between the satellites and thereby routes the data packet through the shortest path.

Figure 5 shows the data flow structure from a source satellite to a destination satellite for a Leader-Follower formation flying pattern. The Constellation formation flying pattern follows the same approach as the Leader-Follower configuration. For both patterns, the source satellite transmits the data packet to the neighboring satellite and so on until it reaches the destination. Figure 6 shows the data packet transmission for Cluster formation flying pattern. For this configuration, all the satellites in different orbital planes operate at the same frequency. Thus, the source satellites can route the data packets to the satellites in other orbits if the neighboring satellite is found to be busy,

provided it is within the transmission range and closer to the destination satellite as shown in Figure 6.

SIMULATION RESULTS AND DISCUSSIONS

We did extensive simulations for the three different formation flying patterns. An event driven simulator is used to implement the simulations which is built in Java. The system was analyzed using three different parameters.

- *Average end-to-end delay* -It is defined as the amount of time taken by a data packet to reach from the source satellite to the destination satellite [12].
- *Average access delay*-The average access delay is defined as the amount of time each satellite has to wait before it gets access to the channel for transmission [12].
- *Throughput* -The throughput is defined as the amount of time that is used for a valid transmission of the total simulation time.

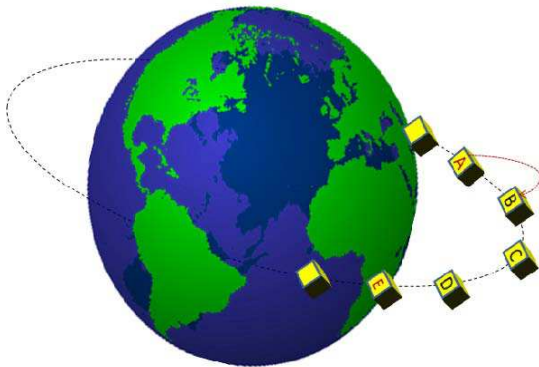


Figure 5: Leader-follower formation flying pattern [12]

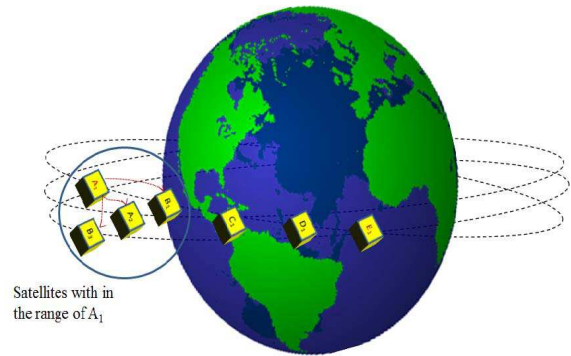


Figure 6: Cluster formation flying pattern [12]

The three different systems are simulated using 10,000 data packets. We need to run the simulations for a large number of data packets for the system

to reach its stability and thereby retrieving accurate results. The simulation parameters are based on the assumptions that are summarized in Table 1.

TABLE I: Simulation Parameters

System Parameters	Value
Size of cubesats	1 U
Transmission power	500 mW to 2 W
Orbital altitude	Lower Earth Orbit , 300 km
Number of orbits - M, N	3
Orbital separation, y	2 km
Transmission frequency	2.4 GHz
Orbital velocity	3 km per s
Inter-satellite range	10 km to 25 km
Number of packets simulated	200 packets per satellite
Data packet length	Exponential distribution
Data packet arrival	Poisson distribution
DIFS	28 μ s
SIFS	28 μ s
RTS	50 μ s
CTS	50 μ s
ACK	14 μ s
Average packet length	1s
Contention window size W	2m

A. Leader-Follower (A-Train) Formation Flying Pattern

For the Leader-Follower formation flying pattern, we consider a circular orbit at an inclination of 45° at an altitude of 300 km above the earth. First, we simulated with 10 satellites in orbit with an 8 km separation distance between each satellite. Hence the relative distance between the satellites is the same and thus the satellites appear stationary to each other. Then we increased the number of satellites in the orbit to 20 and then to 30 satellites. Figures 7, 8 and 9 show the simulation results of the Leader-Follower formation flying pattern. The average end-to-end delay increases as the number of satellites in the orbit increases, since the total orbital length increases from 80 to 270 km as seen in Figure 7. The average access delay also increases when we increment the number of satellites in the system as observed from Figure 8.

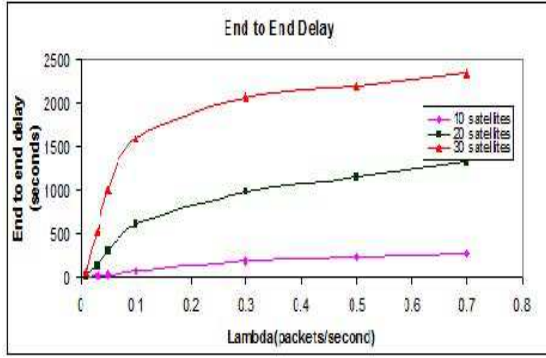


Figure 7: Average end-to-end delay for Leader-Follower formation flying pattern

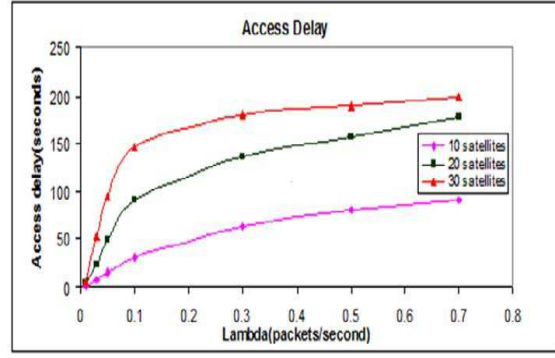


Figure 8: Average access delay for Leader-Follower formation flying pattern

This is due to the fact that, the overall traffic increases and the satellite have to wait for a long time to get access to the channel. The throughput of a system is inversely proportional to delay, i.e., when the overall delay increases, the throughput decreases. The throughput of the Leader-Follower configuration is shown in Figure 9. We observe that in the case of 10 satellites in orbit, the throughput is less compared to 20 and 30 satellites in the system. This is because, for the case of 10 satellites in the system, the over all traffic is considerably less and the channel is not utilized effectively in comparison to 20 and 30 satellites. We can achieve a maximum throughput of 24%.

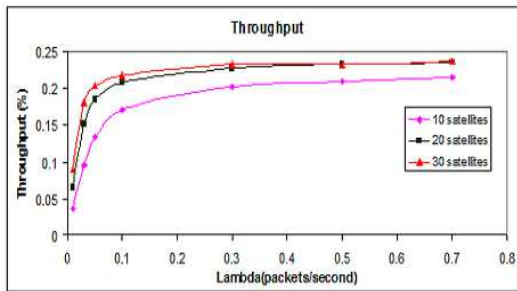


Figure 9: Throughput for Leader-Follower formation flying pattern

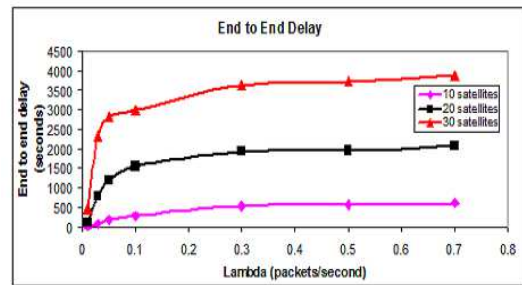


Figure 10: Average end-to-end delay for Cluster formation flying pattern

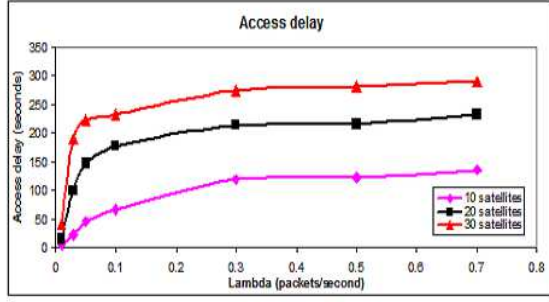


Figure 11: Average access delay for Cluster formation flying pattern

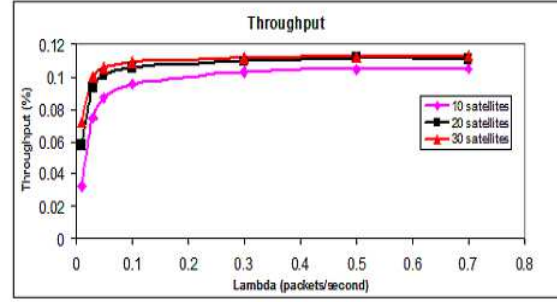


Figure 12: Throughput for Cluster formation flying pattern

B. Cluster Formation Flying Pattern

We consider three circular equatorial lower Earth orbits for the Cluster formation flying pattern at an inclination of 45° , 48° , and 50° respectively. We assume that all the three orbits share the same frequency for transmission. Similar to Leader-Follower formation flying pattern, we simulated the Cluster configuration for 10, 20 and 30 satellites in the orbit. As can be seen from Figures 10 and 11, the average end-to-end delay and average access delay is less when there are 10 satellites in the orbit. As observed from Figure 12, throughput for the system with 10 satellites is less compared to 20 and 30 satellites. The same reason holds true in this case too, similar to the Leader-Follower configuration. We observed that, for heavy traffic, the three curves converge very well since all the systems attain its saturation with effective channel utilization.

C. Constellation Formation Flying Pattern

For the Constellation formation flying pattern, three orbits at an inclination of 30° , 60° , and 90° are considered for the simulation model. We assume that the satellites in various orbits are deployed at various time instants and the satellites fly at a velocity of 3 km/s. We assume that the satellites share the same frequency band. In our simulation, we simulated the mobility pattern of the satellites by calculating the 3D location of each satellite every second and then finding the neighboring satellites. Analogous to Leader-Follower and Cluster formation flying patterns, we simulated the system with 10, 20 and 30 satellites in each orbit. Figures 13, 14 and 15 show the simulation results for

the Constellation formation flying pattern. For the system with 10 satellites, the average end-to-end delay and average access delay is less, analogous to the other formation flying patterns for the same reasons as previously mentioned.

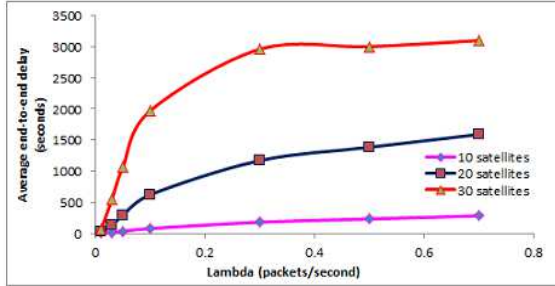


Figure 13: Average end-to-end delay for Constellation formation flying pattern

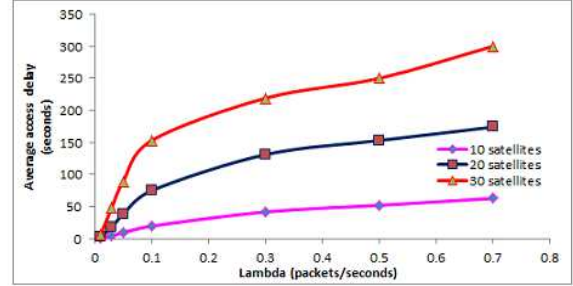


Figure 14: Average access delay for Constellation formation flying pattern

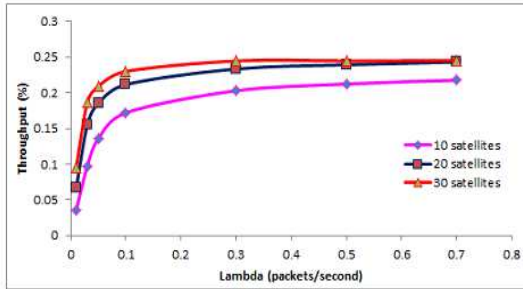


Figure 15: Throughput for Constellation formation flying pattern

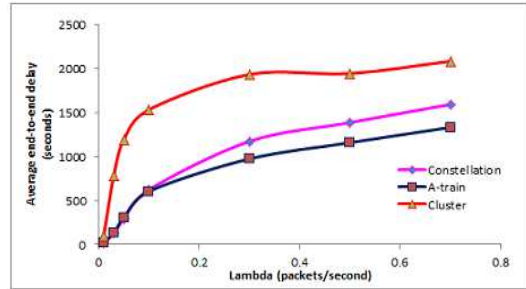


Figure 16: Average end-to-end delay comparison

D. Comparison of Simulation Results

The Figures 16, 17 and 18 compare the simulation results obtained from the three different formation flying patterns. For comparison, we considered the scenario in which each of the various formation flying patterns consists of 20 satellites per orbit. As observed from Figures 16 and 17, the average end-to-end delay and average access delay is less for Leader-Follower and Constellation formation flying pattern in comparison to Cluster formation pattern. This is because, for Cluster configuration, the orbits share the same frequency band and there are more number of satellites in the vicinity of each satellite which results in more contention and hence increased delay. For Constellation, though the satellites in various orbits share the same

transmission frequency, the satellites in one orbit will not communicate with satellites in the other orbit as they are deployed at various time instants according to the proposed model.

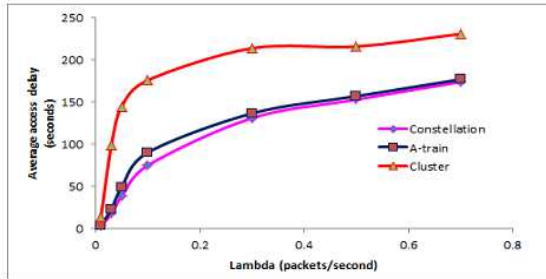


Figure 17: Average access delay comparison

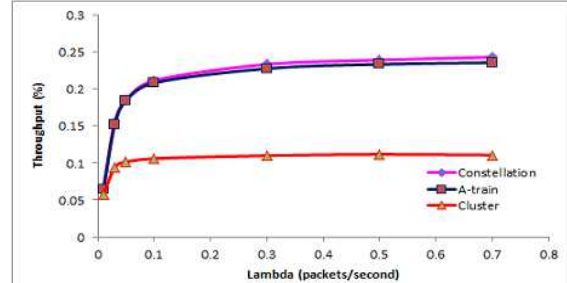


Figure 18: Throughput comparison

For Leader-Follower and Constellation formation flying patterns, the maximum throughput that can be achieved using the proposed CSMA/CA/RTS/CTS protocol is around 24%. As the average access delay and average end-to-end delay is comparatively more for Cluster formation flying pattern, the maximum attainable throughput is 11% as can be seen in Figure 18. Figure 17: Average access delay comparison

CONCLUSIONS

In this paper, we investigated three different formation flying patterns, namely, Leader-Follower, Cluster and Constellation. We proposed a feasible MAC layer protocol, i.e., modified CSMA/CA/RTS/CTS protocol that addresses the design needs of a small number of cubesats within a reconfigurable network. The proposed protocol is suitable for science missions that can tolerate communication delays among satellites. We proposed to use shortest path algorithm for routing of data packets between the satellites. The various system parameters have been evaluated by extensive simulations for different configurations of small satellites in different scenarios. The maximum throughput that can be accomplished using the proposed protocols for Leader-Follower and Constellation formation flying pattern is around 24% and for Cluster formation flying pattern is 11%. The average end-to-end delay and average access delay is more for Cluster formation flying pattern in

comparison to the other two formation flying patterns. The decision of which formation flying pattern to choose depends on various parameters mainly the mission application, mission architecture, number of satellites to be used for a particular mission, orbital strategies, power etc.

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DEVELOPMENT OF PRODUCTS FOR PERSONS WITH DISABILITIES IN KENYA

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ABSTRACT

A recent survey established that very few graduates of design are providing products and services for the disabled in Kenya. Design researchers, professionals and students may be focussing their attention on an increasingly competitive area whereas there are opportunities and more critical need in providing services to the disabled persons in our society. With estimated 650 million disabled persons in the developing countries, we cannot continue to focus our products and services to abled persons. Universal design provides principles that should govern design of products & services that acknowledge the presence of and needs of the disabled. And, designers are well placed to provide the lead in applying these principles in providing products and services that favour the disabled persons especially in the design of low cost appliances, mobility aids and environments. Because very few design graduates are absorbed in this area, critical design services are inadequately addressed. As a result, the inclusion of the disabled into society is hampered. Wheelchairs for example, in Kenya are in one design and only two sizes. The assumption is that one size fits all. This paper discusses the absence of designers in the development of products and services for the disabled persons. It recommends ways in which design students, researchers and professionals can increase their involvement.

Key words: Universal design, products and services, disabled persons.

1. INTRODUCTION

For over forty years that design has been taught in the University of Nairobi, there has been very little effort to embrace design for the disabled members of the society. Most graduates opt to look for employment in the traditional design industries of advertising and media, fashion, interior and jewellery. Few graduates venture into employment in organizations that manufacture

products for the disabled such as The Association of the Physically Disabled Persons of Kenya (APDK). The student projects also have a bias towards projects for the more abled-members of the society. For example, many students prefer to create interiors with an "African ambiance" as opposed to interiors for the Aged or disabled; more students prefer to develop toys and other functional products for the abled-persons but not for the disabled. Fashion students develop fashion for the ideal body forms that fit the ideal model bodies but not for the disabled. Organizations such as Bombolulu Workshops and Cultural Centre in Kenya, employ design graduates. But, their role is not to design products for the disabled, but rather to work with the disabled to develop products for the abled-persons. So typically, at Bombolulu, the designer would be working with persons on wheel chairs and crutches, to develop jewelry, or textiles or leather bags for sale in the export and local market. Kenyan designers do not design for the disabled.

The UN Convention on the Rights of the Persons with Disabilities - CRPD (UN, 1993) outlines clearly the definition of disabled persons, their rights and need for equality. CRPD goes further to states that designers shall design products, environments, programmes and services to be used by all people under the Universal design principles. Kenya like most countries of Africa, is a signatory to the UN and has therefore adopted these articles in the constitution of 2010.

A survey of some low cost appliances and mobility aids for the disabled in Kenya showed that there is a heavy reliance on a few medical personnel and technicians for their design. For example, in the physiotherapy clinics, much of the equipment is improvised from bits and pieces of found objects. The Association of the Physically Disabled Persons of Kenya (APDK) is the only producer of wheelchairs and some appliances for the disabled in East and Central Africa. They produce wheelchairs in two sizes only, one for adults and one for children. For new product design, they depend on one individual who is a medical physiotherapy specialist. The question therefore that this paper explores is why designers do not get actively involved in the development of products for the disabled and, what steps need to be taken to get designers

taking a lead role in developing products and services for the disabled persons.

2. DISABLED PERSONS

Disabled persons are people with different abilities or with physical, sensory or mental impairments that can make performing an everyday task more difficult (Bolanle and Ajokpaniovo, 2009). Among the types of disability or impairment are learning and applying knowledge; communication, mobility, self care and domestic life (WHO, 2011). The report acknowledges that many countries have taken action to improve the lives of the disabled but much more remains to be done. Non-discrimination of persons with disabilities; their full and effective participation and inclusion in society; respect of difference and acceptance as part of human diversity and humanity and equality are articulated in the United Nations Convention on the Rights of Persons with Disabilities (CRPD) (United Nations, 1993). Under the CRPD the role of the designer is outlined in "Universal design" which is defined as "design of products, environments, programme and services to be usable by all people, to the greatest extent possible, without need for adaptation or specialized design." It goes on to state that Universal design shall not exclude assistive devices for particular groups of persons with disabilities where this is needed (United Nations, 1993). The convention recognizes designers as able to undertake or promote research and development of universally designed goods, services, equipment and facilities. CRPD urges members to embrace universal design in the development of standards and guidelines. Kenya is a signatory to this convention and has embraced it in the constitution of 2010 in Article 2 (6 and 7) and Article 9. Article 9, spells out the legal framework aimed at integrating and improving the participation of the disabled persons in development. The spirit of the constitution is to take deliberate steps to "redress any disadvantage suffered" by the disabled in the earlier constitution. It thus states that there shall be reasonable access to all places, public transport and information, to use Sign language, Braille or other appropriate means of communication; and to access materials and devices to overcome constraints arising from the person's disability (The Constitution of Kenya,

2010). The issues around inclusion of disabled persons in society is more critical in the developing countries, "where a vast bulk of estimated 650 million people with disabilities reside, (Bolanle and Ajokpaniovo, 2009)."

Assistive devices are only one aspect of rehabilitating the disabled. They also have psychological, social and economic needs. People with disabilities often suffer from self pity and feeling of hopelessness that can lead to lowered self esteem. They therefore require counselling from specialists who will make them have a positive outlook to life and have emotional balance. Part of the proposed rehabilitation programme is to address mobility of the disabled person, by providing for a wheelchair, or a seeing eye-dog and conducive environment. It also involves exercises to train them in skill acquisition to compensate for social, vocational, sexual and marital defects (Bolanle and Ajokpaniovo, 2009). These interventions lead to the disabled individuals living sustainable lives.

In Kenya, The Association of the Physically Disabled of Kenya (APDK) was established in 1958 with the aim of rehabilitating persons with disabilities. It is supported by international donor agencies and is the umbrella body made up of other organizations and stakeholders in Kenya. Its aim is to address disability equality concerns through legislation and advocacy and awareness creation. Other significant organizations include the Kenya Society for the Blind, Kenya National Association for the Deaf, Autism Society of Kenya and Kenya Society for the Mentally Handicapped. APDK offers physiotherapy and occupational therapy services. The APDK fabricate orthopaedic appliances such as crutches, cushions and support; materials and aids, rehabilitation exercises, wheel chairs, wheelchair accessories, walking aids, callipers, surgical boots and polycentric prosthetic knee. The concern is that local design experts are not involved in the development of these products.

3. UNIVERSAL AND INCLUSIVE DESIGN

It has been proven that embracing the principles of universal design to accommodate the disabled actually benefits everyone and are cost-effective in the long run. WHO (2011) states that adopting universal design and

implementing reasonable accommodations are two important approaches to mainstreaming the disabled. The founder and programme director at The Centre for Universal Design at North Carolina State University, Ronald Mace (1941 - 1998) developed the Universal design principles on the concept that the design of products should serve the broadest range of persons, regardless of levels of ability or mobility, age, gender or physical stature without the need for adaptation or specialized design. The Centre consolidated the principles into seven for universal design. And they went further to state that the principles "...may be applied to evaluate existing designs, guide the design process and educate both designers and consumers about the characteristics of more usable products and environments," (Betty Rose Connell *et al*, 1997).

These principles have been adopted widely and in Nairobi, there has been some effort in the building industry with universal principles being inserted into the city by-laws especially in the access to public places and include to provide, ramps, rails, lifts and specific washrooms that cater for those on wheelchairs or crutches or other inabilities. But it can be said that the uptake is slow maybe because of weak reinforcement laws. For example, there is only one church that was recently publicized that serves the deaf in Nairobi. During the live broadcast, the deaf were shown praising and worshipping in sign language. The whole service was conducted in sign language. In the broadcast media, only one popular television channel provides a sign language interpreter for its news segments (refer Figure 1). Wanjiku, one of the interpreters says that she has a passion for the deaf and her dream is that one day all the media houses in Kenya will emulate KTN and interpret news for the deaf (www.standardmedia.go.ke).

Figure 33: Local media news presentation with sign language interpreter.
Source: www.standardmedia.co.ke. 2014



The same sentiments were expressed in the area of HIV AIDs education and awareness where very little information trickles to the disabled (Kyeti, 2014). It was noted that there are initiatives towards inclusive design, but that it is inadequate and there is room for much more to be done. For example, there is legislation to force all the television channels to provide sign language interpreters and/or subtitles that has been drafted can be accelerated and implemented.

4. CHARACTERISTICS OF INCLUSIVE PRODUCTS

Design is intrinsically intertwined with quality of life and it is said that the level of development of any community can be gauged by their level and adoption of design. The world today is critically aware of the need to conserve the environment for the future generations and as a result we are embracing sustainable design. We design products and systems that serve their purpose without endangering further the environment or human life. Good products are those that fit seamlessly into the lifestyle of the user; its conception, production and disposal do not cause environmental distress or harm to

human beings; furthermore, they are appealing to the user and those who see and feel them.

Products for the disabled requires the designer to understand the nature of disability. Furthermore, they have to engage in extensive work with many persons and involve the disabled in the design process. As seen in the APDK product design, the orthopaedic and the engineer are very important to the process. The main drive in the design process is to help the disabled persons to achieve optimal functioning (Bolanle and Ajokpaniovo, 2009). However, it can be said that the products can be improved with involvement of a designer. The orthopaedic and engineer are not trained adequately to make the products achieve optimal functioning and pleasure for the disabled users. This is where the designer would be most useful, because the designer has the knowledge to unearth the user needs and streamline them into the functioning needs.

5. TRAINING FOR THE DESIGN OF PRODUCTS FOR THE DISABLED

The successful design of products for disabled persons needs action and inputs such as increased sensitization of students and staff, a curriculum intervention and the involvement of other stakeholders such as agencies for the disabled, engineers and certain experts. For example, the development of training manuals into Braille require the team to rely heavily on sign language experts and computer software engineers.

5.1 *Student research and projects*

The academia engage research and product innovation constantly. And design students are well placed to develop products for the disabled that are more affordable, better looking and more customized. In their final year of study, design students of the University of Nairobi, undertake a project that is based on research into the design needs of organizations, communities or individuals. A peek into a random selection of 104 out of a possible 200 projects shows that there are a few projects that address the disabled persons. whereas, most projects dwell on African aesthetic (33%), Universal design stands at almost ten percent (10%). Other project themes are

environmental design at twenty three (23%); Visual aids and education are at twenty eight (28%) and others at less than six percent (6%).

From these records, there were 10 projects on Universal design theme that tackled some form of disability. Ranging from educational institutions such as kindergartens and primary schools for the visually impaired to interior design of homes for the aged persons. Over the six year period, most of the work on Universal design started after 2009. From this it can be said that there is a marked increase in the number of students (from 0 in 2007 to 10 in 2012) undertaking projects for the disabled.

Most of the projects undertaken for the disabled are in the area of interior design. The other specializations such as graphics has had no project, fashion has had one student (examining application of universal design to uniforms for the Kenya team to the paralympics), product design has also had 1 student (examining the design of toys for children with visual impairment).

It can be concluded therefore that there is some movement towards attempting projects for the disabled persons. However, the effort can be accelerated and expanded considerably. For example, in collaboration with institutions such as APDK and Bombolulu, student projects can be increased even during earlier years of study. This would act to sensitize the students and identify the opportunities earlier in the courses.

5.2 The APDK product design

The APDK is the largest manufacturer of assistive devices and products for disabled persons within the East Africa region. Their mission is "To enable people with disability to overcome their physical limitations and empower them socially and economically to become self reliant and fully integrated members of their communities." In the product category APDK supplies wheelchairs, special seats, trikes, walking and standing aids, exercise equipment orthopaedic products and materials. Many of these products are imported mostly as donations while some are manufactured locally.

In the wheelchairs that are manufactured by APDK, the features (size, form and anthropometrics) are originated from the orthopaedics who take measurements and ergonomic sizes from the patients and present them to the engineers. The result are basic functional items such as the wheelchair (see Figure 2).

Figure 34: A typical wheelchair
Source: The APDK workshop, 2014



The assembly of the seat is undertaken in the workshops with the engineer instructing the welders and technicians. The materials used are locally sourced such as mild steel and paint. The mild steel is used on walking sticks as well because it is stronger than aluminium. Motorized wheelchairs are not produced at APDK although special adjustments can be undertaken on request. This has seen the development of the *Salama* seat that is adjustable and the *Tumaini* seat that is for people with cerebral palsy (see Figure 3). The adjustments are very few and rare maybe because of cost implications.

Figure 35: Tumaini seat for children with autism

Source: The APDK, 2014



Figure 36: Club foot cast

Source: The APDK, 2014



Another example in product design is the Club foot (also called talipes equinovarus) that refers to a range of unusual positions of the foot. These include the foot (especially the heel) being smaller than normal; the foot pointed downwards and in extreme cases, the bottom of the foot pointing up. It may be noted that with early intervention in children, most clubfoot persons can lead a normal life. The intervention includes design and development of a cast (shaped to the clients size) made from melted polypropylene and cushioned (see Figure 4). It is held in place with belts and padding (APDK, 2014). The design and production is undertaken by the technicians with information from the orthopaedic.

There are other assistive devices available for the disabled. For the visually impaired there are available talking books, talking computers, closed circuit televisions (CCTV), Perkins Brailier and large print books. Machakos Technical Institute for the Blind started in 1958, for example, offers training in knitting, leatherwork, building construction, entrepreneurship communication,

Shiatsu (Japanese massage) and computer skills as can be seen in Figure 5 among others. It is the only one of its kind in the east and central region and attracts students from outside Kenya. World re-knowned long distance runner, Henry Wanyoike (Figure 6) is an alumni of the institution. After orientation, the students are taught mobility and Braille literacy which allows them to be self sufficient within the institution. Ochokoo (2010), a final year interior design student, studied the need for proper design of their facilities with a view to make the lives of the blind students as suitable and efficient as possible. The significance of this project was that approximately 518,000 Kenyans are blind according to the Kenya National Survey for Persons with Disabilities (2007) census. Among the assistive devices that Ochokoo (2010) examined were new technology platforms that help the blind to access the same information and services as the sighted including software that allows computer text to be converted to audio files and vice versa; the white cane with a red tip that is internationally recognized symbol of blindness; reading devices such as large print and Braille

Figure 37: Blind students undergoing computer training
Source: www.google.com. 2014



Figure 38: Henry Wanyoike, world re-known long distance runner
Source: www.google.com. 2014



While making recommendations Ochokoo (2010) applied Universal design principles and focussed on the safety of the students especially as most equipment in the workshops used electricity; the furniture arrangement; the lighting systems and landscape in order to boost the morale of the students.

Looking at the cases above, it can be seen that design can intervene to make the products more accessible, comfortable and user friendly. For example, the wheelchair in Figure 2, through design innovation, maybe the cost of customization can be reduced significantly; maybe there are other materials that can be used in production; maybe some parts of the wheelchair can be made adjustable to enhance comfort.

In the case of Machakos Technical Institute, projects by students like Ochokoo, can be used to explore ways of implementing them. More research and evaluation of the whole interior and exterior spaces needs to be undertaken to make them safer for the blind and to make it easier for the blind students to manoeuvre their way with ease.

Content and software development is another area where designers could be involved in to create more audio visual material specific for the visually impaired. The need for content development also spurs the need for training of designers. Considering the varied types of disabilities and the varied

extent of those disabilities, it can open big frontier for design training and research.

6. CHALLENGES OF PRODUCT DEVELOPMENT FOR THE DISABLED PERSONS

From the research, it was established that some of the challenges experienced in developing products for the disabled are weak institutional and legal framework, low level of public awareness, incompetent persons and cost implications (Kyeti, 2014).

6.1. Weak institutional and legal framework

In Kenya, there are many pieces of legislation domiciled in different ministries and implemented to various degrees within the counties. The National Environmental Management Authority (NEMA) is mandated to oversee and licence all developments that impact on the environment. It's ability to effectively address this has not been established. Public awareness on issues to do with inclusive design is extremely low. The county governments have many incompetent persons providing services that they are ill prepared to provide. The critical persons who can ensure the planning and implementation of inclusive design are lacking either because of lack of finance (to pay them), lack of qualified personnel, inability to retain the high calibre of staff and general laxity of the public (Kyeti, 2014). The institutions implementing the laws on streamlining of disabled persons should be more active. They should promote their activities and communicate more to the public. More funding should be allocated for these activities.

6.2. Cost implications

Cost implications is probably the single most important factor that hinders development of inclusive environments. Lifts, washrooms fittings, interior fitting in houses and offices are all disproportionately expensive (Kyeti, 2014). These facilities and features can cost more than four times the cost of the ordinary or "normal" fittings. This means that it will take more than will power to create all-inclusive environments for our disabled community.

Most of these are sourced by donors and non-governmental organizations. There is a problem with access to these devices mainly due to the cost and local in-availability (Kyeti, 2009). If these agencies rely on importation, then the government can reduce the tax on the products for the disabled, or provide other incentives for those who are importing them so that they are locally available. Once that is done, the government can go further to subsidize the cost of these products so that more people can access them. Part of funding set aside for the streamlining of the disabled persons should be used for this purpose.

6.3. *Research and collaborative capacity*

Developing products for the disabled is a highly collaborative activity and involves various stakeholders. The designer has to work with the disabled person, involve the sociologist, the engineer, architect, marketer and manufacturer. Often it is difficult to constitute such a team and work effectively together. Much of design research that can be turned into new products are not developed because of the loose linkages among the stakeholders.

If they stakeholders worked closer together then they could develop products that are more customized, appealing and accessible to the disabled. designers can undertake design research to identify materials, designs and products that are cost effective.

6.4. *Inclusive design curriculum*

The WHO report (2011) has categorised the community and identified the roles they can play for the development of the disabled. For academicians, it is stated that they should remove barriers to the recruitment and participation of students and staff with disabilities; ensure that professional training courses include adequate information about disability, based on human rights principles; and conduct research on the lives of persons with disabilities and on disabling barriers, in consultation with disabled people's organizations. Many of these are challenges to design institutions much more than other disciplines because apart from undertaking research, they can go further to develop products, services and environments.

It is encouraging to see that students are moving towards research in Universal design and much more needs to be done to continue into this and other new frontiers of design research. Design for the disabled should be the automatic choice for students project research. And stakeholders should be invited to assist in the prototyping, testing and commercialization of these products. again, funding and incentives for this activity can come from government and donors and other sources.

More disabled students need to enrol for design studies. Again, there is need for research to establish the impediments to joining design schools. These research results should be used to create awareness, encourage and ensure that the number of disabled students in design schools is increased. From observation, it cannot be said that the disabled cannot undertake design studies or training. This is because there are blind and partially blind persons engaged in jewelry and leather production; there are disabled persons for example, using crutches and walking aids engaged in product design and development (Bombolulu Workshops and Cultural Centre), and there are many others in the informal sector making their livelihood from design related activities. If the disabled do not qualify to join university, special training programmes may need to be developed for them so that they are recognized and appreciated.

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INTERNET OF HOPE: PERCEPTIONS OF INTERNET IN MARGINALISED COMMUNITIES OF THE CAPE OF GOOD HOPE

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ABSTRACT:

Khayelitsha and Mitchell's Plain (K&MP) are amongst the poorest communities in Cape Town – South Africa. These communities are plagued with social ills (poverty, crime, abuses, maladies, etc.). In addition, both these communities have very low levels of Internet penetration, with access driven mainly through public access points. Given the impetus of both national and regional policy to promote information society goals, the local government of the city of Cape Town is contemplating taking affordable internet access to these communities. This paper describes the preparedness of K&MP to adopt and use the Internet.

Qualitative data was gathered in order to read a prediction of Intention to adopt and use Internet on the basis of three conceptual elements: experience of accessing and using computers and the Internet, the perceived usefulness of Internet, and the hope of betterment as a result of using Internet.

The key findings suggested that despite not being sufficiently exposed to computers and the Internet, K&MP residents are keen to adopt and use the Internet at home mainly on the basis of their perceived usefulness and the Hope they have for the future. These findings have theoretical and practical significance as they suggest a broadening of the scope of technology adoption research to also consider "Hope" as a precursor of intention to use the internet; and as they inform policy making about the change in mentality towards ICTs despite an inadequate prior exposure to the Internet.

Keywords and phrases: Digital Inclusion, Internet preparedness, Technology Acceptance Model 2 (TAM2); S&CI; ICT4D

INTRODUCTION

Khayelitsha and Mitchell's Plain (K&MP) are underprivileged communities in Cape Town – South Africa. They are plagued with poverty, illiteracy, unemployment, crime, substance abuses and maladies: arguably the legacy of apartheid (De Swardt et al., 2005; Ndegwa et al., 2007). In addition, these communities have very low levels of Internet penetration, with access driven mainly through public access points; usually libraries or cybercafés (Chigona et al., 2008).

The city of Cape Town has invested in ICTs and the Internet with the acquisition of a world-class ERP system; the development of an important Internet presence with its website (<http://www.capetown.gov.za>) and its accounts on various social networks; its complaint notification system (C3 system); the “SmartCape initiative” which puts PCs in libraries throughout the city; and the implementation of its broadband initiatives including the construction of a city wide optical fibre network (City of Cape Town, 2010; Odendaal, 2011). All that investment contributes into the national requirement for universal service and access stipulated in the Electronic Communication and transaction Act (Republic of South Africa, 2002). However, Khayelitsha and Mitchell's Plain are still poorly included into the Internet grid of the city; and it is not clear whether the introduction of the Internet would improve the lives of residents of these communities (Chigona et al., 2008).

Some authors argue that a better access to Internet would do little for digital and social inclusion (Chigona et al., 2008); while others have seen in ICT and the Internet opportunities for leapfrogging development and inclusion (Steinmueller, 2001). Thus in the specific case reported in this paper, the problem stems from a lack of knowledge about the preparedness of Khayelitsha and Mitchell's Plain residents to take up and make use of the Internet if it were brought to their homes.

The study ascribes to inquiries into the preparedness of previously underprivileged communities towards an inclusion into the information society sought by the republic of South Africa.

COMMUNITY PREPARATION FOR ADOPTION AND USE OF INTERNET

There are many ways of framing the process of making a technological innovation part of one's life. It has been done following models of technology diffusion (Rogers, 2003), models of technology translation (Callon, 1991; Latour, 2005), or models of technology appropriation (DeSanctis & Poole, 1994) (for the most visible ones). For analytical purpose and in order to emphasize a particular role for concepts to be used, this paper follows the model of technology diffusion and reduces it to a linear process which comprehends precursors, followed by perceptions, then attitudes and finally behaviours.

Much research has been dedicated to the process of adoption and use of ICTs, thus of the Internet; mainly interrogating perceptions and attitudes to predict behaviour (Davis, 1989; Venkatesh et al., 2003; Benbasat & Barki, 2007). However, questions raised by practical issues in implementing ICT projects in developing countries (Heeks, 2008; Heeks, 2010; Heeks, 2014) pointed at determining the inhibiting and enabling elements (Centefelli, 2004) of a community everyday life which influence perceptions and attitudes, and which could be leveraged in preparation of adoption of the Internet (In this case).

Internet as an enabler: Social informatics, Community Informatics and ICT4D

A social context that is exposed to a technological innovation is expected to be transformed in some extents. That change is investigated by social informatics (Kling, 1999).

In addition, the notion of Community Informatics understood as a discipline that connects economic and social development efforts with opportunities enabled by the use of technology (Gurstein, 2000) is introduced to emphasise the potential of technology for breaking through cultures, distances, religions, geographical boundaries, social bias and other differences, and focuses on the community as a nucleus that can be considered in support of the individuals living in it.

Social informatics and community informatics acknowledge the transformative effect of ICTs on individuals and on the communities in which they live; suggesting that the Internet could be conceptualised as an enabler or an empowering elements for underprivileged individuals and communities.

That belief of ICTs and the Internet in particular providing developmental positive impact as a “*digital provide*” (Jensen, 2007) is also present in the field of ICT for Development (ICT4D) (Heeks, 2010).

The Internet is understood in this study as an enabler of social positive change.

Precursor to the intention to use the Internet: TAM based research

In order to use ICTs and the Internet for a purpose, Davis (1989) argues that the individual would accept and adopt them following a path framed by his Technology Acceptance Model (TAM). TAM is based on the Theory of Reasoned Action (Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980) and is constructed around the beliefs of perceived ease of use and perceived usefulness of a technology. Venkatesh & Davis (2000) extended the model by introducing psychological determinants including control, intrinsic motivation and emotions with the perspective of adjusting and anchoring the two TAM beliefs. These new determinants gave to TAM the ability to explain the behaviours resulting from an initial interaction with the technology and more over to predict the result of continuous usage: that was TAM2.

However, the model is expected to indicate whether the technology (Internet in this case) as suggested in innovation diffusion theory (Rogers, 2003) will be accepted or rejected, but does not recommend what will make a system useful or so easy to use as to predict effective intention to use (Legris et al., 2003). Further, TAM studies are heavily criticized for their simplistic characteristics, lack of innovativeness, or their inability to be extended using understandings from other fields of study (Benbasat & Barki, 2007). Nevertheless, they provide a starting point that justifies further research from their flaws.

This study only uses TAM2 in the analysis of the data because the main focus of that framework is to look at precursors of intention to use the Internet.

Precursor to the intention to use the internet: The concept of Hope

Hope is usually seen as hopeless dreaming, never realising and not bearing any rationality. In opposition to that common knowledge, Snyder (1994:5) conceptualised hope as mental will and way power that an individual has towards achieving a specific goal in life. That definition implies a grounding of hope into a main objective, a plan to achieve it and the will to go for it: hope has a rational. Hope is not a perception nor an attitude, but a precursor to these able to supersede them and drive the intention to use technology.

This study adopts such a definition of hope and does not extend into the positive psychology debates around the many instances and manifestations of human resilience (Lemay & Ghazal, 2001).

METHODOLOGY

The study was performed over a period of three month and followed a qualitative approach with residents' focus groups (Kitzinger, 1995; Morgan, 1996). The objective of the study was to ascertain the *preparedness of K&MP residents for adoption of internet services*. Thus each of the focus group sessions which were conducted entailed a group discussion in which three main questions were sequentially posed, viz.

Q1: What challenges do you have accessing computers and the internet?

Q2: How would having the internet at home be helpful to you and your family?

Q3: How would having the internet at home make you hopeful about the future of yourself and that of your family?

It is to mention that these questions were main questions and have seen their meanings negotiated in order to access participant perspectives. The *Internet* was agreed in reference to a sense of e-Commerce and social media

understanding; *Access* referred to availability, to exposure and to the ability to own a device which allows being on the Internet; *Challenges* referred to any impediment to access and use; *Helpful* had to do with the relationship that the Internet had with valued activities; and *Hope* was related to dreams, aspirations and the future as it could be fantasized for themselves and close relatives.

A total of 10 focus group events were conducted with 150 residents of both Khayelitsha and Mitchell's Plain. The events were conducted inside library premises with participants who have had an experience of using such a facility. 2 Groups (1 from Khayelitsha and 1 from Mitchell's Plain) were constituted by students between the age of 16 and 22; then 2 groups (1 from Khayelitsha and 1 from Mitchell's Plain) were constituted with participants older than 50 years of age; and the remaining sample consisted of residents between 23 and 50 years of age (3 groups per community). All responses were captured using qualitative analysis software called QCA or qualitative content analyser (Bytheway, 2013). Qualitative content analysis was performed on the focus groups' transcripts (Zhang & Wildemuth, 2008).

The data was coded into an initial set of 74 categories, and the development of core themes expressed in 3 main categories:

- ***Internet inaccessibility*** (Lack of computers in the community, Internet cost, poor Internet service, lack of e-Skills, lack of money and personal issues);
- ***Internet usefulness*** (Internet helpfulness, Knowledge, education, job opportunities, social networking, safety, and personal issues) and
- ***Hope*** (Hope for personal and familial future, business opportunities, and life style improvement)

FINDINGS AND DISCUSSIONS: THE INTERNET DRIVEN HOPE OF K&MP RESIDENTS

A reading of TAM2 suggests that the expectation of achieving goals including education, social networking, entertainment, safety, employment and

entrepreneurship is at the root of the intention of using the Internet. In addition, respondents showed willingness to achieve these goals and suggested the internet as a conditional element in achieving them.

“Hope” for the future has appeared as a major precursor of adoption and use of Internet at K&MP (See figure 1). This idea of hope seems to fuel the perception of the usefulness of the Internet, strongly enough to imply intention to use; with disregard as to whether the technology will be easy to use or not.

Finding 1: K&MP residents have expressed a strong sense of inaccessibility when it comes to Internet as suggest these extracts:

“Lack of computers in our community and schools”; “We don’t have computers at home”

“Internet café are expensive and we don’t work”; “It’s expensive”; “Can’t afford Internet services”.

“Lack of assistance”; “I don’t know anything about computers”

This finding is expected to be a deterrent to the adoption of the Internet since it is expected to deteriorate the perception of the ease of using the Internet. However, on the contrary it seems to have become a motivation for adopting the Internet if it were to reach homes. Everything that was hoped for could now be accessible.

Finding 2: K&MP residents pointed at many beneficial use of Internet, perceiving it as helpful and able to be related to the achievement of life betterment:

“Transfer money (save / avoid bank deductions)”; “Apply online”; “Google jobs”; “Selling items on Internet”; “Create business plan”; “Work at home”

“To learn more skills”; “Get registered at schools, colleges and universities early”;

“Being able to stay connected with families from other provinces (e.g.: doing traditional meeting)”; “Internet dating”; “Research on family trees”;

“It would be safer for kids”; “Keep kids off the streets”; “Keep them from gangs”

“Access to game, news and entertainment”; “To download videos”; “To download music”

This finding fits in the TAM2 framework as it expresses K&MP community members' perception of the usefulness of the Internet, and suggests a high level of intention to use the Internet. It allow to believe that they already have knowledge of what the Internet can be used for and they have witnessed, have experienced or have been persuaded of the benefits of having a stable and reliable access to it.

Finding 3: K&MP residents expressed “hope” for themselves and their families which they could derive from using Internet.

“Improve family literacy Skill”; “Better education for your children”; “Hoping the employment rate will rise”;

“Get business opportunities”; “Get funding to start your own business”

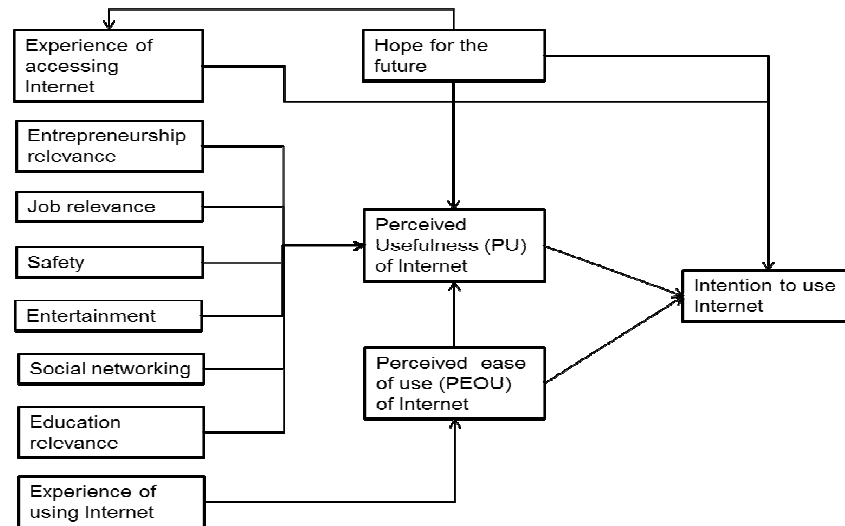
“Help you live life better (Improve life style)”; “Change life style. Kids would have options at hand to choose a career”

This finding identifies “Hope” as the fuel for K&MP community members' intention to use the Internet. It seems to be the most important element, even more important than the usefulness of the Internet in predicting their intention to use.

These findings are not so novel in the realms of ICT4D or Community Informatics, but they suggest a change of mentality linked to prior exposure to the Internet at K&MP, and they open up interrogations about the underlying *realities* in the process of adoption and use of Internet, when a most important precursor (Hope) can be constructed around specific objectives (employment, entrepreneurship, social connectedness, etc.), attainable via a certain acknowledged routes and the eagerness to achieve that despite the hardships of their current situation. Hope in this setting fuels the perception of Internet Usefulness and also seems to derive from an understanding of the Internet as

an enabler of needed capabilities (e.g.: opportunities, skills, entertainment, etc.) for a better live.

Figure 1: TAM2 and Hope in K&MP (source: Authors)



CONCLUSION

The paper was a description of the preparation of K&MP to adopt and use the Internet if it were to be brought to residents' homes. The main contribution here is an acknowledgement of a change in mentality within K&MP regarding the Internet, to the extent of associating Usefulness and Hope to it.

K&MP residents engaged in the focus groups welcomed the idea of having an affordable access to the Internet:

- They considered Internet very much presently inaccessible to them
- They pointed at many beneficial use of Internet, perceiving it as helpful, thus useful.
- They suggested “hope” for themselves and their families which they could derive from using Internet.

In these impoverished communities the Internet is seen as a symbol of hope. It is therefore critically important that:

- Any deployment of Internet into communities takes places in parallel with social and economic development programs which are able to harness the many benefits of the internet;
- e-Skills program be available to those whom demand it. Government may have to play a role in subsidising such skills programs.
- The development of a marketing and awareness campaign will be essential.

This study identifies “hope” as an important precursor to the intention to use the Internet in developing countries. It requires further research to look at the reality of Hope driven Internet adoption and use in developing countries.

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UNDERSTANDING GROUP WORK IN HIGHER EDUCATION: ESTABLISHING A CULTURE OF DELIBERATION AMONGST DESIGN STUDENTS

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ABSTRACT

This paper explores the perceptions of senior Industrial Design students about group work, and documents findings from a workshop with students to frame the issue. The goal of Higher Education is to provide students with the simple and complex skills and knowledge required for their future professions, as well as active citizenry. Some skills required of a professional Industrial Designer include the ability to frame issues, explore creative and contextually relevant solutions, and critically assess possibilities and potential solutions. Some designers focus on participatory practices that include users and communities within the process. The influence and importance of involving user and community members in the process cannot be overstated, as noted by Heskett (2002:4) "While the influence of context and circumstances may be considerable, the human factor is present in decisions taken at all levels in design practice". Students themselves represent a community, a community of practice. One benefit of developing a community of practice within the educational design studio is that students progress from simply engaging with knowledge to actively taking part in the creation and use of knowledge. This complete immersion within a selected field encourages full participation in the community and helps the students develop their own voice. Democratic practices can give students a stronger hand in shaping their future. These practices can promote

democratic values and stimulate the learning (Mathews, 2014:119) that allows students to combat many of their own problems. Deliberative dialogues can help students unpack a shared issue, viewing the class as a community. The aim is for them to become active learners who can apply processes of problem framing and decision making within the classroom, around their own issues, and externally in community engagement projects they work on.

In design education, focus is placed on collaborative projects and group work scenarios to facilitate and develop students' interpersonal and communication skills, including active listening and democratic decision-making. These skills are key in enabling empathetic and active participation between designer and community members (or users). The goal of this case study was two-fold; firstly to develop student issue-framing skills for application in community based projects, and secondly to identify and explore group work issues within the student community. Findings from the workshop informed the creation of an Issue Framework which can be used as the impetus for further research into the impact of democratic practices and deliberative dialogues in design education.

Keywords: *Deliberate dialogues, design, issue framing, design education, group work, active citizenry*

INTRODUCTION

The International Council of Societies of Industrial Design (ICSID) describes design as follows: "...a creative activity whose aim is to establish the multi-faceted qualities of objects, processes, services and their systems in whole life cycles. Therefore, design is the central factor of innovative humanisation of technologies and the crucial factor of cultural and economic exchange" (ICSID, 2008). Industrial Design is a field that explores and develops possibilities, often in the form of a product, to specific client requirements. The process of design is grounded in collaboration: between designers, users, manufactures and other professionals. The Industrial Design course, offered at the Cape Peninsula University of Technology (CPUT), aims to prepare students for the diverse range of skills and knowledge required of an entry-level Industrial Designer. These include theoretical and research skills as well as knowledge and skills relating to practical activities, including: participatory user research activities to establish requirements, product conceptualisation,

technical specifications, rendered images and physical or virtual 3D-models, to name a few. Key to the success of a project is the ability of the Industrial Designer to collaborate with others - to discuss key needs with potential users, facilitate sessions to develop the design brief and work closely with others to realise the design. The focus on collaborative practices, or group work, can be traced back to the origin of formalised design education. The Bauhaus school, viewed by many as the origin of formalised design education, was based in collaborative master-apprentice learning systems. Group work allows for an array of viewpoints, solutions and interpretations, which supersedes and expands an individual student's perceptions and abilities. It is this characteristic that makes the design studio a place of collaboration. Studies² during the early part of the 21st century highlighted the lack of research exploring student perceptions (often negative) of group projects and learning.

This paper outlines a workshop in which deliberative dialogue was introduced to BTech design (Bachelor equivalent) students as a tool to explore their experiences and perceptions of group work, and frame their issues and responses to it.

DELIBERATIVE DIALOGUES AS A CATALYST FOR DEMOCRATIC RESOLVE

Resolution of issues that may arise in the classroom is vital for the continuation of productive learning. One area of contention highlighted, and the focus of this paper, is group work. Not the act of working together specifically, but rather the problems that may undermine productive group dynamics. Deliberative dialogues are useful for framing the problems-behind-the-problems, fundamental and systemic problems that contribute to more obvious ones (Mathews, 2014:xvii), in this case, the issue of group work.

Students might often bargain or try to negotiate with one another but, as Gutmann and Thomson (2004) suggest, this only facilitates individuals getting

² Payne and Monk-Turner, 2006; Kolb *et al.*, 2005; Colbeck *et al.*, 2000;

what *they* want. They suggest however that when deliberation takes place, “[students] can expand their knowledge, including both their self-understanding and their collective understanding of what will best serve their fellow citizens” (Gutmann & Thomson, 2004:12). The classroom of today can be a pluralistic place, with students coming from many different backgrounds and having a diverse range of beliefs. The studio community in higher design education is, initially, a community of interest, with the field of study bringing this group together. Here, students exchange ideas and thoughts about design and its systemic themes, but may know, or indeed care, little about each other outside of their course. Group work is important for bringing students together within certain modules and around emergent themes in their studies; and in design education, around students collectively developing possible solutions to issues that arise in relation to these themes. Another aim of group work is to move from a community of *interest* to a community of *practice*, where students share information and experiences with the class, collectively learning from each other and building a positive learning environment. However, due to class diversity, polarisation and disagreement can take place. Deliberation is proving to be a well adapted form of dialogue for reaching democratic resolve amongst a diverse class.

Deliberative dialogues can facilitate the collective formation, by students, of common issues they might face. In student-centered learning it is important not only to acknowledge student interests and issues as important, but to also equip them with the skills they need to bring their issues to light. Lecturers need to continually ask if their students have the knowledge and resources to frame and tackle issues that might arise. Marshall Ganz states three necessary narratives as imperative in bringing people together to work on issues of common concern, these are: the story of *self* (individual viewpoints and narratives), the story of *us* (shared perspectives of the group), and the story of *now* (issues and choices the group must make to move forward) (Ganz, 2011:282). Similarly, deliberation can provide a platform for a community, in this case the students, to progress through these phases and frame the issues at hand. It generally does so by identifying individual concerns with an issue, which can then be grouped. This gives all members a

voice and begins to form a co-defined issue framework; collective identification of possible actions related to working through these issues, and; identification of trade-offs or downsides the group might have to accept and work through.

By deliberating together, students can identify issues they face in the classroom and define options for resolve, unpack possible trade-offs, and collectively make decisions on how to move forward. Through this practice, students learn about, and from, others' views of an issue. This collective learning is very important in facilitating understanding and solidarity amongst students, and promotes reflective practice. Donald Schön (1983) defines reflective practice as "*the capacity to reflect on action so as to engage in a process of continuous learning*". Developing design students as reflective practitioners is important as designers are increasingly dealing with complex, large scale issues termed 'wicked problems' (Rittel & Webber, 1973: 155). It is necessary to tackle these problems across disciplines and with the affected citizens. Deliberation and group work are thus increasingly important skillsets students need when entering the workplace.

Schön emphasises the fact that problems of real-world practice do not present themselves as well-formed [obvious] structures, often not even as defined problems, but rather messy, indeterminate situations. When confronted by these indeterminate zones of practice, Schön describes our general knowing-in-action (tacit knowledge) responses as hindering problem solving - as novel problems cannot necessarily be solved with existing knowledge, that is, tacit knowledge alone. Instead, he proposes approaching uncertainty through reflection. The development of new knowledge happens best in a group, when a community identifies and critically reflects on an issue, learning from one another and collectively formalising actions.

GROUP WORK IN DESIGN HIGHER EDUCATION.

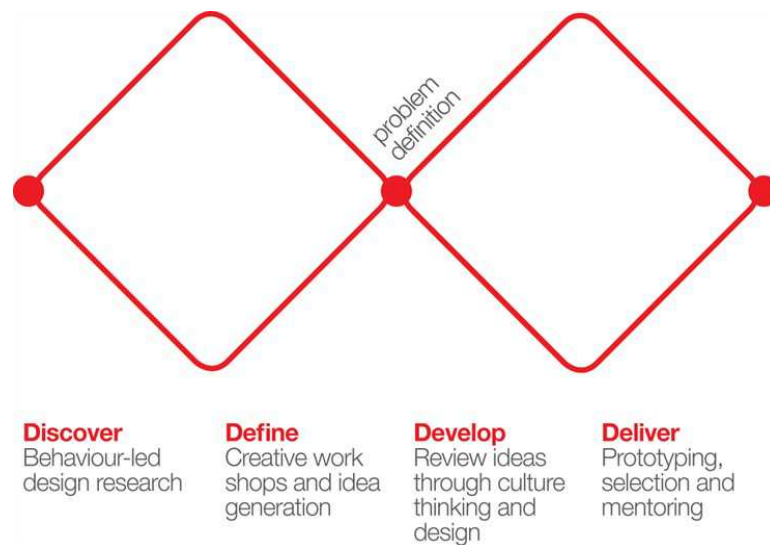
The ability to analyse a situation and make appropriate decisions, within predetermined boundaries, describes the underlying foundation of all design activities. Unlike many other disciplines, which are taught in a traditional large

group lecturing style, design is taught in a collaborative design studio. The studio is a space of sharing, exploring, stumbling, reflecting and learning. It is the learning environment which best reflects the way in which design professionals work, and can thus offer particular kinds of learning experiences that are essential for developing a professional approach: “Like other types of pedagogies, design studio pedagogy conveys, conserves, and transmits the values of design professions and society at large” (Salama & Wilkinson, 2007:3). The design studio embodies the first institutionalised Problem Based Learning (PBL) approach pioneered by Bannister (1954)³.

Design education is characterised by studio based education, as well as an unique teaching process: formal and informal engagements between students and lecturers, and students as a group create an environmental of practice, learning experiences and reflection on actions (design). The entire design education process reflects cycles of engagement, action and responsive adjustments. There are many different models explaining the process of design, as it relates to design education but broadly one can refer to the following phases: 1) *Context and Calculation*, 2) *Creative Exploration*, 3) *Selection & Production* and 4) *Reflection, Adaption and Reflection*. The Design Council developed the ‘Double Diamond’ model to illustrate these four phases: *Discover, Define, Develop and Deliver*.

³ Later examples explored by John Dewey, Donald Schon and others (Kuhn 2001; Shaffer 2004).

Figure 1: The 'Double Diamond' design process model⁴



The Design Council (2013) describes the four phases as follows:

- *Discover*: “The start of a project is a period of discovery, gathering inspiration and insights, identifying user needs and developing initial ideas.”
- *Define*: “The second quarter represents the definition phase, in which designers try to make sense of all the possibilities identified in the Discover phase.”
- *Develop*: “The third quarter marks a period of development where solutions are created, prototyped, tested and iterated. This process of trial and error helps designers to improve and refine their ideas.”
- *Deliver*: “The final quarter of the double diamond model is the Deliver phase, where the resulting product or service is finalised and launched. The key activities and objectives during this stage are: final testing, approval and launch, targets, evaluation and feedback loops.”

During the first phase, *Discover*, the design problem is explored thorough investigation of the topic. Following this investigation, a design brief is defined and created. These steps form the first of the two process diamonds.

⁴ Image from: David Galbraith, 2014 (<http://davidgalbraith.org/what-i-do/>)

Collaboration and group activities during this phase are often linked to a designer exploring the problem and context with various users in participatory scenarios. Collaboration is also required to identify required professionals needed to work on the project. Within the educational design studio these professional collaborative activities are facilitated through group activities and social research tasks, including workshops with users, ethnographic studies and user testing sessions.

The second diamond refers to the prototyping, production, implementation and final validation of the proposed design solution or intervention. In terms of learning theory, this phase of the model corresponds to the social learning and constructivist learning theories in that the learner decides which information and past experiences are relevant to understanding new knowledge by testing it in a group setting (Johnson and Johnson, 2004). In social constructivist theory, dialogue and interaction internalises learning (De Witt, Siraj and Alias, 2014: 91). Collaborative activities during this phase of the product design process include: group brainstorming, design conceptualisation, group critique, liaising with professionals to fabricate solutions, end user validation etc.

Reflection is an important part of the design process both during and after the project. Once a design is finalised, Schön (1987) encourages *reflection-on-action*, during which the process is evaluated as a whole and information on how to improve future projects is collected. The final review of the project may appear to fall beyond the scope of the Double Diamond model, however it is key step, which may result in new findings and adaptations as part of the iterative process. Bosworth (1994) identified five key skills learners need to effectively collaborate: interpersonal skills; group management skills; inquiry skills; conflict resolution skills; synthesis and presentation skills. These skills are developed throughout the design process, through a range of activities and interactions from the discovery phase to reflecting on the final design solution, as a design professional or as a design student.

The role of a designer in today's world is more varied, with many designers choosing to work on projects in which they use their skills to address social

and environmental challenges. The Design Council explored the evolving roles of designers, through the *Design of the Times* (Dott07) project, and found that designers work as: Co-creators, communicators, strategists, capability builders, entrepreneurs, researchers and facilitators (Tan, 2014). These new roles expand the field of design and further accentuate the need for interpersonal and collaboration skills. Roles like ‘co-creator’ and ‘facilitator’ require empathic interaction with communities within a group context. The challenge within design education is simulating these complex interactions, which have become key to the design profession.

Figure 2: Examples of the 2014 5K products⁵



At fourth year level, students in the Industrial Design programme at the Cape Peninsula University of Technology take part in a real-world project referred to as the *5K Project*. The goal of the project is to simulate a real-world environment and asks students to research, design, produce, market and sell

⁵ The 5K project requires students to develop products through concept, into production and manufacturing.

their product to generate profit. The project requires students to work in groups. Other collaborative activities include research activities with users; workshops, co-design sessions and user focus groups. Students are also required to approach students or professionals from other disciplines, if needed, to aid them in the development of graphic materials and branding strategies. The multidisciplinary interaction, the community/user collaboration, and the co-creation activities that characterise the project mirror the experiences they will have as professionals.

THE WORKSHOP: ENHANCED PARTICIPATION THROUGH DELIBERATIVE DIALOGUES

The Issues Framework (explored in a later section) and data presented in this paper reflect findings from a workshop with senior Industrial Design students. There were 17 student participants and 3 neutral facilitators at the workshop. The participants of the workshop, although from the same generation, represent a diverse group in respect of gender, race and age.

To establish the perspective of students concerning group work, the fourth-year Industrial Design group completed a questionnaire at the beginning of the workshop. Further data was generated through qualitative observation and reflective, post-session questionnaires. The goals of the workshop were to a) establish student views and attitudes concerning group work, b) to introduce students to deliberative dialogues as a collaborative technique to strategically work through a problem and come to a group consensus regarding possible solutions, and c) to establish whether students found this technique beneficial.

The student group had been involved in a number of collaborative projects during their undergraduate studies and had just completed the 5K project in groups. The students thus had a historic and recent perspective on group work activities and experiences. Degrees of conflict had also been experienced in most of the 5K groups, and thus the theme of *group work* was relevant for exploration in the workshop.

Figure 3: Student collaboration during the workshop session.

A shared characteristic is that all students are from the Millennial generation (also known as Generation Y⁶). Individual work traits of this generation include the demand for public praise, the need for immediate response, a very confident view of their own abilities, and high expectations of future employers (Ninemeier and Hayes, 2009:413). Work style traits of this generation are often described as highly collaborative (favouring team work activities) and as being good communicators via mediated channels such as e-mail, social media and via text messages (Gibson, 2013). While this is true, and the rise of social networks has seen relationships flourish online, this generation could also be described as digitally connected but emotionally *disconnected*. Their digital relationships could be described as artificial and shallow. The relative safety and distance created by online technologies and platforms have allowed the rise of a lack of online manners, responsibility and sensitivity (Black, 2010:96).

The workshop consisted of three sections, detailed in table 1. The role of the facilitators was important; to manage workshop logistics, to introduce the subject and methods of Deliberative Dialogues, to act as neutral parties in asking relevant questions where necessary, to mediate any conflict arising, to act as scribes to ensure the maximum participation and engagement of all group members in discussions, and to reflect upon and accurately record any other observations from the workshop. The perceptions of this group of

⁶ Generation Y refers to individuals born between 1979 – 1994 (Ninemeier, 2009)

students were thus established through their individual contributions (questionnaires), group discussions and facilitator observations.

Table 1: Workshop outline and data description

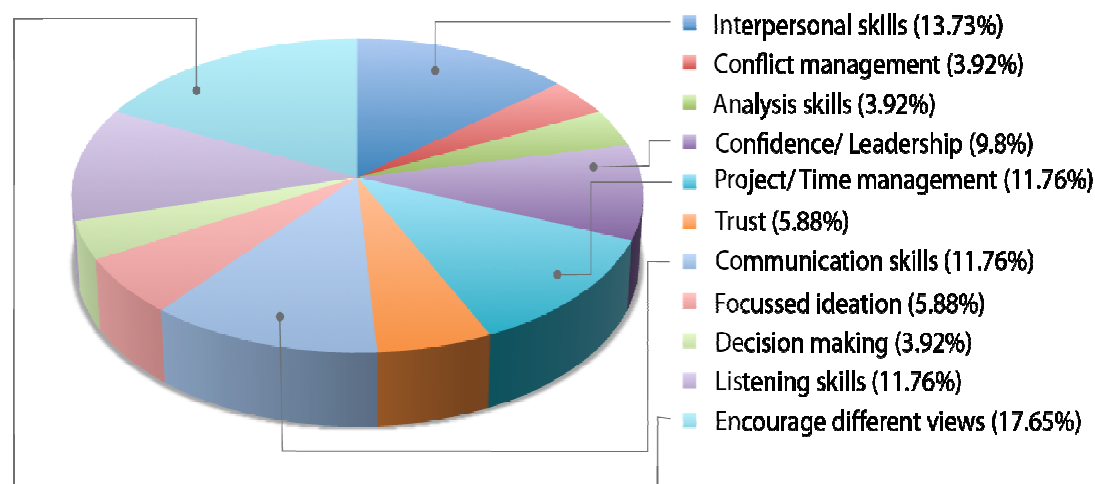
Workshop Session	Goal	Data Type	Data Analysis
Reflective Questionnaire	To explore group experiences in the 5K project as well as other group work projects.	Qualitative answers to questions.	Data was analysed using an inductive approach to identify themes and group experiences. The contributions from participants were completed anonymously, thus data was coded using randomly assigned numbers.
Introduction to Deliberative Dialogues and development of Issues Framework	Explore students as a community; explore issues within this community of practice. Introduce democratic practice. Guide students through creation of Issues Framework.	Observations during sessions. Photographs Generated exploration materials (A3 pages) Generated Issues Framework templates.	Key ideas and student comments recoded by objective group facilitators, who also functioned as scribes for the group. Observations grouped into themes.
End Questionnaire	To establish suitability of Deliberative Dialogues as a group decision-making technique.	Qualitative answers to questions.	Data was analysed using an inductive approach to identify themes and group experiences. The contributions from participants were completed anonymously, thus data was coded using randomly assigned numbers.

STUDENT PERCEPTIONS AND RESULTS

The Reflective Questionnaire was completed at the beginning of the workshop in order to explore group experiences in the 5K project as well as other group

work projects. There were 51 responses to the question ‘*What positive skills can group work develop?*’. The most responses (18%) listed *encourage different views* (a variety of perspectives) as a positive skill, with *interpersonal skills* also significant (14%). *Project/ time management*, *listening* and *communication skills* were each considered the next most important proficiencies developed from group work (12% each), with *confidence/ leadership* just less than these (10%).

Figure 4: Clockwise, students’ perceptions of skills developed through group work.



All the respondents (100%) responded positively when asked whether they thought group work was valuable in design higher education, with a further 38% using “definitely” for emphasis. However positive, students are still aware of the potential for conflict. One student (P10) wrote:

“Group work makes learners more prepared for industry conditions and also teaches students how to function within a team to reach a certain goal.... however there is a very real possibility that it could hinder some students in their learning if the group dynamic is turbulent or toxic.”

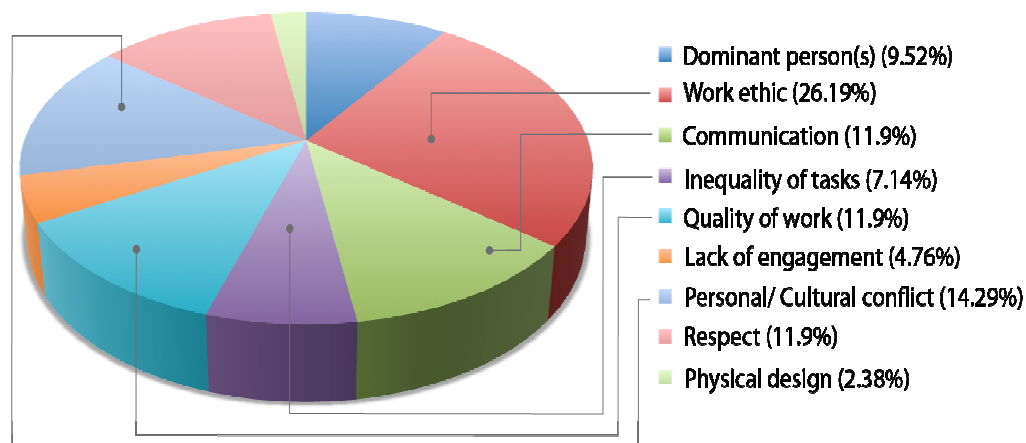
An overwhelming 77% of participants reported having experienced conflict in group work. The primary issue identified as causing conflict was *work ethic* (26%). Student P12 explains, “Everyone should be equally involved and committed in order for it to be fair”. A *personal/ cultural clash* was also a

significant factor in group conflict (14%), and in some cases this related directly to the work, with

“People taking things personally and not being able to separate themselves from their work on a personal level” (student P13).

The issue of *respect* was described separately (12%) as a source of conflict, along with *communication* (12%). The *quality of work* was seen as equally important (also 12%), but ties to the most important factor listed above (work ethic). It would be interesting to observe whether the focus on work was as significant in less academic settings, where there is a notable focus on grades. Only 10% of students listed a *dominant person(s)* as a major cause of conflict.

Figure 5: Clockwise, students' perceptions of causes of conflict during group work.



Despite all these issues of potential conflict, the majority of participants (77%) felt that their opinion was heard in group work situations. However, this does highlight that almost a quarter (23%) of participants felt that they had no voice in a group situation. Given that *encourage different voices* is listed as the most significant potential benefit from group work, it is crucial that all voices are heard. The deliberative method of dialogues aims to create a more democratic group work environment.

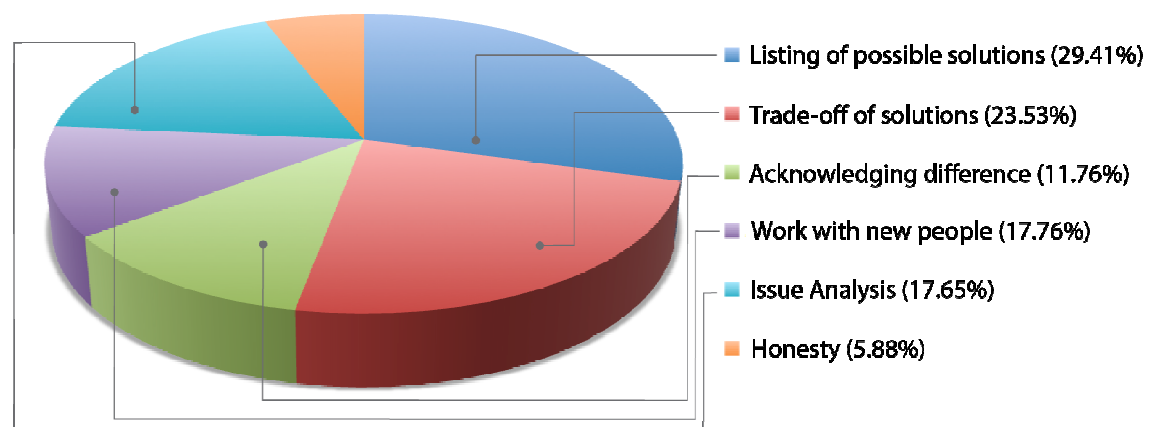
The goal of the end questionnaire was to establish the suitability of Deliberative Dialogues as a group decision-making technique. The majority of students (71%) reported feeling differently about the issue of group work after the workshop:

“...yes, because my level of understanding has deepened by unpacking ‘group work’.” (Student P8)

“Even establishing honesty and trust [was] something that I had not really considered, but now I understand how important it is.” (Student P10)

Nearly 30% of the students described the *listing of possible solutions (diverse opinions)* as the most useful part of the workshop. This links to what 29% of students listed as a positive aspect of group work – the exposure to different views (see figure 6, below). A further 24% named the *discussion of tradeoffs of possible solutions (negative effects)* as most useful, and 18% found the means of *issue analysis* most useful. *Acknowledging difference, working with new people* and *honesty* were also considered valuable aspects of the deliberative dialogues workshop.

Figure 6: Clockwise, most valuable aspects of the workshop as indicated by students

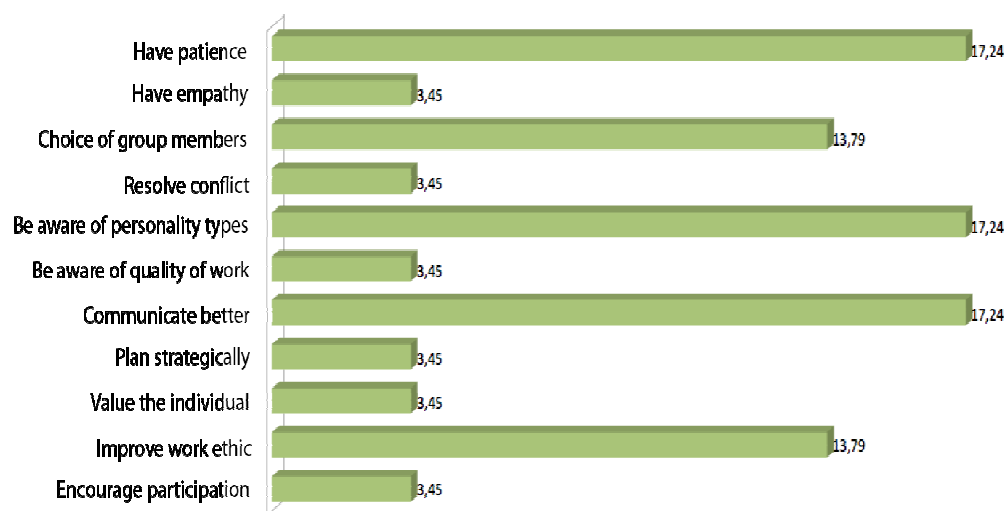


The workshop was a thorough exploration of the topic ‘group work’, with 75% of participants saying they had discussed aspects of group work that they had not previously considered. Student P6 agreed,

"Yes, cultural expectations and ethics were issues I had thought of, but not yet applied to the context of group work."

The potential future value of the deliberative dialogues workshop becomes clear when asking students the question, *"what will you do differently in your class as a result of this session?"*. The potential of changed behaviour is clear in Figure 7 below, but the most significant features are all related to careful and respectful treatment of fellow group members, and encouraging participation by all students. "Discussions may be more ordered/ democratic/ fair", was noted by student P12. Future behaviours could include *being aware of personality types* (17%), *being better at communication* (17%), and *encouraging group participation* (17%). A further 14% said that they would *have more empathy*, and others would consider *the value of each individual* (14%).

Figure 7: "What would I do differently next time?", student responses



The deliberative dialogues method was seen as a valuable tool for reaching group consensus, with possibilities for application in the future, with student P13 stating that, "...this will definitely be a beneficial method of consensus for future decision making". Students described potentially using these dialogues for discussions around *improving campus infrastructure* (27%) and *personal life management* (also 27%), as well as for *student event planning* (20%). Other discussions that could use this method were listed as the *quality of lectures*, *negotiating deadlines*, *improved quality of work* and *career preparation* (all 7%).

The resulting issue framework for group work

An issue framework is a way of “naming problems and framing issues that give citizens a greater ability to chart their future and solve problems” (C.F.Kettering Foundation, 2011:3). The students in this study engaged in a deliberative dialogue, resulting in an issue framework that identified and assessed a common problem they encountered, namely, group work in design education. Students and lecturers alike believe in the effectiveness and need for group work in higher education, however there are often underlying issues that hinder this effectiveness. The issue framework, adapted from the collaboration between the Kettering Foundation and National Issues Forums’ (NIF) guidelines⁷, presents the collated concerns, possible actions and resulting trade-offs related to group work. This issue framework is the summary of student outputs. It must be noted that these issues and options are derived directly from the students’ deliberations about group work.

The issue naming and framing session was opened by facilitators managing a general class discussion around the topic of group work. Students voiced their opinions and discussed the topic in general terms, related to their personal experiences. These student narratives formed the basis for further deliberations. Students were then placed into three groups of between 5 and 7 people, and each allocated a facilitator/scribe. These three groups then (separately) further explored the subject, with all participants stating their concerns with group work. These lists were then grouped according to theme in the individual groups. These collated concerns then formed the basis of the solution/possibility mapping. Here, students proposed possible examples of what might be done to resolve each of the issues listed. This saw initial collaborative problem solving, as students would propose possible solutions to issues raised by other members of the group.

⁷ <http://www.nifi.org/> & <http://kettering.org/periodicals/issue-guides-and-issue-frameworks/>

Figure 8: Students collaborating on creation of the 'Issues Framework'



After offering possible ways forward, students then identified trade-offs for these solutions. After the groups had worked through the issue of group work they presented their findings to the rest of the class. It was noted that even though these students were in the same class, there was definitely some variation in naming and framing of the issue between individual groups. By separating the class into smaller groups, students could delve deeper into the issue than if the entire class were a single group. These parallel naming and framing sessions were necessary in moving through the issue in less time without excluding anybody. They also offered an opportunity for each group to learn from the next.

On completion of the workshop, all the groups' work was collated into a collective issue framework. The three options students saw as ways to improve group work were: 1) *Really* getting to know each other through formal an informal settings; 2) Outlining roles, rules and responsibilities upfront, and; 3) the formation of a supportive environment. These three options could be seen as nested within each other with Option 1 focussing on individual relationships possibly before forming groups, Option 2 focussing on members within a group, and Option 3 focussing on the group as a whole.

Figure 9: Completed ‘Issue Framework’



>> Group Work in Design Education

What Can We Do to Improve Group Work Experiences?

OPTION ONE

Really Get to Know Each Other, through Formal and Informal Settings.

This option embraces students as unique individuals and aims at information sharing and relationship building between potential group members. Groups can breakdown due to too much similarity or difference; this option aims at balancing the personalities and skill sets before embarking on a project.

The drawback to this option is that it might polarize certain students' perceived shortcomings or differences, leading to exclusion of weaker students. Students, if forming their own groups, might only do so with friends and thus enter the workforce unprepared for the complexities of group dynamics.

EXAMPLES OF WHAT MIGHT BE DONE

Students could get together beforehand for an informal debrief with the aim of interacting with and getting to know one another in a relaxed environment. Delay group formation until after event.

Class members could create a personal asset map, with students sharing their possible contributions to a group in terms of skill set, talents, experience and contacts.

Students could share CV's and portfolios for critique by the rest of the class, which could inform task allocation.

Students could have a 'speed-dating' event focused on getting to know aspects of other members not normally discussed in class.

SOME CONSEQUENCES AND TRADE-OFFS TO CONSIDER

This would probably need to happen after hours, limiting availability of students who use public transport.

Could create an informal hierarchy in the class, polarizing students around class and access.

This could have an adverse affect by highlighting weaker students upfront, thus making them 'unemployable' within a group.

Certain beliefs or personal aspects might be highlighted that deter students from wanting to work together. This can shift focus from a common goal to focusing on personal differences.

OPTION TWO

Outline Roles, Rules & Responsibilities

This option relates to members within a group. Students often perceive their role in a group based in their own view of their strengths and weaknesses. These roles and responsibilities can differ from other group members' perceptions, resulting in a tension between actual and perceived roles. Clear outlines can facilitate better collaboration.

A drawback to this much pre-management could inhibit emergent roles based in learning that takes place. Students would need to collectively negotiate group aspects throughout the project.

EXAMPLES OF WHAT MIGHT BE DONE

Establish roles of individual members, with the aim of closing the gap between actual versus perceived roles.

Students could distribute workload based on skills, availability and assets of group members. This would be established up front and negotiated through the project.

Establish rules to facilitate communication, time management, and full participation of members, based on inclusion and equality.

Groups could run themselves as businesses, allowing 'resignations' and 'firing' of members. A code of conduct would need to be established beforehand, outlining warning system and fireable offences.

SOME CONSEQUENCES AND TRADE-OFFS TO CONSIDER

Weaker students are often allocated less important roles, further hindering their learning and contribution to the group. This could perpetuate their underperformance.

Students needing to work to support their studies are often less available and can be perceived as having less commitment to a group. This again could limit the student's growth in areas of least proficiency.

Means of communication need to be accessible to all the students, including the person with the least amount of access to communication platforms. Team members may incur additional costs.

Increased workload, tensions between individuals. The code of conduct could become a tool for persecution of team members.

OPTION THREE

Create a Supportive Environment

This option relates to the group as a whole. Group work can be hindered due to conflicts unrelated to the project, often around underlying, emergent or unforeseen personal issues. By establishing supportive physical and social environments, trust and respect can be achieved, minimising arguments and increasing productivity.

The drawback to this approach is that students would possibly need to share personal information with people not close to them, making them feel uncomfortable. It can also slow down project work as students can spend awhile focusing on the 'soft' aspects of group work.

EXAMPLES OF WHAT MIGHT BE DONE

Students should agree upfront on a neutral meeting space or spaces.

Students should establish a community of trust where critique is encouraged and constructive, and all viewpoints are heard and considered.

Students could have daily check-ins with the rest of the group giving updates on both personal headspace and work plan.

Students should establish communication and work-sharing platforms or spaces upfront.

SOME CONSEQUENCES AND TRADE-OFFS TO CONSIDER

This needs to be based on the availability of transport of individuals, context of project, mechanical and digital needs of individuals.

Additional time to train students

Students may need to relinquish a certain degree of privacy.

These need to be accessible to all the students, including the person with the least amount of access to communication platforms. Team members may incur additional costs.

CONCLUSION AND RECOMMENDATIONS

The studio-based education of designers relies upon an environment that can facilitate formal and informal engagement with staff and fellow students. As the whole design process is a series of cycles of engagement, actions and responsive fine-tuning, the significance of collaboration is clear. Design education therefore simulates industry and client relationships through real world and collaborative projects. This study has enabled the authors to explore the student perceptions of group work amongst senior Industrial Design students, at a University of Technology.

For many students, the major benefit of group work is *encouraging different views* (a variety of perspectives). However, this diversity can be the cause of considerable conflict in a group, suggesting that the students would benefit from a tool or framework for mediating the complexity of their group work. After the deliberative dialogues workshop, the most useful aspect of the workshop for students was the *listing of possible solutions (diverse opinions)*.

The deliberative dialogues format could thus be considered as a useful tool to mediate group work and achieve consensus amongst students.

The collective learning that took place during the process of naming and framing is a pronounced benefit of collaboration, and can impact positively on future scenarios where students need to engage in problem solving, a constant in design education. The merits of student deliberation include the ability to collectively define issues and work through possible solutions, the formation of a more resilient student body, and the ability to outline possible repercussions before moving forward. These all have direct impact on the field of design where practitioners increasingly need to work collaboratively across disciplines, work in complex, pluralistic settings, and, be aware of the repercussions of every design decision.

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THE DESIGN OF A CAMERA SYSTEM FOR AN EARTH OBSERVATION CUBESAT MISSION

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ABSTRACT:

The proposed project investigates developing a camera payload for a CubeSat nanosatellite. The mission for such a satellite could provide low-cost imaging for less developed parts of sub-Saharan Africa. Communities in Africa without access to near real-time images of their environment are susceptible to being caught off-guard about natural disasters and do not have readily accessible information about population dynamics. Up to date information about the African environment will contribute towards social innovation and helping disadvantaged communities. Hardware requirements for the mission are discussed, with topics such as image sensors, memory, compression, lens design, controllers and a mock prototype being suggested. Earth observation is discussed, with various applications and benefits being presented.

Keywords: Camera, cubesat, development, EOS, innovation, technology

INTRODUCTION

The technologies employed by CubeSat developers are growing at a rapid pace. Traditional satellite developers are at times hesitant to try new technologies on their satellites for fear of failure. CubeSats allow for the freedom to risk more than a larger satellite operator would, which leads to innovation. Universities around the world are working to promote space science and technology and are making waves within the space community. Many spin off companies have grown from the success of university CubeSat programmes.

This paper discusses a CubeSat imaging payload and its use in providing value for those living in underdeveloped parts of the world. Various

applications for this payload development are mentioned. The primary driving force for the use of a CubeSat is its small size and low mass, making launches far more cost effective. The vast majority of groups who have adopted the CubeSat standard as a platform for learning and development have been universities. Previously it was not possible for many countries to engage in space operations as actively as it is with a CubeSat. In a decade, CubeSats have made it possible for modestly funded university laboratories to engage in space system development. The large satellite builders are taking note and some have their own CubeSat programmes, which they use to evaluate hardware.

The technologies that have been in use on larger satellites are now being introduced to the much smaller nanosatellites. Systems such as deployable solar panels, advanced optics, propulsion and precise control are becoming available to small satellite builders. These technologies are allowing the smaller groups to develop missions that are on the cutting edge of space payload development.

Many of the CubeSat projects coming from universities become the first satellites that are launched from those respective countries, marking a great moment in that country's history. The CubeSat platform gives these countries an opportunity to enter the space domain without having to enter through a prohibitively expensive programme as so many countries did in the past.

This paper describes a low-cost Earth observation payload for a CubeSat which would be able to provide value to African users.

EARTH OBSERVATION

Earth observation satellite (EOS) missions are popular due to the interest that humans have in our own planet. By putting a low Earth orbit (LEO) satellite in a polar orbit, it will pass over the same region of the Earth about twice a day. Over time, the satellite would pass over almost every part of the Earth allowing for effective remote sensing. Typical applications include disaster monitoring, meteorological observation and surface terrain topography. Disaster monitoring allows for fires, floods and oil spills to be managed in a far

more coordinated manner. Meteorological observation would include watching storms, cloud cover and land and ocean temperatures, all aiding in furthering our understanding of the Earth. Surface terrain topography includes providing mapping and geographical information of urban and rural populace centres and structures.

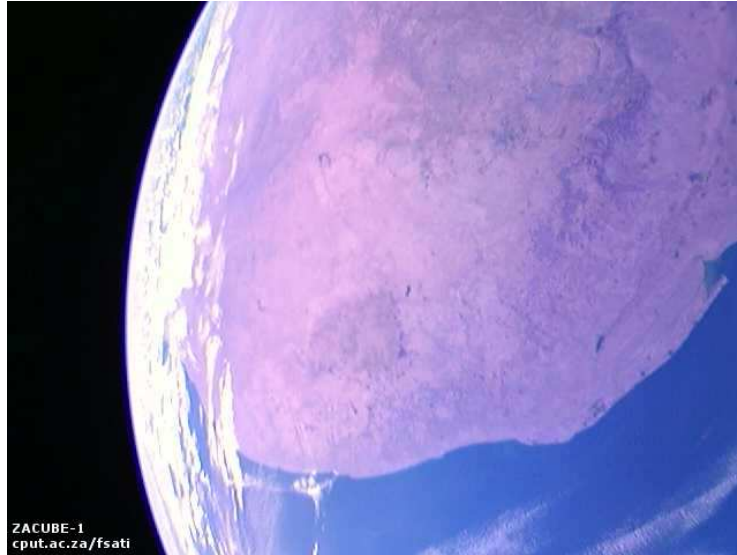


Figure 1: Earth observation image taken by TshepisoSAT (F'SATI, 2014)

Concepts that determine the characteristics of an Earth observation mission are that of spatial and temporal resolution. Spatial resolution relates to the ability of the imager to observe small objects on the Earth's surface. Improving the spatial resolution would mean either moving the two points, Earth and satellite, closer or by having improved optics. The increase in the focal length of a lens affects many other considerations, such as how big the satellite needs to be to accommodate it and how accurate the attitude control system would need to be to keep the spacecraft stable. CubeSats are at a disadvantage with how large the focal length can be of the lens, yet catadioptric lens systems could be incorporated to help with this issue. The attitude control systems of many CubeSats are becoming very accurate and allow for imaging to take place with very little disturbance.

An increased temporal resolution is required if you need to pass over a specific region of interest more often than is possible with a single satellite. The answer to this problem is to use a constellation of satellites. Many

satellites are placed in the same orbit with the same purpose and coordinated to effectively reduce the revisit time. CubeSats are ideal for this purpose as their low cost allows many to be built and launched for the same cost as one larger satellite.

MISSION OBJECTIVES AND CONTRIBUTING TOWARDS SOCIAL INNOVATION

Objectives include developing a low-cost imaging solution with a relatively fast revisit time capable of providing important socio-economic information. Information retrieved from the images could assist in monitoring or predicting natural disasters, populace dynamics, climate changes as well as managing natural resources. This information will assist in making informed and innovative decisions.

HARDWARE DESIGN

The mission requires that hardware be designed and selected for an Earth observation subsystem. This section describes the typical hardware implemented and some of the criteria required in order to make a selection.

Sensor selection

Types of sensor technologies that are typically used include charge-coupled devices (CCD) or active-pixel sensor (APS) also referred to as a CMOS sensor. Both have advantages and disadvantages however the sensor which is selected will be determined by the application. The sensors typically used in CubeSats have an array or matrix of pixel sensors resulting in a full image being captured each time. In a matrix sensor each detector element of the sensor will correspond to a pixel on the ground (Wertz and Larson, 2010: 266-278).

There exist a wide variety of image sensors available on the market. Selecting an appropriate sensor is important and affects the final product dramatically. The final image coverage and lens selection are dependent on the sensor's

characteristics. Two popular manufacturers of commercially available image sensors include Omnivision and Aptina.

Various sensors were investigated with the most popular for nanosatellite missions being:

- IDS UI- 1646LE USB 1.3 Megapixel used in MCUBED satellite by MSU,
- C3188A with OV7620 sensor used in ITU-pSAT-1 and Tokyo University CubeSat X1-IV,
- MCM20027 1 Megapixel CMOS sensor used in AAUSAT at the University of Aalborg, Denmark,
- PC67XC-2 CCD camera used in Norway's nCube1 and nCube2,
- μ CAM TTL camera used in ZACUBE-1 (TshepisoSat) by CPUT,
- OV7648FB imaging sensor used in COMPASS-1 by Aachen Univ, Germany,
- HDCS-2020 CMOS sensor used in CAN-X1 by University of Toronto, and
- OV5647 5 Megapixel sensor commonly used in Raspberry Pi camera boards.

The OV5647 sensor, manufactured by Omnivision, was selected due to its high pixel count and availability.

Memory selection

Choosing the correct memory for this application is paramount as large high-speed data transfer takes place when capturing images. The space environment is harsh with cosmic radiation being able to cause havoc on susceptible electronic systems. Data storage is particularly prone to errors where radiation is able to cause bit-flips and thereby corrupt data. There are however ways to mitigate this risk through the use of radiation tolerant parts and error correcting algorithms.

Ferroelectric random access memory (FRAM) has been gaining popularity due to its inherent tolerance to radiation and overall robustness in harsh

environments. The downside of the technology is that the storage capacities are relatively low for their price compared to other well established memory devices. Static RAM (SRAM) is popular due to its fast speed and low cost per bit of storage, yet it is volatile memory and is only suitable for temporary storage. SRAM should also be used in conjunction with an error control techniques given the harsh environment.

Controller

Finding a controller that is able to balance between performance and low-power consumption is important for this subsystem. The controller needs to be able to handle large amounts of data coming from the image sensor, processing and storing said data, and transferring the data to a permanent storage location. Suitable controllers may include the likes of either an FPGA or an ARM processor typically used in cellphones. Solutions exist where a microcontroller is embedded in the fabric of an FPGA which has the advantage of providing the flexibility and parallel throughput of the FPGA along with the general purpose nature of the microcontroller into one device. One such device is the SmartFusion device by Microsemi. The controller will be required to interface to a number of peripherals including the memory, an onboard computer (OBC) as well as the camera sensor or module.

Compression

Compression techniques are implemented on the captured image in order to reduce the size of the overall image. This is done as a form of post-processing and can either be performed on the satellite or on the ground. Depending on the application it might not be desirable to compress the images due to information that will be lost as a result of the compression algorithm. In such a case the raw data would have to be transmitted to a ground station. This method may require that a faster downlink on the satellite be implemented in order to fulfill the link budget.

There are many benefits which are gained by reducing the data rate within the satellite. Most importantly, a reduction in the amount of data to be transmitted yields a reduction in transmitter power, especially at higher data rates. This

yields a significant reduction in power consumption and mass as less battery capacity is required; mass having a direct impact on the cost of the launch. The compression algorithms can be implemented on programmable hardware.

In the early 1990's, JPEG image compression was introduced with good results and is still the most popular standard for storing images today. There are however issues with the JPEG image compression standard. These include:

- No lossless compression option- For many applications, loss of quality is unacceptable.
- Block effects- Since the image is partitioned into blocks, there is not a smooth transition between blocks of a compressed image.
- Many of the problems associated with JPEG were solved with the incorporation of the Discrete Wavelet Transformation in JPEG2000. The JPEG2000 uses two transformations, one is for lossless compression and the other for lossy compression.

Some of the features and enhancements of JPEG2000 over JPEG include:

- Better compression- JPEG2000 produces higher-quality images for lower bit rates.
- Regions of Interest- Users can identify Regions of Interest in an image and encode them at a higher resolution in the compressed version of the image.
- Larger image size- JPEG is only capable of handling images sizes up to 64000×64000 while JPEG2000 can handle image sizes of $4,294,967,295 \times 4,294,967,295$.
- Multiple channels- JPEG only allows for the compression of three channels, while JPEG2000 can support compression of up to 256 channels, making it particularly useful on board a spacecraft where various wavelengths may be captured by the imager.

From the benefits listed above, JPEG2000 was chosen as the compression scheme for this mission. As with JPEG, JPEG2000 consists of four basic steps. Preprocess, transformation, quantization and encoding. If the compression is chosen to be lossless, then the quantization step is skipped.

The amount of compression is user selectable. The quality of the image is important and should not be degraded to the point where it is noticeable to the human eye. For lossless compression, the memory savings are about 30 %, which results in 5.6 bits per pixel from an 8 bit image. If lossy compression is utilised, the compression rate is 2.2 bits per pixel. Which results in a 72.5% saving, making lossy compression a good choice for this mission.

Communication

Transferring image data to the satellite's OBC will be necessary in order for the images to be later transmitted back to Earth via the onboard radio communication system. Utilising a high-speed data transfer link such as a serial peripheral interface (SPI) will allow for a reliable connection to the satellite's control computer.

The OBC will control the imager payload with a low speed serial interface such as inter-integrated circuit (I2C) or universal asynchronous receive transmit (UART). Issuing of commands and retrieving telemetry will be possible over this connection.

Lens selection

There are a number of factors that determine the selection of the lens. These may include but are not limited to the size of the image sensor, the distance of the subject from the image sensor, the area of the image on the ground to be captured and the quality of the image required. Other limiting factors include physical constraints, CubeSats are structurally small and have weight restrictions to ensure structural integrity. Specifications for the mission and sensor parameters will define the focal length of the lens. As the example below illustrates, a satellite at an orbital altitude of 500 km expecting a 50 m

ground resolution will require a focal length of 14 mm. This is capable given the size and weight constraints of a CubeSat.

$h = \text{orbit height} = 500 \text{ km}$

$d = \text{pixel size of sensor} = 1.4 \text{ }\mu\text{m}$

X = cross track ground pixel resolution = 50 m

f = focal length of lens

$$f = \frac{h \times d}{X}$$
$$f = \frac{500 \text{ km} \times 1.4 \text{ } \mu\text{m}}{50 \text{ m}} = 14 \text{ mm}$$

Pointing requirements

In order to facilitate the requirement of taking images of the Earth it is required that the imager accurately point in the direction of the Earth. This will require that the satellite be stable in all three axes. In order to achieve this stability a subsystem referred to as an attitude determination and control system (ADCS) will be required. These subsystems typically utilise star and sun sensors, magnetometers or a combination to determine their orientation or attitude in relation to the Earth. Magnetorquers or reaction wheels are then used to position the satellite based on an algorithm to achieve the required stability.

Prototype concept

Figure 2 shows an example of a prototype imager. The sensor and lens would need to be mounted on a PC/104 board which would also be populated with the controller and memory.

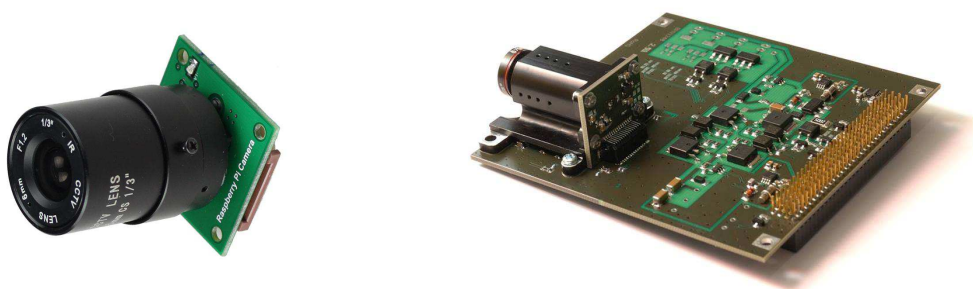


Figure 2: Typical imager prototype [Arducam, 2014] [ESTCube, 2013]

CONCLUSION

Utilising off the shelf components for this payload is feasible to realise the mission objectives. Low cost electronics such as the Raspberry Pi provide a platform to interface a CMOS camera module. The general acceptance of such low cost hardware allows lenses to become widely available making sensor and lens selection less complex and more cost effective. Despite the size and weight limitations of the CubeSat platform, it is feasible to include a camera module that can provide an adequate ground resolution to contribute to scientific data.

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RESULTS FROM THE QB50 PRE-CURSOR LAUNCH CAMPAIGN

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ABSTRACT:

Regular and affordable access to space is a critical prerequisite for advancing nanosatellite design. Though its ISL subsidiary the Dutch company ISIS-Innovative solutions in Space have been at the forefront of acting as interface between satellite developers and launch providers worldwide over the past more than 5 years. In 2013 ISL was directly involved in 11% of all nanosatellites launched.

The QB50 mission aiming to launch 50 nanosatellites into LEO from a single rocket launch presents unique challenges to nanosatellites launch providers and ISL have been developing a compatible launch interface system over several years culminating into a modular and generic system first launched with the QB50 precursor mission in May 2014. This paper presents a brief overview of the ISIS quadpack launch enclosure and the iMDC deployment controller also highlighting the South African contributions in preparing it for its first launch in a very short timeframe. Besides the history and design overview of the system some flight results will also be presented.

Keywords: Nanosatellite Launch system; QB50 precursor; deployment; Flight Results

INTRODUCTION

ISIS- Innovative solutions in space is a Dutch company based in Delft, The Netherlands. Today the company is well known for technical solutions within the growing and evolving nanosatellite field encompassing both subsystems and complete platforms. In addition the technical team have completed several full missions (including all traditional project segments like ground segment, space segment and launch segments) for delivery to clients while doing research and development for new products, production of existing products and working on internal missions.

ISIS is organised in a few business units. Besides the R&D “engine house” which is ISIS housing the technical engineering teams and support staff there is also a separate daughter company (ISL – Innovative Space Logistics) focused on providing launch opportunities by acting as an interface between spacecraft teams looking to launch their systems to space and launch providers who may have excess launch capacity available. Another daughter company (IDS – Innovative data solutions) focus on the applications possible with data that may be obtained by nanosatellites and constellations.

Marketing of subsystems and platforms provided by ISIS and several other collaborating companies are provided to prospective customers through a separate business unit called www.cubesatshop.com. This service also intends to showcase the ever evolving capabilities of this exciting class of spacecraft.

ISIS LAUNCH SERVICES

A major challenge to the development of any new satellite system is to have regular and repeated access to space. This is even truer for Cubesats and other nanosatellites where the operational lifetime has traditionally been relatively lower, but the complexity of securing launch slots may be higher than other satellites. With this in mind the ISL subsidiary of ISIS was formed to act as an interface between cubesat developers and launch vehicle operators around the world.

The idea is to have standard orbital deplorers (POD's) qualified for use on specific launch vehicles and as such mitigating the risk towards these vehicles and their main payloads sufficiently to be allowed as secondary payloads. Once this objective has been reached the logistical challenge is to bring together available launch opportunities with satellite missions ready for launch in specific launch campaigns.

Figure 39- The ISIPOD deployer for a 3U satellite platform



A first example of such a campaign was performed with 100% success rate for 4 separate customers on an Indian launch vehicle in 2009. In 2013 ISL was responsible for a unique launch of a nanosatellite out of a larger Russian satellite the BION-M. The Nanosatellite was deployed 2 days after the main satellite was already delivered on orbit by opening the ISIPOD container door. ISL also successfully interfaced to American (Antares), Chinese (Long March) and European (Vega) launch vehicles delivering nanosatellites on orbit 100% successfully in all cases for our clients from around the world.

In November 2013 ISL was responsible for a major launch campaign launching 14 satellites from 12 countries on a Dnepr launch vehicle. This launch brought the total portion of the nanosatellites launched in 2013 by ISL to more than 11% and again confirmed the ability of the company to manage large and complicated multinational launch campaigns.

Figure 40 - Liftoff of the Dnepr rocket from Yasny - November 2013



QB50 PROJECT BACKGROUND

QB50 is an ambitious project by the Von Karman Institute for Fluid Dynamics to study the lower thermosphere. The target is to simultaneously launch and release 50 2U cubesats carrying dedicated instrument packages in a very low earth orbit and monitoring their orbital decay over a period which is expected to last roughly three months. Besides being active in several of the technical working groups ISIS is responsible for the launch vehicle interfacing and orbital dynamics analysis. A unique aspect of this launch is that the nanosatellites in their combined launch platform will form the main payload for the mission.

The design of the launch interface system eventually evolved from a specific design for QB50 alone to a very generic system which can also be used on several of the other launch vehicles that ISL has experience in interfacing with. The system is built on two modular building blocks. Firstly an ISIS “Quadpack” was designed to offer 4 times the launch capacity offered by a single ISIPOD in a single enclosure. The Quadpack can be configured to deploy 4 doors independently and may be mounted in various orientations. Each door has a redundant hold down and release mechanism (HDRM) as well as deployment confirmation signals both for the opening of the door and the ejection of the payloads. Depending on the payload satellite requirements it may be configured to deploy anything from 1x12U satellite to 24x1U satellites.

For bigger launches like QB50 several of the Quadpacks may be combined to provide the required capacity. In this case the interface to the launch vehicle can also form an obstacle due to the large number of deployment and confirmation signals that needs to be handled by the system. For this reason ISIS also developed a modular deployment controller the iMDC which acts as a single control node for controlling several Quadpacks. Just like the Quadpack it may be configured as required by the launch vehicle with the option to operate it completely from internal power and to interface it to the launch vehicle telemetry system or to add an independent radio beacon for deployment confirmation after launch. The design is both modular and redundant taking care to eliminate potential single point failures.

QB50 PRECURSOR MISSION.

Before attempting the full QB50 mission a precursor launch campaign was designed to de-risk the main mission. Besides testing the entire launch interface for the first time two 2U precursor satellites was designed and build by ISIS to gain flight heritage of the main QB50 sensor packages.

Figure 41 - The Two QB50 precursor satellites prior to launch in the ISIS cleanroom



The launch was not limited to the QB50 precursor missions only but included 22 satellites from 8 nationalities and was again scheduled to be included in a Dnepr launch from Yasny in Russia.

In order to fulfil the launch requirement 5 quadpacks was included in the launch manifest as well as a single iMDC system with internal battery power and VHF beacon transmissions as launch confirmation.

Figure 42 - Quadpack and iMDC hardware during the Fit check and vibration test in Ukraine

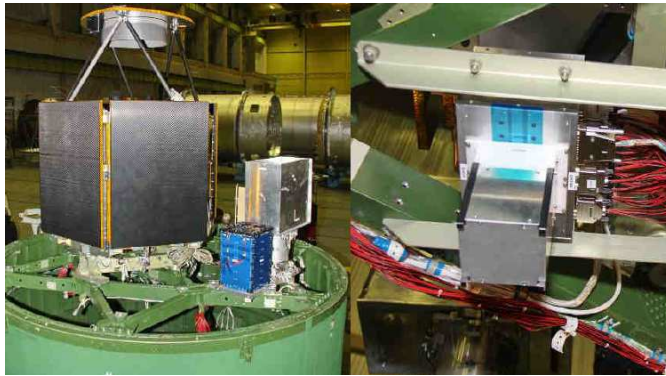
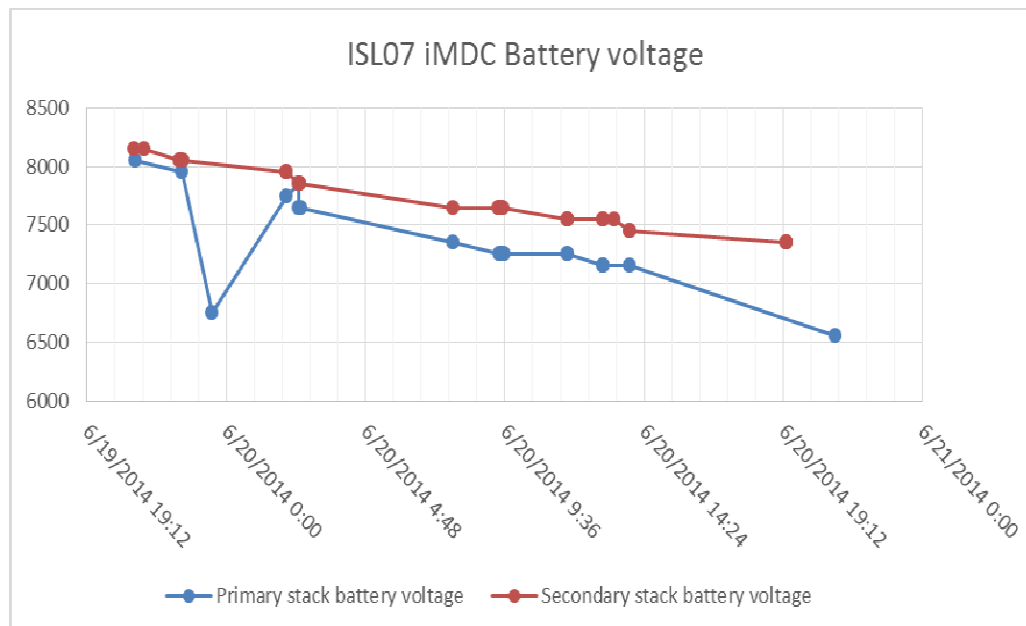


Figure 43 - Full manifest prior to the closing of the rocket fairing



The launch of the precursor mission went according to plan on the 19th of June 2014. The nanosatellites were deployed after the primary launch payloads between 5 and 10 minutes after launch with roughly 20 second intervals between deployments. Less than 5 minutes after deployment the first satellite signals were received from South Africa. iMDC beacon transmissions confirmed that all satellites were deployed over the course of 24 hours after launch and were received both by ISIS groundstations in South Africa and The Netherlands and by a team of radio amateur volunteers around the world.

Figure 44 - Battery voltage over time for iMDC power system



From the graph it can clearly be seen that the battery voltages decrease over time in the absence of any solar panels on the iMDC. The voltage of the power system driving the beacon transmitter decreased faster than the other just driving the standby current of the deployment system.

Temperature of the power system started at about 15°C but decreased to around -5°C after 1 day in orbit.

Radio signals from the iMDC beacon showed a strong signal but with slow fading as the upper stage it was attached to slowly rotated.

SOUTH AFRICAN CONTRIBUTION

ISIS-South Africa was involved from the beginning in the design and systems engineering of the electrical control system the iMDC. Two commercial contract was placed with South African companies in relation to the iMDC. The flight model of the iMDC controller PCB's was produced locally with support from the production team at Denel-Spaceteq and embedded software engineers from CPUT-FSati helped to develop the control software for this system. The tracking of the beacon signals by South African ground station from the iMDC and precursor missions also contributed to the early confirmation of mission success.

CONCLUSIONS

ISL plays an important role in providing launch services for nanosatellite developers around the world. This role is expected to continue and increase in scope also building on the modular launch interface hardware originally designed for the QB50 mission and flight proven with the QB50 precursor launch. The collaboration between ISIS in the Netherlands and some South African partners via the interfaces provided by the ISIS-South Africa branch helped to provide a project mutually beneficial to all involved.

THE PERFORMANCE EVALUATION OF DISTRIBUTED INTER-SATELLITE COMMUNICATION PROTOCOLS FOR CUBE SATELLITE SYSTEMS

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ABSTRACT:

The usage of small satellite systems is of great importance to the space community due to the reduced cost of space missions without a great compromise in performance. Small satellites flying in formation help to provide better spatial and temporal resolutions of the target and thus could be useful in many science and environmental applications like gravity mapping, tracking of forest fires, finding water resources, and space weather. Inter-satellite communication is a key aspect when satellites fly in formation. This paper focuses on designing and simulating suitable MAC and routing layer protocols for distributed small satellite network. Given that we use the Open System Interconnection (OSI) as a framework, this work represents a focus on layer 2. To validate our proposed system model, extensive simulations are executed. The performance of the proposed work is evaluated using three different parameters: throughput, average access delay and average end-to-end delay. These findings indicate that, the Leader-Follower and Constellation formation flying patterns have the maximum throughput and minimum delay, thus ensuring reliable communication and higher data rate with low cost.

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environmental applications like gravity mapping, tracking of forest fires, finding water resources, and space weather. Inter-satellite communication is a key aspect when satellites fly in formation. This paper focuses on designing and simulating suitable MAC and routing layer protocols for distributed small satellite network. Given that we use the Open System Interconnection (OSI) as a framework, this work represents a focus on layer 2. To validate our proposed system model, extensive simulations are executed. The performance of the proposed work is evaluated using three different parameters: throughput, average access delay and average end-to-end delay. These findings indicate that, the Leader-Follower and Constellation formation flying patterns have the maximum throughput and minimum delay, thus ensuring reliable communication and higher data rate with low cost.

Keywords: *Small satellites, Formation flying of small satellites, Distributed systems in space, Inter-satellite communications, MAC and Routing layer protocols, CSMA/CA/RTS/CTS Protocol.*

INTRODUCTION

Future space missions are envisioned having low cost, autonomous, and distributed space networks using small satellites. Small satellites are artificial satellites with lower mass and smaller sizes (mass less than 180 kg (Staff, 2014)). A group of small satellites offers numerous capabilities that cannot be achieved by a single large satellite. The concept of multiple satellite mission is becoming attractive because of their potential to perform coordinated measurements of remote space. A large number of government organizations and universities are developing Earth observations and interplanetary space mission concepts using multiple small satellites (Gao, 2008: 66-69; Angadi, 2011: 1-15). Technical advancements in microelectronics, adaptive and reconfigurable hardware, and micro sensors have enabled, the design and development of highly integrated multi spacecraft systems using small satellites (Dennehy, 2014). Space based wireless sensor networks using small satellites can be useful for many missions, like servicing or proximity operations of large mother ships. It provides multi-point coverage, thereby increasing the spatial and temporal resolution and also enables extended communications for low powered surface vehicles around other planets or asteroids (Vladimirova, et al., 2008: 1-10).

Distributed space missions consist of two or more satellites working cooperatively to achieve an objective (Vladimirova & et al, 2007: 43-50). These missions consist of numerous satellites that communicate with each other using Inter-Satellite Links (ISL). The ISL has also been called cross links in literature (Kerri & Michael, 2000). A satellite can have several communication links with other satellites. Depending on the mission objective, ISL can carry different types of traffic like voice, data, video, or telemetry data. The cross links can be used for connecting two or more separate satellite networks, thereby expanding the coverage area. It is important for interplanetary or deep space missions, where it is difficult to control the system from Earth stations. Inter-satellite communications can be used for attitude control and timing synchronization in multiple spacecrafts. The ISL eliminates the need of ground stations around the Earth to control the satellites. However, these systems have limitations, both at the transmitting and receiving end, for example, limited power, mass, antenna size, on board resources, computing capabilities etc. Iridium, Orblink, Teledesic (Kerri & Michael, 2000), Proba-3 (Llorente & et al, 2013: 38-46), Edison Demonstration of Smallsat Networks (EDSN) mission (Cockrell & et al, 2012) and QB-50 mission (Gill & et al, 2013: 110-117) are some examples of multiple satellite space missions with inter-satellite links.

The Open System Interconnection (OSI) model serves as a reference tool for communication between different computer systems connected in a network which divides the communication process into seven layers (Simoneau, 2006). It is a conceptual framework that helps to understand complex interactions within a network. Each layer has well defined functions and offer services to the layers above and below it. It can be used as a framework for the network process for inter-satellite communication in small satellite systems. The OSI model has seven layers; physical, data link, network, transport, session, presentation and application. The second layer, i.e., the data link layer is the primary focus of our research. This layer is responsible for physical addressing (Medium Access Control/MAC address) and also ensures error free data transmission. In this paper, we propose the appropriate MAC and routing protocols for the three different formation flying

patterns (Leader-Follower, Cluster and Constellation) of small satellite systems.

The performance of the entire system largely depends on the design of multiple access protocols. The MAC protocol should take into account mission specifications like mission application, network topology, number of satellites, etc. Also, it has to consider several system constraints of small satellites, for example, limited on board power and computing resources. There are several researches being conducted on various multiple access methods for inter-satellite communications in small satellite systems (Bedon & et al, 2010: 1-6; Radhakishnan, et al., 2013: 11-24; Chen & Yu, 2011: 409-413; Sun & et al, 2012: 21-32; Sidibeh & Vladimirova, 2008: 255-262; Heidari & Truong, 2013: 1-6; Radhakrishnan & et al, 2014: 255-262). In this paper, we are proposing a modified MAC protocol, i.e., Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) with Request-To-Send/Clear-To-Send (RTS/CTS) protocol and routing protocols for the three different formation flying patterns. The proposed protocol is suitable for science missions that does not require tight communication links between the satellites and has a small number of satellites in the system. The novelty and contribution of this work are that: 1) To the best of our knowledge this is the first work to propose and validate a MAC protocol for inter-satellite communication for various formation flying patterns of small satellite system and 2) The contribution lies in the experimental results that quantifies the performance of the various small satellite configurations. The proposed system models are analyzed using three different parameters: throughput, average access delay and average end-to-end delay respectively.

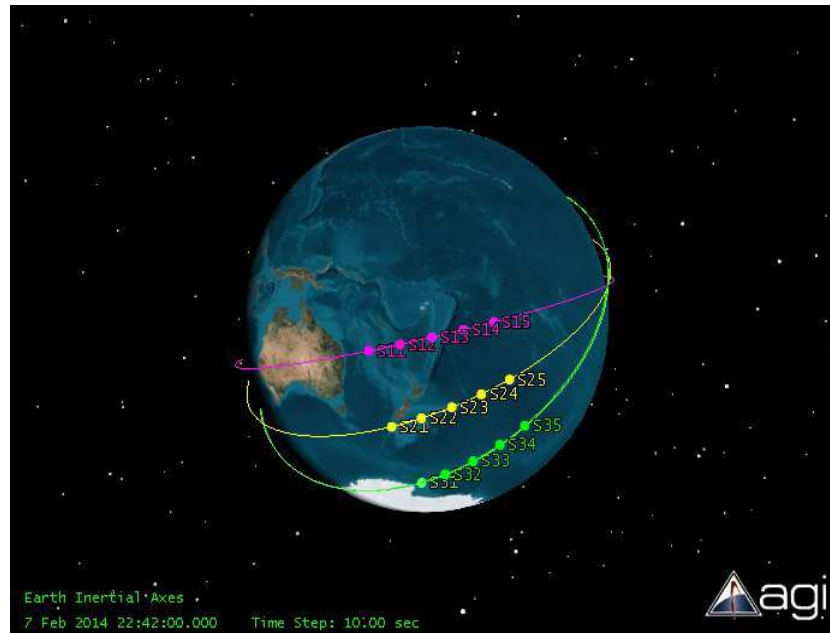
The rest of this paper is organized as below. Section 2 briefly describes the various distributed systems in space. A brief description of the proposed system models for the various formation flying patterns are described in Section 3. A brief outline of the proposed MAC and routing protocols is also given in Section 3. The simulation results for all three formation flying patterns are discussed in Section 4 and the paper is concluded in Section 5.

DISTRIBUTED SYSTEMS IN SPACE (DSS)

Small satellites with distributed computing capabilities can fly in various configurations, like formation flying spacecraft, satellite constellation, swarms and fractionated spacecraft (Sundaramoorthy, et al., 2010). These multi-satellite configurations are new prototypes for interplanetary explorations and remote sensing. Multi-satellite configurations are subsets of a more general class described as Distributed Space Systems (DSS) (Leitner, 2004).

Formation flying spacecraft

In accordance with the engineering definition, for formation flying of spacecrafts, it is required to maintain relative separation, orientation or position among the spacecrafts (Mc Vittie, et al., 2007). The Leader-Follower (A-Train) is a good example of this pattern. In Leader-Follower pattern, multiple spacecrafts will be orbiting the Earth in the same orbit, separated from each other at a specific distance. The A-Train or Afternoon-Train is an example of the Leader-Follower formation flying pattern, which initially consisted of eight U.S. and international Earth science satellites that fly approximately within seconds to minutes of each other to enable multiple science missions. As of June 2012, there are five active satellites namely, GCOM-W1 (SHIZUKU), Aqua, CloudSat, CALIPSO and Aura (Stephens & et al, 2002: 1771--1790). The Orbiting Carbon Observatory-2 (OCO-2) is scheduled to join the configuration in 2014. The joint measurements provide an excellent sensor system for Earth observations. Figure 1 shows the Leader-Follower formation flying pattern.

Figure 45: Leader-Follower formation flying pattern

Satellite constellation

A satellite constellation is a set of similar or dissimilar satellites distributed in space so that, they overlap well within the coverage area to accomplish mission objectives (Burlacu & Lorenz, 2010). A Cluster configuration is a subgroup of Constellation as it covers a smaller portion of the Earth. A Cluster consists of a number of satellites distributed in different orbital planes that operate cooperatively. The Flower constellation (Vladimirova & et al, 2010: 1-14) and TECHSAT-21 (Martin & Kilberg, 2001: 13-16) are examples of Cluster configuration. A satellite constellation is a more generalized configuration covering a larger portion of the Earth's surface. There are no governing rules for interdependency for the satellites in a Constellation. The Global Positioning System (GPS) and IRIDIUM are examples of Constellation configuration. The IRIDIUM consists of 66 Low Earth Orbiting (LEO) satellites arranged in 6 orbital planes, with 11 satellites per plane, at an altitude of 780 km above the Earth's surface (Iridium, 2014). Figures 2 and 3 show the Cluster and Constellation configuration pattern for small satellites.

Swarms

A satellite swarm is defined as a self-organized, self-functioning satellites that communicate directly or indirectly that enables to achieve a common mission. It can be considered as a set of agents that take decisions independently without ground station intervention. It is highly autonomous with very high possibilities of reconfiguration or extension. The whole system is very complex and also requires precise navigational accuracy (Sundaramoorthy, et al., 2010).

Figure 46: Cluster formation flying pattern

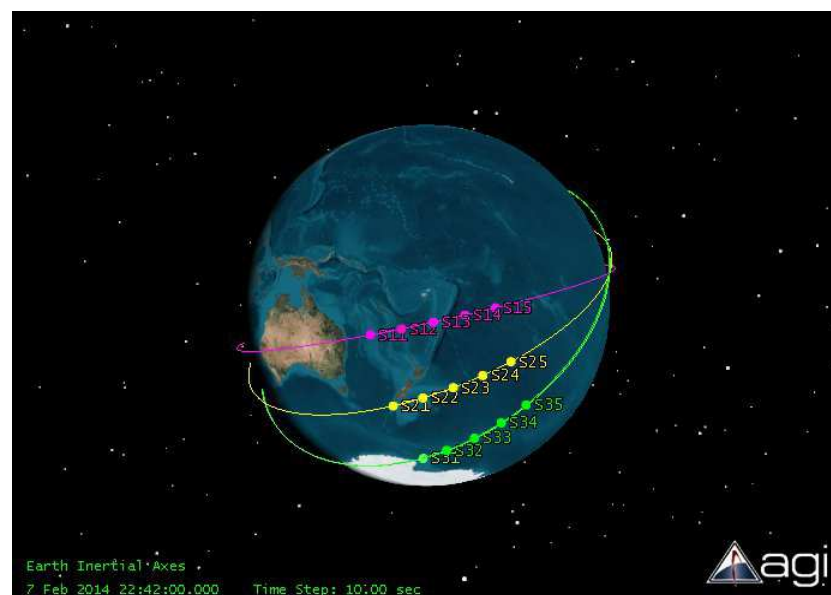
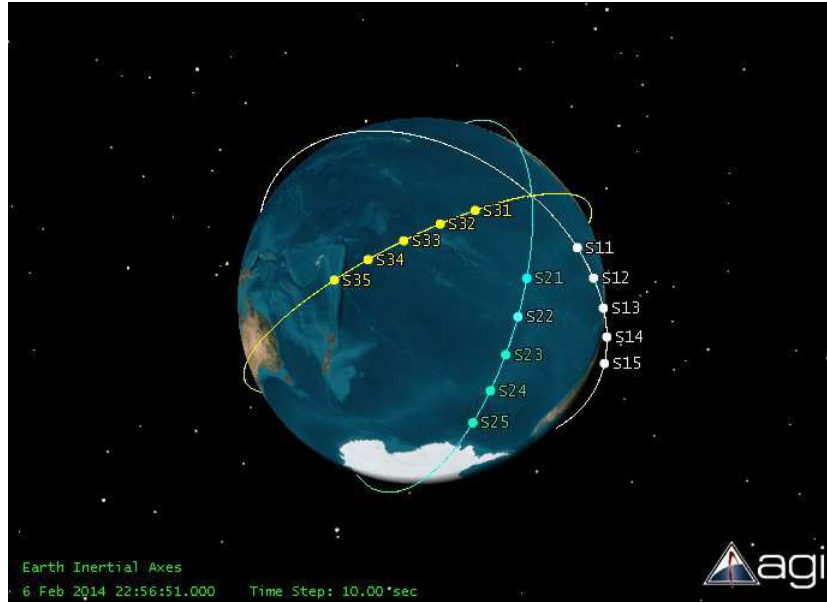


Figure 47: Contellation formation flying pattern

Fractionated spacecraft

A fractionated spacecraft is a new architectural model, whereby the functionalities of a large satellite are distributed across a cluster of small satellites which are wirelessly interconnected. Each small satellite has different functionalities making the whole system heterogeneous. This configuration needs higher position and orbital control of the individual satellite with a moderate system design complexity (Sundaramoorthy, et al., 2010). Such a system enhances robustness and flexibility in the architecture, while shortening development time and launch constraints.

PROPOSED WORK

System model

This paper mainly concentrates on Leader-Follower, Cluster and Constellation formation flying patterns of small satellites. In our research, we consider closely 1 U cube-satellites with a mass less than 1.33 kg (10 cm cube). The transmission power of 1 U cube-satellite ranges from 500 mW to 2 W. We assume that the satellites operate at the S-band frequency in the magnetic spectrum, i.e., the frequencies ranging between 2 GHz to 4 GHz. In the

proposed system model, we assume that the satellites are deployed in nearly circular Lower Earth Orbits (LEO).

We consider a single orbit for Leader-Follower formation flying pattern and for Cluster, M number of orbits are considered with a separation distance of no wider than y km. For Constellation formation flying pattern, we consider N orbital planes, spaced x degrees apart. In order to avoid collision of small satellites at the poles, it is assumed that the satellites are deployed at different time instants, such that the separation distance between the satellites is greater than the minimum inter-satellite distance, according to the link budget. We can also consider a scenario, where the satellites are deployed at the same time, but in different orbital planes that are not at the same altitude, thus avoiding the spacecrafts colliding with each other at the poles. For the three configurations, it is assumed that the satellites in all orbital planes share the same transmission frequency band.

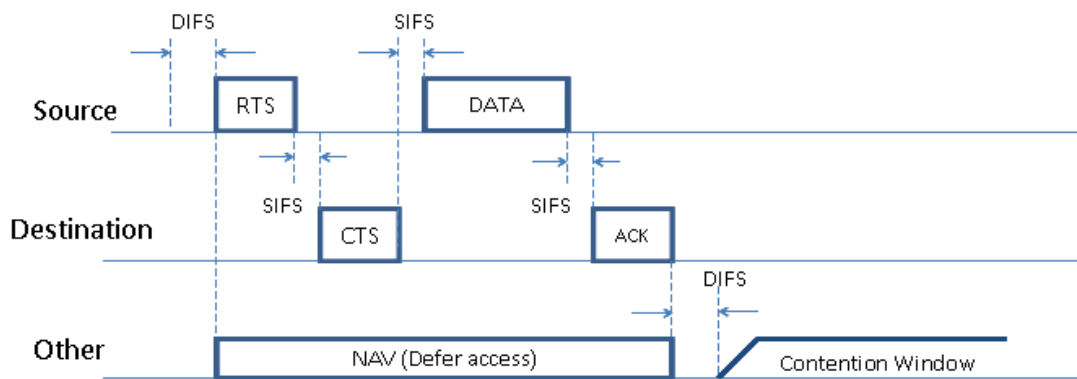
The CSMA/CA/RTS/CTS protocol

The MAC layer provides channel accessing schemes for several terminals within a multiple access network that uses a shared medium. IEEE 802.11 standards specify both physical and MAC layers. It offers two services i.e, contention based, implemented by Distributed Co-ordination Function (DCF) and contention-free services, employed by Point Co-ordination Function (PCF). The DCF is based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). The CSMA/CA/RTS/CTS (Request-To-Send/Clear-To-Send) multiple access is a good choice for a distributed network of small satellites compared to other traditional MAC protocols, because it can solve the hidden and exposed terminal problems. (Athanasia & Laurensen, 2008: 817-831).

The carrier sense multiple access scheme is based on sensing the transmission channel to infer the channel conditions. If the channel is found to be idle for a time slot greater than Distributed Co-ordination Function Inter Frame Space (DIFS), then the sender satellite continues transmission by sending the Request-To-Send (RTS) control frame to the receiver satellite.

After an interval of Short Inter Frame Space (SIFS), the receiver satellite sends back the Clear-To-Send (CTS) control frame. Upon receiving the CTS, the sender satellite sends the data packet after waiting for a period of SIFS. The receiver processes the data packet and sends an acknowledgment (ACK) after waiting for another SIFS time frame. The RTS and CTS include the total time it takes for the current transmission including the ACK. It will be sent to the neighboring satellites too, so that they will refrain accessing the channel and thereby avoiding collisions and loss of data packets. After receiving this information, neighboring satellites setup the network timer called the Network Allocation Vector (NAV). If the NAV timer is zero, satellite initiates channel access. Figure 4 shows the CSMA/CA/RTS/CTS protocol (Youssef, et al., 2002).

Figure 48: CSMA/CA with RTS/CTS



When a satellite senses that the channel is busy, it turns on a random back-off counter or Contention Window (CW) that determines the amount of time the satellite has to refrain accessing the transmission channel. The IEEE 802.11 MAC protocol follows exponential back off, i.e., CW size ranges from 0 to 2^m . Every time the satellite experiences a collision, the CW size is doubled and it is reset to the initial value of 0, whenever the satellite succeeds to get access to the channel. During the back off time period, if there is another data packet transmission in its neighborhood, the back-off counter will be frozen to avoid collision. It will be resumed when the channel is sensed to be idle subsequently.

Modified CSMA/CA with RTS/CTS protocol

The CSMA/CA with RTS/CTS Protocol is originally designed such that the control frames, RTS and CTS are transmitted in an omnidirectional way. In this paper, we propose to use smart antennas at the physical layer. For small satellite systems, CSMA/CA/RTS/CTS protocol can be modified by transmitting the control frames, RTS and CTS using a directional/omnidirectional antenna based on the different configurations. For example, for a Leader-Follower formation flying pattern (A-Train), RTS and CTS can be transmitted directionally using smart antennas, thus saving power (Radhakishnan, et al., 2013). For Cluster formation flying pattern, as there are more number of satellites within the transmission range of each satellite, RTS and CTS can be transmitted using omnidirectional antennas. For Constellation pattern, as per our design, the satellites in one orbital plane will not come within the transmission range of the satellites in another orbital plane. Therefore, communication take place between the satellites placed in its own orbital plane and hence RTS and CTS can be sent using bi-directional antennas. Data frame can be also transmitted using directional antennas, thereby ensuring longer battery life of the small satellites.

Routing protocols

There are two possible routing schemes, proactive and reactive routing, respectively. In the proactive scheme, each satellite knows the entire network topology and whenever a satellite needs to send a data packet, it finds the route and establishes the connection. However, when the network becomes more complex, it is difficult to maintain the routing tables and also it consumes more power and bandwidth which are the major constraints for small satellite systems. The reactive scheme is based on on-demand routing, i.e., a satellite tries to find an optimal path to the destination only when there is a need to have a communication. We propose to use reactive routing scheme for our system model.

Transmission power and time are the two network optimization objectives for data packet routing. When the data packet is transmitted to the destination satellite by multi hopping, there is a significant reduction in power for

communication. It is important to determine an optimum route for a data packet that is being transmitted between a sender and a receiver. For A-Train formation flying pattern, we can use the Bellman Ford algorithm (Radhakishnan, et al., 2013), since it computes the shortest distance between the satellites and thereby routes the data packet through the shortest path.

Figure 5 shows the data flow structure from a source satellite to a destination satellite for a Leader-Follower formation flying pattern. The Constellation formation flying pattern follows the same approach as the Leader-Follower configuration. For both patterns, the source satellite transmits the data packet to the neighboring satellite and so on until it reaches the destination. Figure 6 shows the data packet transmission for Cluster formation flying pattern. In this configuration, all the satellites in different orbital planes operate at the same frequency. Thus, the source satellites can route the data packets to the satellites in other orbits, if the neighboring satellite is found to be busy, provided it is within the transmission range and closer to the destination satellite as shown in Figure 6.

Figure 49: Leader-Follower formation flying pattern

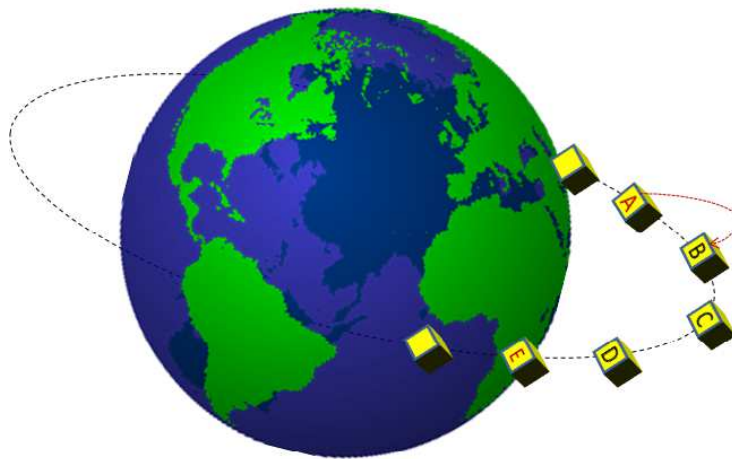


Figure 50: Cluster formation flying pattern



SIMULATION RESULTS AND DISCUSSIONS

We did extensive simulations for the three different formation flying patterns. An event driven simulator is used to implement the simulations which are built in Java. The system was analyzed using three different parameters.

- *Average end-to-end delay* - It is defined as the amount of time taken by a data packet to reach from the source satellite to the destination satellite (Radhakishnan, et al., 2013).
- *Average access delay* - The average access delay is defined as the amount of time each satellite has to wait before it gets access to the channel for transmission (Radhakishnan, et al., 2013).
- *Throughput* - The throughput is defined as the amount of time that is used for a valid transmission of the total simulation time.

The three different systems are simulated using 10,000 data packets. We need to run the simulations for a large number of data packets for the system to reach its stability and thereby retrieving accurate results. The simulation parameters are based on the assumptions that are summarized in Table 1.

Table 3: Simulation parameters

Simulation parameters	Value
Size of cubesats	1 U
Transmission power	500 mW to 2 W
Orbital altitude (LEO)	300 km
Number of orbits M, N	3
Orbital separation y	2 km
Transmission frequency	2.4 GHz
Orbital velocity	3 km/s
Inter-satellite range	10 km to 25 km
Number of packets simulated	200 packets per satellite
Data packet length	Exponential distribution
Data packet arrival	Poisson distribution
DIFS	28 μ s
SIFS	28 μ s
CTS	50 μ s
ACK	14 μ s
Average packet length	1s
Contention window size W	2^m

Leader-Follower (A-train) formation flying pattern

For the Leader-Follower formation flying pattern, we consider a circular orbit at an inclination of 45° at an altitude of 300 km above the Earth. First, we simulated with 10 satellites in orbit with an 8 km separation distance between each satellite. Hence the relative distance between the satellites is the same and thus the satellites appear stationary to each other. Then, we increased the number of satellites in the orbit to 20 and then, to 30 satellites. Figures 7, 8 and 9 show the simulation results of the Leader-Follower formation flying pattern. The average end-to-end delay increases as the number of satellites in the orbit increases, since the total orbital length increases from 80 to 270 km as seen in Figure 7. The average access delay also increases when we increment the number of satellites in the system as observed from Figure 8. This is due to the fact that, the overall traffic increases and the satellite have to wait for a long time to get access to the channel. The throughput of a system is inversely proportional to delay, i.e., when the overall delay increases, the throughput decreases. The throughput of the Leader-Follower configuration is shown in Figure 9. We observe that, in the case of 10

satellites in orbit, the throughput is less compared to 20 and 30 satellites in the system. This is because, in the case of 10 satellites in the system, the overall traffic is considerably less and the channel is not utilized effectively in comparison to 20 and 30 satellites. We can achieve a maximum throughput of 24%.

Figure 51: Average end-to-end delay for Leader-Follower formation flying pattern

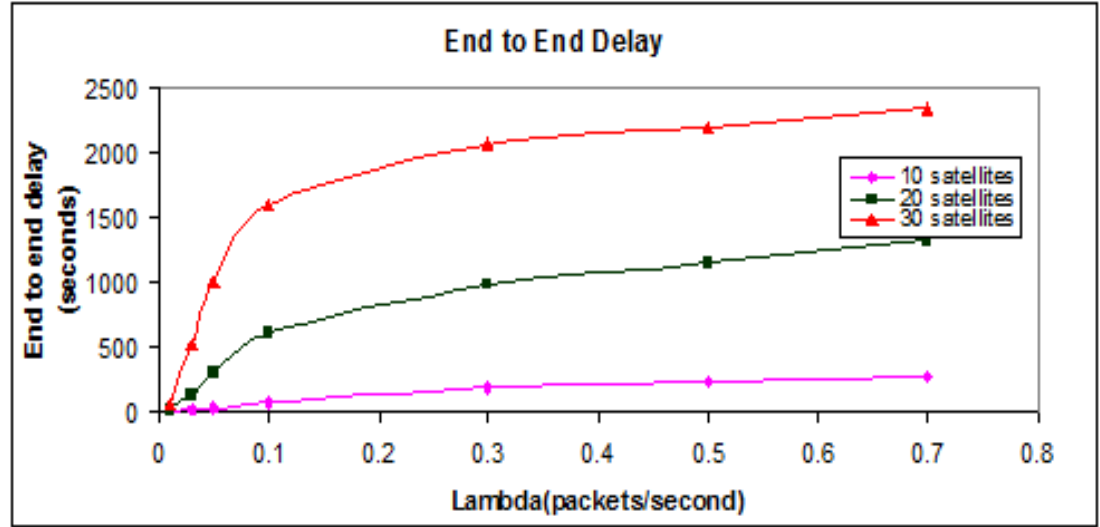


Figure 52: Average access delay for Leader-Follower formation flying pattern

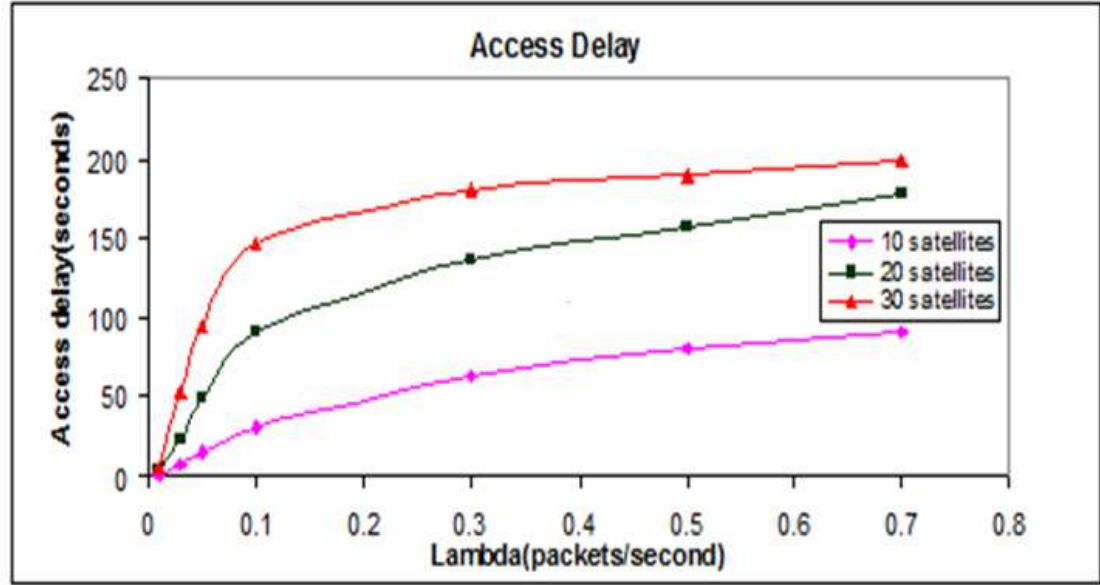
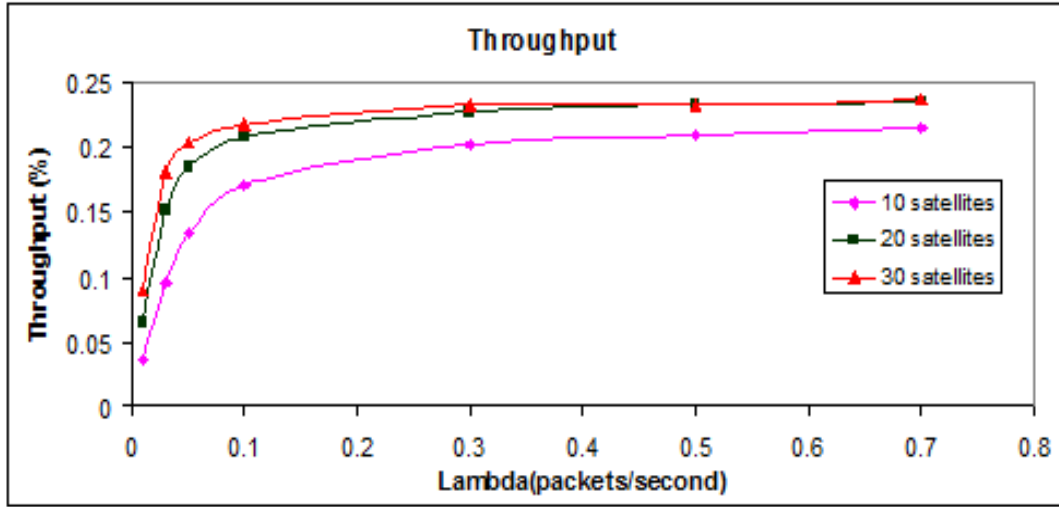


Figure 53: Throughput for Leader-Follower formation flying pattern***Cluster formation flying pattern***

We consider three circular equatorial lower Earth orbits for the Cluster formation flying pattern at an inclination of 45° , 48° and 50° respectively. We assume that, all the three orbits share the same frequency for transmission. Similar to Leader-Follower formation flying pattern, we simulated the Cluster configuration for 10, 20 and 30 satellites in the orbit. As can be seen from Figures 10 and 11, the average end-to-end delay and average access delay is less when there are 10 satellites in the orbit. As observed from Figure 12, throughput for the system with 10 satellites is less compared to 20 and 30 satellites. The same reason holds true in this case too, similar to the Leader-Follower configuration. We observed that, for heavy traffic, the three curves converge very well since all the systems attain its saturation with effective channel utilization.

Figure 54: Average end-to-end delay for Cluster formation flying pattern

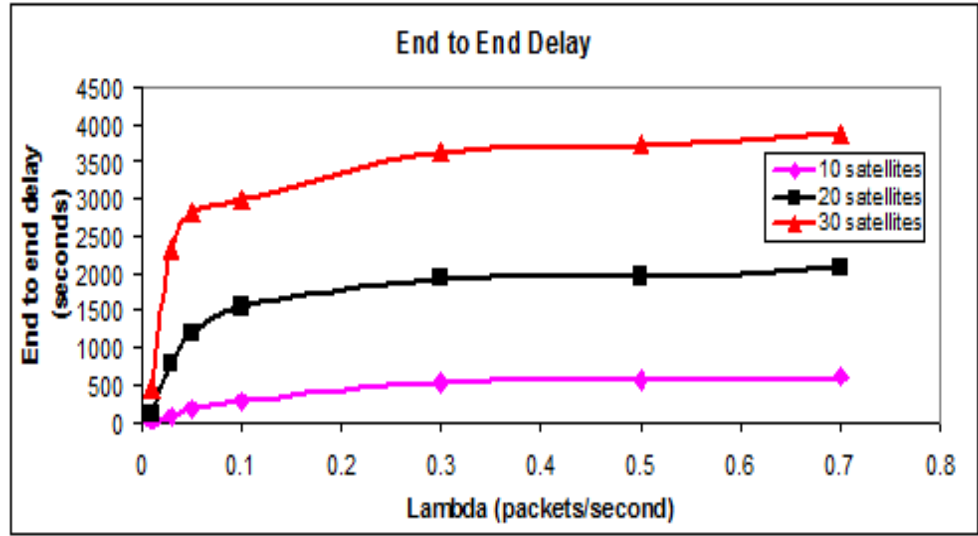


Figure 55: Average access delay for Cluster formation flying pattern

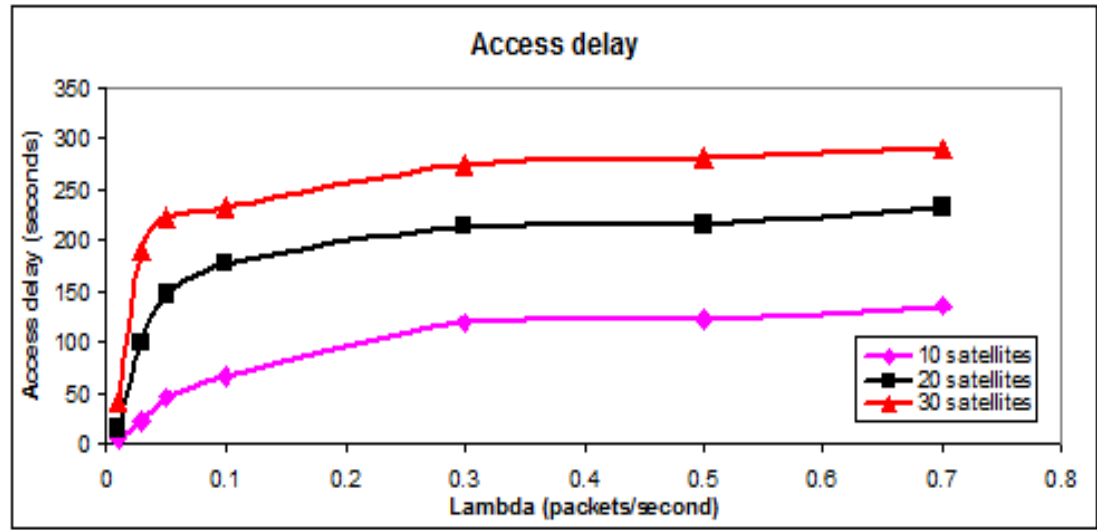
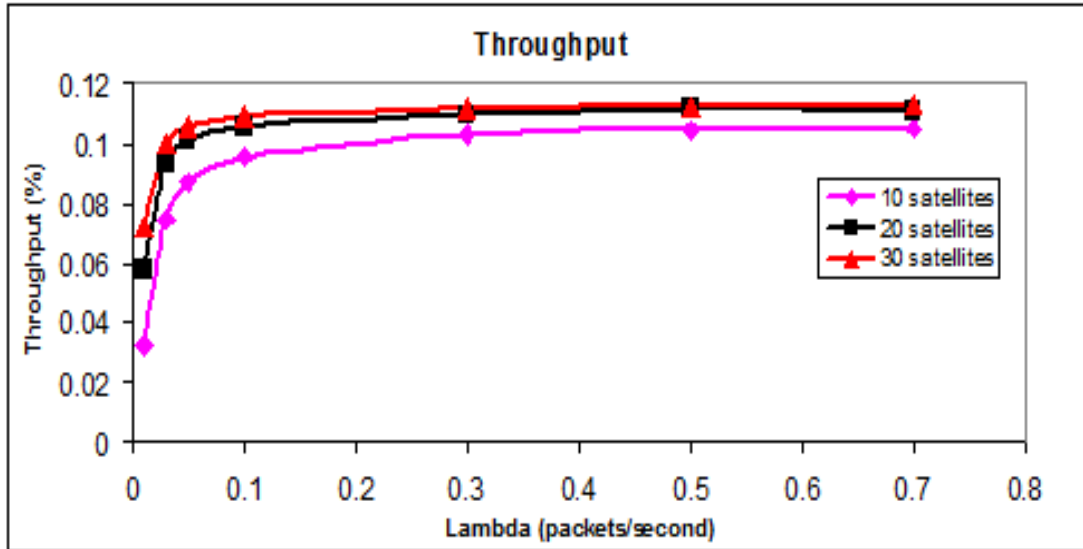


Figure 56: Throughput for Cluster formation flying pattern

Constellation formation flying pattern

For the Constellation formation flying pattern, three orbits at an inclination of 30° , 60° , and 90° are considered in the simulation model. We assume that the satellites in various orbits are deployed at various time instants and the satellites fly at a velocity of 3 km/s. We assume that the satellites share the same frequency band. In our simulation, we simulated the mobility pattern of the satellites by calculating the 3D location of each satellite every second and then finding the neighboring satellites. Analogous to Leader-Follower and Cluster formation flying patterns, we simulated the system with 10, 20 and 30 satellites in each orbit. Figures 13, 14 and 15 show the simulation results for the Constellation formation flying pattern. For the system with 10 satellites, the average end-to-end delay and average access delay is less, analogous to the other formation flying patterns for the same reasons as previously mentioned.

Figure 57: Average end-to-end delay for Constellation formation flying pattern

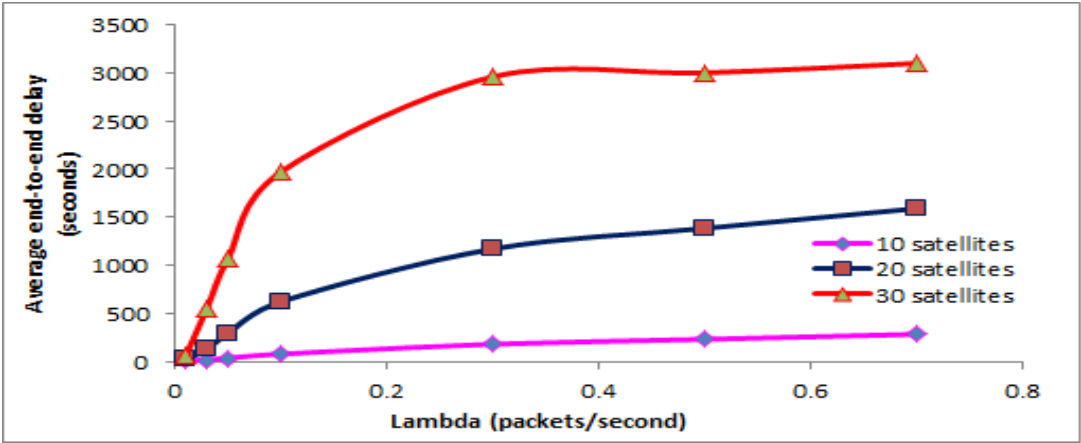


Figure 58: Average access delay for Constellation formation flying pattern

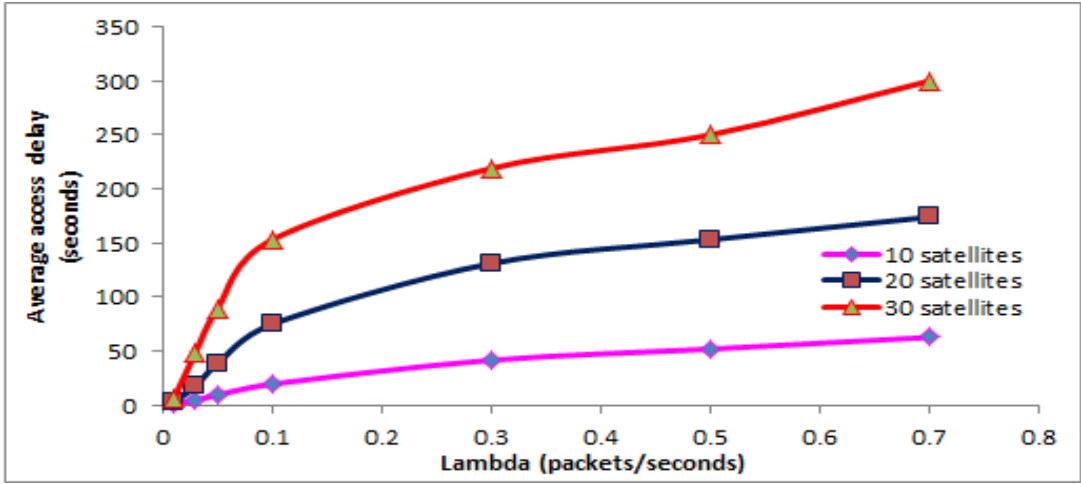
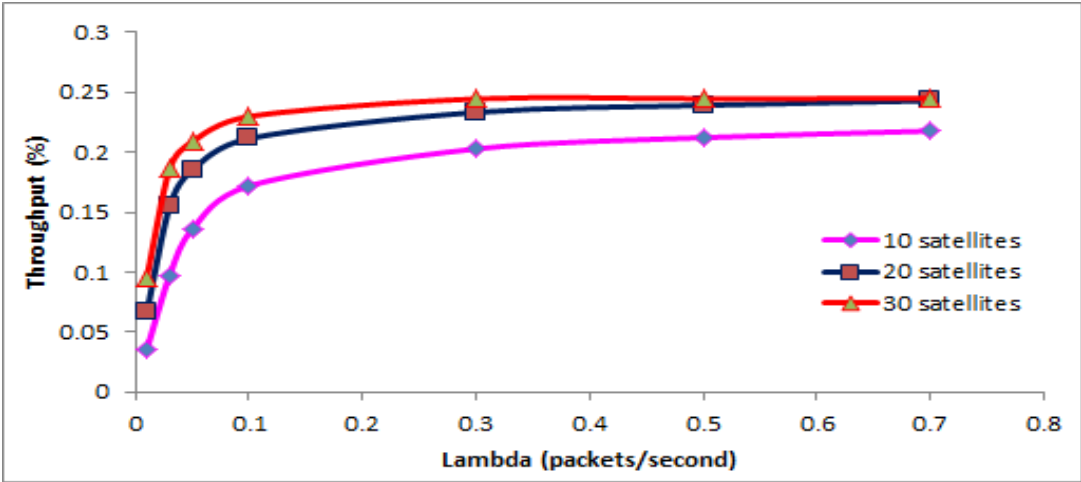


Figure 59: Throughput for Constellation formation flying pattern



Comparison of simulation results

The Figures 16, 17 and 18 compare the simulation results obtained from the three different formation flying patterns. For comparison, we considered the scenario in which each of the various formation flying patterns consists of 20 satellites per orbit. As observed from Figures 16 and 17, the average end-to-end delay and average access delay is less for Leader-Follower and Constellation formation flying pattern in comparison to Cluster formation flying pattern. This is because, for Cluster configuration, the orbits share the same frequency band and there are a number of satellites in the vicinity of each satellite which results in more contention and hence increased delay. For Constellation, though the satellites in various orbits share the same transmission frequency, the satellites in one orbit will not communicate with satellites in the other orbits, as they are deployed at various time instants according to the proposed model.

Figure 60: Average end-to-end delay comparison

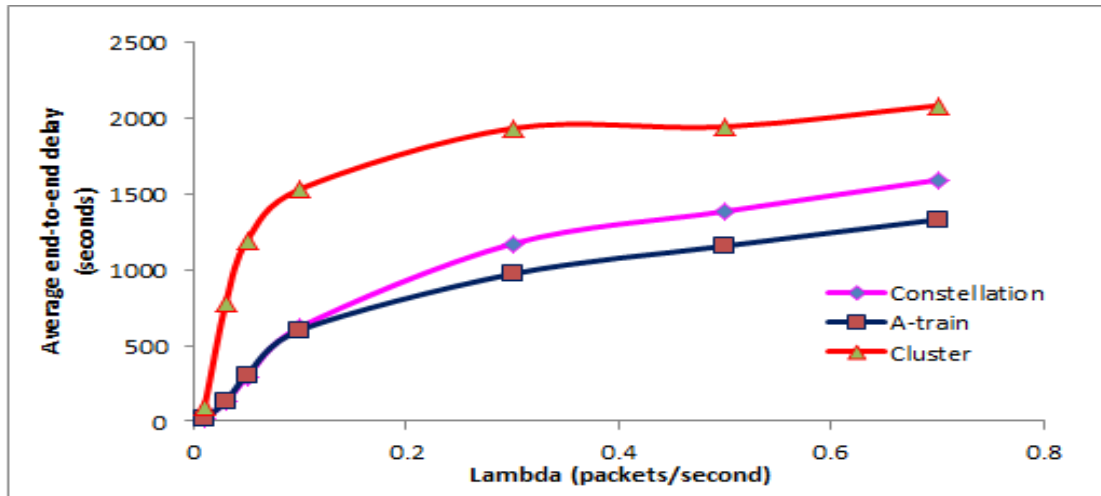


Figure 61: Average access delay comparison

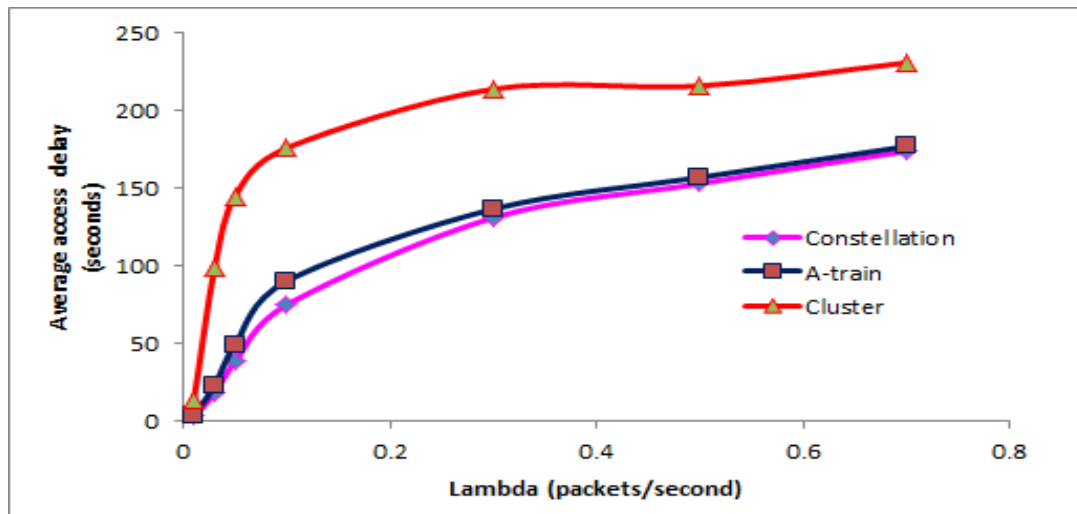
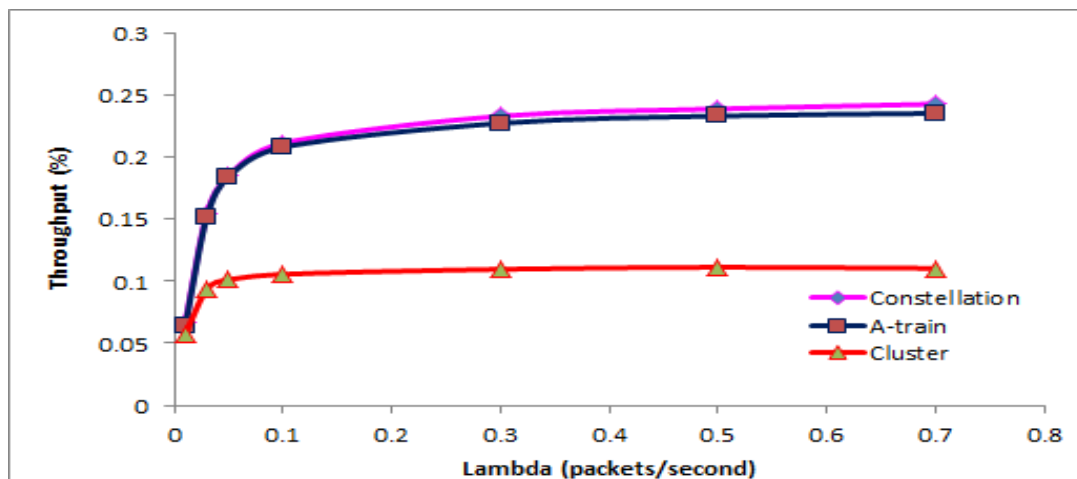


Figure 62: Throughput comparison



For Leader-Follower and Constellation formation flying patterns, the maximum throughput that can be achieved using the proposed CSMA/CA/RTS/CTS protocol is around 24%. As the average access delay and average end-to-end delay is comparatively more for Cluster formation flying pattern, the maximum attainable throughput is 11% as can be seen in Figure 18.

CONCLUSIONS

In this paper, we investigated three different formation flying patterns, namely, Leader-Follower, Cluster and Constellation. We proposed a feasible MAC layer protocol, i.e., modified CSMA/CA/RTS/CTS protocol that addresses the design needs of a small number of cubesats within a reconfigurable network.

The proposed protocol is suitable for science missions that can tolerate communication delays among the satellites. We proposed to use the shortest path algorithm for routing of data packets between the satellites. The various system parameters have been evaluated by extensive simulations for different configurations of small satellites in different scenarios. The maximum throughput that can be accomplished using the proposed protocols for Leader-Follower and Constellation formation flying pattern is around 24% and for Cluster formation flying pattern is 11%. The average end-to-end delay and average access delay is more for Cluster formation flying pattern in comparison to the other two formation flying patterns. The decision of which formation flying pattern to choose depends on various parameters mainly the mission application, mission architecture, number of satellites to be used for a particular mission, orbital strategies, power etc.

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DESIGN FOR SOCIAL INNOVATION IN FAVELA IN RIO DE JANEIRO: FROM OCCUPY WALL STREET TO "*OCCUPY ALEMÃO*"⁸

C. Cipolla, R. Bartholo, R.C.M. Afonso

ABSTRACT:

This article aims to place the environment conducive to social innovation found in the favela in the city of Rio de Janeiro, showing and analyzing a case in the "Complexo do Alemão" inspired by Occupy Wall Street movement.

The favelas of Rio de Janeiro is undergoing a major transformation resulting from public policies. Official information from this intervention by the state in a territory previously dominated by drug trafficking show substantial improvements. However, their youth residents are frustrated with the limit of top down interventions while strong social capital in the territory created a favorable environment for designing a project undertaken by them, influenced by access to information enabled by ICT environment, reshaped and reinvented a new form of occupation, with adaptations to local culture. Looked at from the perspective of networks and social ties, the paper points to a anthropophagic appropriation of a movement, Occupy Wall Street, resulting in a new design, reinvented on strong local bases, the "Occupy Alemão".

Keywords: *Favelas and Social Innovation; Occupy Alemão and Social Innovation; Design for Social Innovation; Anthropophagic Design*

BACKGROUND: DESIGN FOR SOCIAL INNOVATION

Informal settlements⁹ are complex social ecosystems, characterized by their lack of basic services (which has led to their being described as *underserved*

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⁹Informal settlements are: 1. areas where groups of housing units have been constructed on land that the occupants have no legal claim to, or occupy illegally; 2. unplanned settlements

communities) and by the (relative) density of specific forms of social ties (from traditional ones, such as those of family, clan and village, to new ones that have emerged in the particular context of informal settlements – including those imposed by criminal gangs).

Different social networks form these popular spaces, which facilitates the relations among their actors, in the search for individual and common benefits. Larissa Lomnitz (2009), a Latin-American thinker who researches about the central role of social networks within urban studies, claims that organizations that arise from informal communities use traditional institutions to survive. These institutions are "family, friendship, membership of an ethnic group or system of beliefs", that base themselves on their "cultural definition of trust and loyalty, which are central elements to the work of informal networks" (Lomnitz, 2009: 19). "A social network is a field of relations among individuals", that establishes "complex relations within a specific social space" (Lomnitz, 2009: 19). These relationships allow the formation of solidarity networks, what "implies in an exchange system of goods, services and information that occurs within the sociability" (Lomnitz, 2009: 19).

New arrangements of social actors are formed from these networks, what permits them to find new ways to solve their daily problems and to promote local qualities. The first working hypothesis assumed here is that these social networks are one of the key drivers fostering the development of social innovations in these localities.

The word "social" in "social innovation" refers both to the means and the end. As a means, it indicates that these innovations are based on the capabilities of the people who activate and benefit from the innovation, and also on unexpected interactions and partnerships between citizens, institutions, businesses, and governments. As an end, it indicates that the social effort is targeted to solve commonly recognized social problems that existing

and areas where housing is not in compliance with current planning and building regulations (unauthorized housing)" (OECD, 2013 n.p.).

businesses and technological solutions have failed to address (Mulgan et al. 2007).

Design for social innovation is an activity developed in two directions: the monitoring and empowerment of existing social innovation cases: or the design of solutions that are able to foster new social innovations.

In the first case, the activity of monitoring and empower social innovation cases, uses design skills to identify and describe social innovations as solutions, designed by local people, or non-designers. It assumes that design activity is considered "a multi-faceted cognitive skill, possessed in some degree by everyone" (Cross, 2009: 115) and the "silent" type of design (Gorb and Dumas, 1987). It is considered that designers, professionals and researchers have much to learn from social innovation cases and also that design can have a role in empowering, multiplying, envisioning and connecting social innovation cases (Cipolla and Moura, 2011).

The second direction, the design of solutions that are able to foster new social innovations, presents an approach that considers people and communities, not as problems, but as those who bring capabilities and the characteristics of the local context and their qualities (Manzini, 2007).

This paper, although considering that both directions on design for social innovation practices are related, place its focus in the first direction, more precisely, analysing a social innovation case, the "Occupy Alemão". The case takes place in the group of favelas called "Complexo do Alemão" in Rio de Janeiro and the objective of this paper is to take up lessons for design for social innovation research and practices, considering a specific context: the informal settlements and its characteristics. The broader background to this paper is the same as that of the DESIS¹⁰ Thematic Cluster¹¹ called Formal,

¹⁰ DESIS-Design for Social Innovation for Sustainability is a network of design labs based in design schools (or in other design-oriented universities) promoting social innovation towards sustainability. These DESIS Labs are teams of professors, researchers and students who

Informal, Collaborative (IFC) and constitute a partial result of this research activity.

RESEARCH QUESTIONS AND METHODS

Moving on from these hypotheses and conceptual framework, the paper presents and analyse the "Occupy Alemão" case, considering particularly these research questions:

Which role have the social local ties (or local social networks) played in fostering the "Occupy Alemão" case?

How are these local social ties affected by the global connections allowed as, for example, by the TICS?

Investigation was undertaken in the favela called "Complexo do Alemão", where the "Occupy Alemão" case was developed.

The qualitative research included: (a) desk research, which encompassed news, reviews and official communication; (b) semi-structured interviews with the group; (c) observational research (or field research) with direct observation in its "natural" setting; (d) monitoring the group's activities in networks, especially Facebook.

The interviews were interpreted and analysed with reference to the research question.

orient their didactic and research activities towards starting and/or facilitating social innovation processes.

¹¹ Thematic Clusters are initiatives promoted by groups of DESIS Labs that have found a theme of common interest, and agreed to align and systemize their on-going, programmed activities, with the aim of creating the most favourable conditions to conceive and enhance, locally and/or internationally, new and stronger outcomes. More about IFC thematic cluster on: <<http://www.desis-ifc.org>> [Accessed 1 August 2013]

CASE: THE "OCCUPY ALEMÃO"

The favelas of Rio de Janeiro and public policy

The city of Rio de Janeiro has 763 favelas (GALDO, 2011), the highest number in the country. Of its 6 million inhabitants, 1.4 million, equivalent to 22%, live in favelas (IPP, 2013) constitute the largest population of the favelas in Brazil. The strong arms of drug trafficking is a feature that distinguishes the favelas of this city, the other is the fact that many locate in areas of greatest economic power (IPP, 2013). In Figure 1 the red dots mark the favelas of the state.



Figure 1: Favelas in Rio de Janeiro State
Source: IBGE, 2011

Rio's favelas received in the last decade the deployment of numerous public policies that affect their lives and give them greater visibility. The four we consider most important to the theme are:

- **UPP - Unidade de Polícia Pacificadora**¹² (Pacifying Police Unit) - public safety policy of the State of Rio de Janeiro, was established in 2008, which aimed to "disarm" the drug trade in Rio's favelas. Constitutes occupation of territories by the armed forces and the implementation of community policing stations, encouraging closer ties between police and the population. Today, there are 37 installed, occupying 9,300 police (IPP, 2014).
- **Social UPP**¹³ - is a program that, after the implementation of the UPP, qualifies utilities, urban conservation, cleaning and garbage collection and street lighting (IPP, 2014). It started in 2009, operates in 28 territories, and is coordinated by the municipal authorities in partnership with UN-HABITAT - United Nations Programme for Human Settlements.
- **PAC - Programa de Aceleração do Crescimento**¹⁴ (Growth Acceleration Program) - launched in 2007 is a federal program that encompasses a set of economic policies with priority investment in infrastructure: sanitation, housing, transportation, energy and water resources. In the specific case of favelas, PAC is related to popular housing and urbanization.
- **Rio Digital State**¹⁵ - the policy of the State Government implemented in 2012 in "Alemão", provides signal free internet broadband.

Murray at all (2010) show that persistent social problems, old paradigms, increased costs of services and the government's inability to adequately solve important issues, can be triggers or circumstances that promote social innovation or mobilize citizens to get together positive change. All these characteristics are gathered in the city nowadays.

¹² See http://www.upprj.com/index.php/as_upps_us

¹³ See <http://uppsocial.org/programa/>

¹⁴ See <http://dados.gov.br/dataset/obras-do-pac-programa-de-aceleracao-do-crescimento>

¹⁵ See <http://www.faetec.rj.gov.br/index.php/rio-estado-digital>

Complexo do Alemão

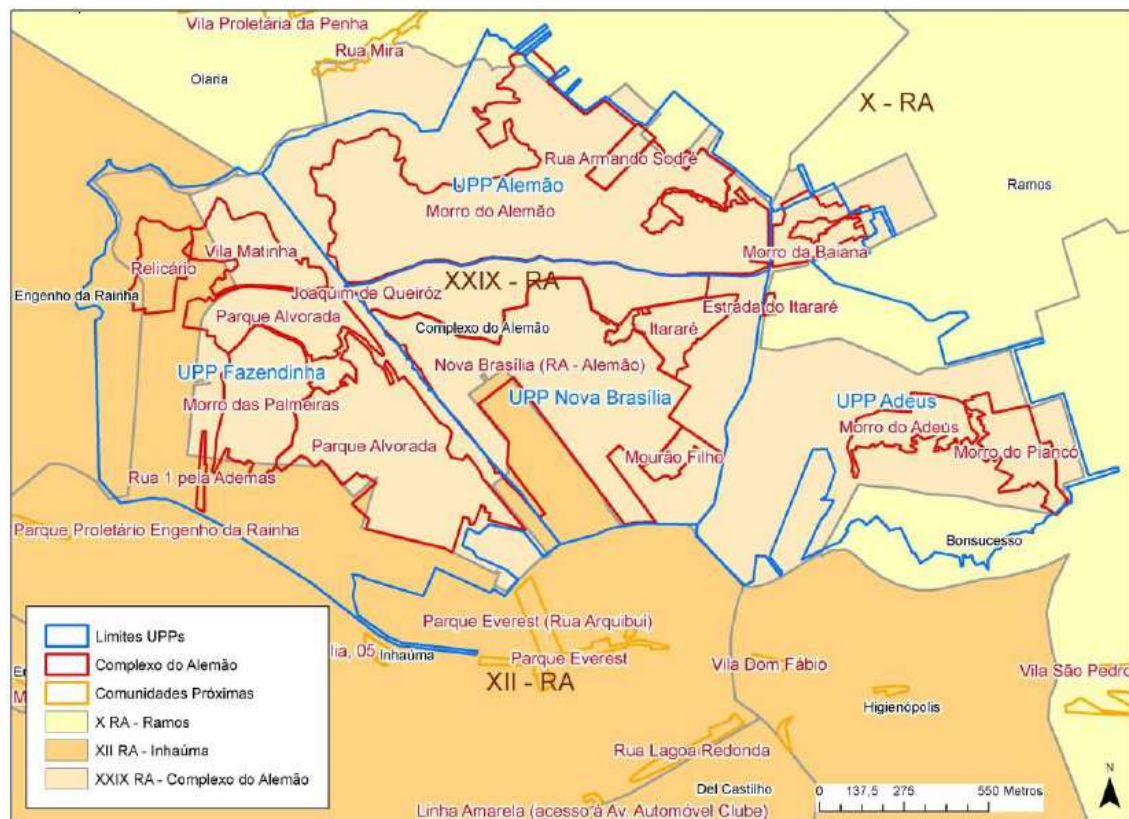


Figure 2: Communities Localization and Alemão's UPPs

Source: SABREN/ IPP, 2011, ISP 2011

The "Complexo do Alemão" is composed by 15 favelas (UPP Social, 2014) with four UPPs, located in the north zone of the city and was once considered the most violent city region suffering from the disputed territory by gangs. Figure 2 shows the location of communities and UPPs. Its total population amounts to 160,000 inhabitants in 18,000 households (UPP SOCIAL, 2014).

With PAC's investments a cable car system was installed, and it is used by residents and tourists who symbolically turned the place: from the more violent favela to a post card of the city¹⁶.

¹⁶

See

images:

<https://www.google.com.br/search?q=imagens+favela+do+alem%C3%A3o&client=firefox-a&hs=NeR&rls=org.mozilla:pt-BR:official&channel=fflb&tbm=isch&tbo=u&source=univ&sa=X&ei=9F97U-ePK8OhqAaL44CwCQ&ved=0CCKQsAQ&biw=1280&bih=891>

In 2012 the State Government has provided free wireless internet throughout the complex, allowing access of computers, laptops, smartphones and tablets (ORTIZ, 2011; Tecnoblog 2012) . The youth reported that 48.9% have the internet as one of the most frequented "cultural spaces"; 8.4% use the internet "always", 20.2% "sometimes", 11.4% "rarely" and 60% "never". Among the main difficulties to participate in cultural activities, 13.5% said "embarrassment by social origin" and 24.2% said the cost of transport (high). 62% of youth reported using the internet to get into social networks and 42.5% said that they use mobile phones for browsing the internet (BARBOSA & DIAS, 2013).

In this context, young Alemão groups emerged linked to political activism and culture. We explore one of them below.

"Occupy Alemão"

The "Occupy Alemão" is a project designed by seven young residents and have free inspiration arising in international mobilizations after Occupy Wall Street, in response to the limits set them by the police occupation, which they call "violence." Barbosa & Dias (2013) explain this vision:

"(...) The "pacification" also represents the period of closing several spaces of youth sociability within the favelas, by order of the command of the UPP were banned samba school activities, closed bars and concert halls, prohibited the closing of streets that were used as recreational space, and prohibited performing funk dances. A participant reported that where he lives people cannot stay outside after ten o'clock at night, which would inconvenience the young sociality and it results causing friction between residents and police" (BARBOSA & DIAS, 2013: 120).

For these young people, the favela shifted control of drug trafficking to the police, with the same authoritarianism. They believe that the solutions to problems that they live can and should come from themselves. The movement developed and publicly delivered a letter to the police command in repudiation of his actions. They claim that the movement was created by the decriminalization of public space in the favela. The group meets autonomous and systematically designing actions that try to rescue / occupy the public

character of the territories of the favela, and the term "occupy" in this case, places the discussion of what is, in fact, public in these territories.

Since 2012, the project brings together the young from Alemão and other favelas in order to promote a political, cultural and affective occupation of local public spaces. They want the favela to be recognized as "part of the town" with the main themes of action "right to the city" and "democracy of access to rights." These young people claim that from the police occupation and mobility projects in the favela, exogenous, the alleys and squares, places originally linked to the local culture, are becoming increasingly spaces of prohibition, repression and arbitrariness.

The occupation of public space was inspired by the Occupy Wall Street, as well as the open plenary and the web space (in this case on Facebook)¹⁷, but the reinvention of interventions has been transformed by the local living. Every cultural activities designed for occupancy, the young immediately activate their networks of friends and it is from them that they obtain funds for their activities.

They have the following main activities:

Free libraries - space knowledge exchange administered by the residents themselves, incorporated into the architecture and geography of the community.

Affective "rolezinho"¹⁸ - walking in the favelas and chat with locals about the rights of the favela, interested tourists to the city or not.

¹⁷ See <https://www.facebook.com/OcupaAlemao?ref=ts&fref=ts>

¹⁸ The term "rolezinho" (diminutive slang for "rolê" or "rolê", which means a walk) is typical of young from favela. In Brazil it is better known as a group in São Paulo scored a "rolezinho" in shopping through social networks, with the goal of getting to know each other. A high social class shopping was "invaded" without warning, thousands young people (the local press arrived to report 5000 youth) which caused a big misunderstanding between authorities, police, administrators malls and population, in a succession of waves of fear that closed several malls in Rio de Janeiro and São Paulo for a period between the years 2013 and 2014.

Cine-muro - films projected on the walls (in portuguese, "muro") of the favelas.

Political- graffitied - art on the walls of the favelas on issues related to rights.

Ties and motivations are linked networks of affection in the favela, as stated by its members:

"It is a relationship of friendship and affinity as a basic principle. The higher affinity we have is the willingness to change the world "(LIMA, 2013).

"What holds us together is the friendship and bond with the territory."

"After thinking about what we do, we activate our friends network for action".

"We all live in the same place, some on the same street, this closeness and friendship make it easier."

"We use the social networks as a tool, but we are friends."

In the city, the favela is commonly represented as something homogeneous, identifying this popular space a "strong socio-spatial stigmatization, especially inferred by residents of other parts of the city" (Silva, 2009: 22-23). We observe that it is precisely this stigma that makes the people come together to work collaboratively towards common social and economic benefits.

CONCLUSION

The "Occupy Alemão" is a social innovation that positively reinvents the territories of favelas, considered the "lack of civility and urbanity" (SILVA & BARBOSA, 2013: 29). It was designed as a response to the problems they

For the newspapers the young organizers define meetings as a "cry for leisure". See more:
<http://epoca.globo.com/vida/noticia/2014/01/origem-bdo-rolezinhob.html> e
<http://g1.globo.com/sao-paulo/noticia/2014/01/conheca-historia-dos-rolezinhos-em-sao-paulo.html>

face locally, including the persistence of social problems and the limits imposed by the police.

"Occupy Alemão" is also a form of creative affection among their members, between them and other residents and between them and the favela. Reaffirming Lomnitz (2009), what unites the group to action are the ties of friendship, the similar belief system – they want to change the world around them - designing the exchange of goods, services and information within the territory, activating their networks. They use the social networks (ICT) as a tool to activate their traditional personal networks, fostering social innovation in the territory.

The case "Occupy Alemão" indicates the impact that the transfer of social innovation ideas, from one context to another, can have. It is clear that the communication media, like internet, local to global connexions and vice-versa, played its role in the dissemination of the case "Occupy Wall Street" all over the world and to make it work. It stresses also the importance of creating specific channels that are able to spread social innovation ideas between communities all over the world. For this purpose, networks and specific projects related to the dissemination (and empowerment) of social innovation ideas are starting to grow and spread¹⁹.

In the specific case analysed, and accordingly with our conceptual framework, young people in the favela "Complexo do Alemão" started up an "silent" design process, there was no involvement of professional designers. People were able to design solutions to their own problems.

Inspired by the cultural "anthropophagic" movement - that happened in Brazil in 1928 (ANDRADE, 1928)²⁰, it is possible to affirm that "Occupy Alemão"

¹⁹ Networks like DESIS (<http://www.desis-network.org>) and SIX – Social Innovation Exchange (www.socialinnovationexchange.org), or projects like Africa Brazil Dialogs, developed by a group of partners from Brazil and Africa, using vídeos to communicate social innovation cases for communities: <https://www.facebook.com/AfricaBrasilDialogs?filter=3>

²⁰ Led by Oswald de Andrade, Brazilian writer and involving actors of the modernist movement in the country, had as the main document "Manifesto Antropófago". This manifesto had proposed as the appropriation of foreign culture (not its negation) in local cultural foundations.

have undertaken an anthropophagic process, starting from “Occupy Wall Street” case.

This was not a simple mimesis, but inspired on the North American case, the South American youngsters, living in a favela, promotes their own “Occupy”, particularly related to their own possibilities and challenges, and the characteristics of their locality. This opens up the possibility to investigate further, what is being called an “anthropophagic design” practice.

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TOWARDS A COMFORTABLE, ENERGY-EFFICIENT OFFICE USING A PUBLISH-SUBSCRIBE PATTERN IN AN INTERNET OF THINGS ENVIRONMENT

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ABSTRACT

The modern office is maintained by air conditioners, heaters, lights, smoke detectors, thermostats and other devices. Manufacturers are continually improving these various devices and adding more features – especially Internet connectivity. These new devices are often called smart devices. The Internet of Things is the new paradigm of more and more physical objects being connected to the Internet. As these objects begin interacting, mechanisms need to be in place to route data messages from the many objects to the correct applications which process that data. For example, the data from the thermostat in Office A must not be routed to the application controlling the temperature in Office B. One such mechanism is the publish-subscribe pattern often just called the pub-sub pattern. The pub-sub pattern enables applications to subscribe to data from certain resources. When a resource publishes data, the surrounding platform ensures that the data is forwarded to the correct subscribers. This paper describes an implementation of the pub-sub pattern specifically for an Internet of Things platform which operated at four levels – sensors (and actuator), Supervisors, Middleware, and application. This platform was specifically instantiated to control a typical office meeting room. The instantiation monitors the state of the doors and windows (open or closed), whether there are people in the room, the current temperature in the room, and the current electrical consumption. It then makes intelligent decisions as to how best to control the air conditioner in the meeting room.

Keywords: *IoT, pub-sub*

INTRODUCTION

The modern office consists of typical digital devices such as computers, fax machines, and telephones and also includes devices which are not primarily thought of as digital devices. These unseen devices consist of items such as air conditioners, heaters, smoke detectors, and lights. However, these devices are becoming more and more digital as manufacturers add features to them. In adding features, these devices start generating data and responding to data.

Beyond the office, the world is full of data. A simple walk down the street could overwhelm a person with millions of bits of data if there was not some sort of discrimination mechanism to filter this information. Sometimes this human discrimination mechanism gets distorted. The prime example of this is when a person buys a new car and then begins to notice that same make and model of that car everywhere in traffic. The prevalence of that make and model car does not increase substantially; the person merely notices the make and model car more often.

The Internet of Things is also full of data. As more and more physical objects become Internet enabled, the amount of data increases. For applications which are monitoring these objects or subsets thereof, a mechanism is needed to enable the applications to only receive data from objects in which they have an interest. One such programming pattern which has been implemented to solve this problem is the publish-subscribe pattern (often called the pub-sub pattern).

In a publish-subscribe implementation, subscribers have the ability to express an interest in a particular event and they are subsequently notified by a publisher when the event occurs (Eugster, Felber et al. 2003, Huang, Garcia-Molina 2004, Tarkoma 2012). This paper describes work in implementing a pub-sub pattern for the Internet of Things linking together four levels of components from sensors (or actuators), a supervisor device, a middleware router, and an application.

BACKGROUND

Since its inception, the Internet has grown from a few inter-connected computer nodes to a network servicing more than a billion users (Kopetz 2011). Physical objects are being enhanced with electronic components giving the objects the capability to interact with the Internet. This connection of physical things to the Internet makes it possible to access remote sensor data and to control the physical world from a distance (Kopetz 2011).

As more physical objects are connected to the Internet, scalability becomes increasingly important. As billions of objects start communicating using the Internet of Things, scalability mechanisms which enable high volume communication become more important (Uckelmann, Harrison et al. 2011).

RESEARCH QUESTION AND METHODOLOGY

The research question addressed with this paper is “Can the pub-sub pattern be implemented for an Internet of Things platform which controls the level of human comfort in an office environment?” Here, the paper investigates a phenomenon which is the result of human activity and also under the control of humans as opposed to activities that are beyond human control. Vaishnavi and Kuechler (2013) indicate that the Design Science Research methodology is well suited for investigating a phenomenon as described here. Purao (2013) also indicates that the goal of the Design Science Research methodology is to change reality through the creation of artifacts in order to address a perceived problem. The problem addressed here is the use of a pub-sub pattern used in conjunction with the Internet of Things in order to control certain aspects of an office environment. From the preceding, it seems that the Design Science Research methodology would suit the current research project well. Therefore, the Design Science research methodology is used in conducting the current research.

The application of the Design Science Research methodology prescribes that an artifact be developed. The artifact could be a construct, a model, a method, and/or an instantiation (March, Smith 1995, Hevner, March et al. 2004). Constructs consist of vocabulary and symbols, whereas, models are

abstractions and representations. Methods are algorithms and practices, whilst instantiations are implementations or prototypes of models and/or methods.

Hevner et. al. (2004) state that the Design Science Research methodology is a design process which is both incremental as well as iterative. What makes the Design Science Research methodology attractive for certain types of research questions is that this methodology makes provision that not all the required knowledge for answering the research question is known at the onset of a project. As described by Vaishnavi & Kuechler (2013), this methodology acknowledges that additional information is gathered during each iteration. Here, an iteration typically consists of three phases, and these are the suggestion phase, the development phase, and the evaluation phase. An additional phase is relevant at the onset of the research, and this phase is called “awareness of the problem”. In addition, a final phase is executed at the end of the final iteration, and this phase is called “conclusion”. Whereas a full iteration comprises of these five phases, not all the phases need to be executed during all the iterations; some iterations may terminate immediately after either the development or evaluation phases have been concluded. Upon such termination, knowledge gained from the current iteration is added to the existing (and incomplete) knowledge base and this process is called “circumscription”.

For the scope of this research project, both a model of how the pub-sub pattern could be used with Internet of Things was created and an instantiation or implementation of that model across four levels of interaction.

Kuechler, Vaishnavi, and Petter state that Design Science Research is also called “improvement research” (Vaishnavi, Kuechler 2007, p. 32) which emphasises the problem solving and improvement nature of the research. The set of five steps mentioned above that comprise awareness, suggestion, development, evaluation, and conclusion, is also known as the General Design Cycle.

All Design Science Research begins with an awareness of a problem. This awareness can be created by reading literature, conversations with colleagues, or personal experience. The suggestions on how to solve this problem can also come from existing literature or can come from conversations with colleagues. These suggestions are then investigated in detail and actually developed. The resulting artifact is subsequently evaluated to see if it solves the problem. Conclusions can then be drawn.

It is important to note that the General Design Cycle is, in fact, a *cycle*. The five steps can be iterated numerous times, with the design usually improving in each cycle.

ARCHITECTURE

An overview of the architecture is depicted in Figure 1. At the lowest level of the architecture are a number of sensors and actuators which communicate with the physical world. These include a passive infrared (PIR) detector, temperature sensor, current sensor, door and window sensors, and an actuator in the form of an air conditioner. All the sensors send their data to an Arduino Uno circuit (Barrett 2012), whilst the same circuit controls the actuator. In turn, the Arduino board communicates with the Raspberry Pi circuit (Barnes 2014) via a USB cable. Python programming language software executing on the Raspberry Pi circuit implements the pub-sub pattern. This software is called the *Supervisor*. Supervisors are designed to communicate with the *Middleware* using either a wired network or wireless network (depending on the capabilities of the particular Raspberry Pi circuit employed in the design). The Middleware executes on a host computer which, in turn, routes messages to the correct application. Communication between the Supervisor and the Middleware is possible using standard Internet communication layer technology such as a wired network (CAT5 or CAT6) or a wireless network such as WiFi. Our implementation makes use of a wired network. Although this architecture makes provision for multiple supervisors, this research project only considers a single supervisor. RESTful HTTP is the higher level protocol that links the Raspberry Pi, the Middleware, and the applications. Communication between the Arduino Uno circuit and

the Raspberry Pi circuit is supported by the open Firmata protocol (Margolis, Weldin 2011).

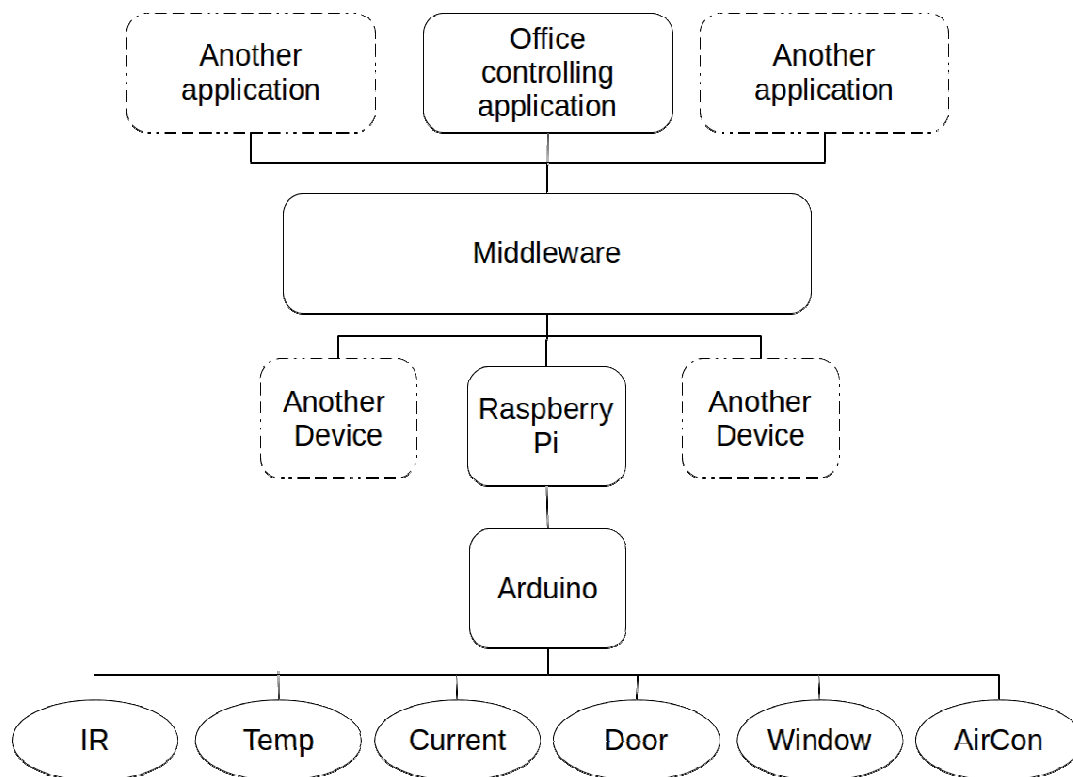


Figure 63: Architecture

In our implementation, all HTTP messages for pub-sub are encoded as JSON (JavaScript Object Notation) messages. It is important to note that the messages for resource discovery (which are not necessarily the subject of this paper) are in CoRE Link format (Shelby 2012) rather than JSON. The actual format of these JSON messages constitute the bulk of this paper.

As more physical objects become connected to the Internet, the imperative to move from IPv4 (Internet Protocol version 4) to IPv6 (Internet Protocol version 6) becomes stronger. IPv6 (Stallings 1996) uses 128-bit addressing, thereby providing for 2^{128} uniquely identifiable devices as opposed to the alternative IPv4 addressing which uses 32-bit addressing and consequently allowing for only 2^{32} uniquely identifiable devices (Hain, Huston 2005). In this model and implementation, IPv6 is only used for communication between the Middleware and the Supervisor. The remaining portion runs on IPv4.

ENROLMENT

When supervisors and/or applications wish to utilise the Middleware, it is necessary to first enrol with the platform. This enrolment process requires information including a unique identifier, and the type of the object. Of primary importance, however, is that the enrolment process includes the IP address (either IPv4 or IPv6) of the object and a port number. Depending on the object type, additional information could be included. For example, in the case of software applications an additional context could be provided. A sample message could look like:

```
{
  "name" : "name of the object",
  "hostAddress" : "host address and optional port number:",
  "uid" : "unique identifier",
  "context" : "optional context of use by software
applications",
  "type" : "the type of the object"
}
```

This information is sent by either the Supervisor or the application to the Middleware using RESTful PUT.

RESOURCE DISCOVERY

In order for the pub-sub pattern to work, it must be preceded by a discovery of the available resources. For example, in Figure 1, if the application shown needs to subscribe to a published value on a sensor, it must first discover that sensor. There are a number of mechanisms which could be used for discovering resources (such as sensors and actuators) (Shelby 2010), but the use of a well-known core file also known as CoRE (Constrained RESTful Environments) Link format (Shelby 2012) was chosen for this research.

In the case of an implementation (such as this one) that uses the Constrained RESTful Environment Link format, each Supervisor publishes a well-known core file. This file is an aggregation of the devices which the Supervisor monitors and actuates. The Middleware then aggregates all well-known core files from each supervisor. In addition, at a higher level, applications can also

publish their own well-known cores which are also aggregated at the Middleware level. An example of an extract from a well-known core file is as follows:

```
<http://[xxxx:xxxx:xxxx:x::312]:8104/window>;rt="window-  
string";uid="20001234";title="Matrix boardroom window state as  
o/c",  
<http://[xxxx:xxxx:xxxx:x::312]:8104/temperature>;rt="temp-  
float";uid="20001234";title="Matrix boardroom temperature in  
Deg C",  
<http://[xxxx:xxxx:xxxx:x::312]:8104/ampere>;rt="ampere-  
float";uid="20001234";title="Matrix boardroom airconditioner  
power consumption"
```

SUBSCRIBE AND UNSUBSCRIBE

When an application or other entity wishes to subscribe to a resource (assuming that discovery has already occurred), a subscription request is sent from the application to the Middleware via a RESTful PUT message. The JSON subscription messages adhere to the following format:

```
{  
    "publisher"    : "publisher identifier",  
    "subscriber"   : "subscriber identifier"  
}
```

Here, the strings "publisher identifier" and "subscriber identifier" represent identifying strings of the publisher and subscriber respectfully. Other security messages unrelated to the pub-sub pattern are implemented to keep track of the IP address (IPv4 or IPv6 as appropriate) in order to send and identify subsequent messages.

Through previous discovery requests, the Middleware knows which Supervisor manages the sensor indicated by the publisher field and forwards the identical message to the Supervisor. In the model, in order to unsubscribe from a resource or sensor, the application must send the identical JSON

request as an HTTP DELETE message. However, in the actual implementation of this feature, it was found that the Java implementation of `HttpURLConnection` does not support a payload with the DELETE request and a modified format was used in the instantiation by sending all the required data as HTTP query parameters.

DATA

In the current implementation, the Supervisor continually monitors data received from the sensors. When appropriate, the supervisor forwards this data to the Middleware as a JSON message of the following format:

```
{
  "resource" : "publisher identifier",
  "values"   : [
    { "timestamp" : "date value" },
    { "value"     : "data value" } ...
  ]
}
```

where "publisher identifier" is the same publisher indicated in the subscription. Any number of timestamp/value pairs can be included in the values array. This bundling of data would be appropriate when Supervisors were offline for periods of time. When the Middleware receives such a message, it forwards it to as many applications as have subscribed to the particular sensor. In other words, data is sent once from the sensor to the Supervisor and once from the Supervisor to the Middleware. Then the data is forwarded multiple times to the various applications that have subscribed to the particular sensor. In addition, the Middleware stores all data on a transaction file for later analysis if necessary.

IMPLEMENTATION

For the actual implementation for this research project, an office meeting room was instrumented with multiple sensors and one actuator. Sensors

were mounted on the door and window which could indicate if the door or window changed state from open to closed or from closed to open. A passive IR sensor was installed to determine if there were people in the room. There were also a room temperature sensor and an electrical current sensor on the air conditioner unit. In addition, there was an actuator which controlled the output of the air conditioner. The air conditioner could be instructed to turn on, to turn off, to increase output, and to decrease output. However, a heater was not implemented in this research project.

Application

In this particular implementation, the application subscribed to the change of state in a door and in a window. That means if the state of the door or the state of the window changed from open to closed or from closed to open, the application received that information. The application also subscribed to the passive IR sensor to indicate if there were people in the room. In addition, the application subscribed to the temperature in the office meeting room and periodically received this information. At the time of authoring this paper the current sensor was not used. The application implemented a number of rules such as:

- e. If the door or window was open, then the air conditioner unit would be turned off.
- f. If the door and window were closed, and there were people in the room, then the air conditioner would be turned on.
- g. If the temperature was above a certain threshold, and there were people in the room, and the door and window were closed, then the air conditioner would increase output.
- h. If the temperature was below a certain threshold, and there were people in the room, and the door and window were closed, then the air conditioner would decrease output.

Supervisor

Although the Raspberry Pi Model B circuit contains a powerful processor along with USB ports, high definition video output capabilities, solid state memory, and Ethernet connectivity, it lacks robust input/output capabilities with which to interface with experimental electronic sensing and control circuits. An often used companion for the Raspberry Pi circuit is the Arduino series of electronic circuits. The Arduino circuits, and specifically the Arduino Uno series, are designed and developed as open technology experimental circuits. These are ideal for novice electronic enthusiasts who want to connect devices in the physical domain to software processes executing in the digital domain. Although the Arduino circuit lacks the processing power, USB ports, Internet connectivity and solid state memory capacity of the Raspberry Pi, it excels at simplicity, convenience, cost, and robustness. These three attributes make the Arduino Uno circuit an ideal companion to the Raspberry Pi circuit when the digital and physical domains have to be interconnected. For the current implementation of the Supervisor, the Raspberry Pi and Arduino Uno circuit combination as described here have been used.

Raspberry Pi Circuit

In the current implementation, the Raspberry Pi circuit executes complicated software routines whereas the Arduino Uno circuit executes relatively mundane routines. Although these routines executing on the Arduino Uno circuit may not be as sophisticated as those executing on the Raspberry Pi circuit, they nevertheless provide the interface between the physical and digital domains which is so important to this research project.

The processes executing on the Raspberry Pi circuit rely on a version of the Debian operating system for support, such as providing access to the Ethernet and USB ports. This version is called Raspbian. All of the custom software executing on the Raspberry Pi circuit were written in the Python interpreted programming language. This language is preinstalled with the Raspbian operating system and is simple to use.

Two software modules are core to the operation of the Supervisor. The first of these is the module which interfaces with the process executing on the Arduino Uno circuit. Using this module, the status of the Arduino Uno circuit's hardware pins can be monitored and controlled. How these pins are used is described in the paragraphs that deal with the Arduino Uno circuit. Depending on how frequently the overall system needs to be informed of changes in the physical domain, the software can interrogate the Arduino Uno circuit at a wide range of timing intervals. In the current implementation, the status of the Arduino Uno circuit's hardware pins are updated at a rate of approximately once a second. Although this rate is not usually required for sensing the status of doors and windows, or determining the temperature in the room, it is very useful in determining the instantaneous current consumed by the air conditioner in the room. These currents can fluctuate widely within the span of a few seconds and it is worthwhile to capture these fluctuations at a resolution of one second intervals. The second software module executing on the Raspberry Pi circuit is responsible for communicating with the Middleware. Communication is accomplished using the Constrained RESTful Environments Link format and JSON formatted messages. Physical communication between the Supervisor and the Middleware is achieved using the Ethernet interface which is available on the Raspberry Pi circuit. An alternative physical communication channel is by means of a WiFi radio, but this research project did not implement this option. The following subsection describes the Arduino Uno circuit which is used in tandem with the Raspberry Pi circuit to create a Supervisor hardware module.

Arduino Uno circuit

A Raspberry Pi circuit is not fully capable of interfacing to the physical domain without the aid of additional electronic circuitry. It is for this reason that the Arduino Uno circuit is used in conjunction with the Raspberry Pi circuit. Together, these two circuits constitute the hardware framework of the Supervisor. A system architect can specify which sensors and actuators should be integrated with the Supervisor framework. In the current design, two separate sensors for a door and a window, a passive IR sensor, a temperature sensor, and a sensor to measure the flow of electrical current to

the air conditioner located in the meeting room are implemented. Although the Arduino Uno circuit does not host a powerful processor such as contained in the Raspberry Pi circuit, it nevertheless has a processor suitable for controlling and sensing connected devices. The same processor also executes software which communicates with those executing on the Raspberry Pi circuit. Communication between these two circuits follows a protocol implemented by the open standard Firmata software suite. This software suite was developed by a volunteer software community and is available for use on a wide variety of processor dependant hardware platforms, of which the Arduino Uno circuit is one. Using the Firmata suite on the Arduino Uno circuit, commands can be received from the Raspberry Pi circuit and results can in turn be relayed back to the Raspberry Pi circuit from the Arduino Uno circuit.

As used in this research project, each of the door and window sensors is connected to one of two input pins respectively on the Arduino Uno circuit. Because the door and window sensors are in the form of reed switches, additional biasing resistors were also attached to the two respective input pins. Without these resistors, and while the reed switches are in an open state, spurious electrical signals might cause erratic changes in the sensed pin; the addition of the resistors eliminates this problem. Both the door and windows sensors are activated by the presence of a magnetic field. To sense whether a door is open, a reed switch is attached at the top of the door frame with this position being on the side opposite to the door hinges. A permanent magnet is in turn attached to the door in a position corresponding to the reed switch. The result is that the reed switch is activated by the permanent magnet when the door is closed, and the reed switch opens again when the door opens. Detecting the status of the window is similar to that of the door. Here, the magnet is attached to the top of the window and the reed switch to the top of the window frame in a corresponding position.

Temperature is sensed using a dedicated sensor procured for this purpose. This sensor has three electrical connections and presents the current ambient temperature in degrees Celsius. Two of these connections supply power to

the sensor, with the third connection being assigned to providing data representing the temperature.

It is not only the temperature sensor that requires a power source; the passive IR sensor also contains its own electronic circuit which must be powered via two wires. As is the case for the temperature sensor, power is supplied by the Arduino Uno circuit. Also similar to the temperature sensor, a third electrical connection provides data that reflect the presence or absence of one or more persons in the meeting room. The data thus provided is maintained on the third electrical connection for a period of approximately 500 milliseconds and can be described as follows: When no person has been detected for 500 milliseconds, the data is set to a binary “0”. However, when a person is detected, the data is set to a binary “1” and remains in that state for 500 milliseconds. After this time has expired the data will be set to a binary 0 until such time as a person is detected again.

Detecting the electrical current that flows to the air conditioner is somewhat more complicated than detecting the binary states of the sensors described above. To detect the electrical current, a device known as a “current transformer” is attached around the “live” wire leading to the air conditioner. A resistor is connected *in situ* and across the current transformer. The result is a varying analogue voltage that provides a direct indication of the current flowing through the live wire. Unfortunately this simple configuration does not cater for a phase difference between the voltage and the current flow in the wire being monitored. However, for the purposes of this research project, this small inaccuracy is acceptable. An analogue sensing pin on the Arduino Uno circuit provides a means of measuring the changing analogue signal.

The final attachment to the Arduino Uno circuit is an infrared emitting diode with which the air conditioner can be controlled. This diode is placed in close proximity to the air conditioner’s own infrared signal receiver, thereby allowing the Arduino Uno circuit to control some of the functions of the air conditioner in lieu of the usual hand controller.

RESULTS

A number of experiments were conducted while the meeting room was in use. Specific problems which were encountered included:

- a. The air conditioner in the office was mounted high on the wall and, initially, the temperature sensor was mounted at that same height. This location was not ideal and the sensor was subsequently moved. Initially, when the air conditioner expelled cold air, the cold air descended below the temperature sensor. This meant that during our original implementation, the application continually received temperatures which were high (hot air rises) and kept increasing the output of the air conditioner unnecessarily. However, the people in the meeting room were experiencing very cold temperatures since the cold air produced by the air conditioner settled at lower levels. Later configurations placed the temperature sensor at desk height.
- b. Passive IR sensors operate by detecting signal changes as a heat source moves across adjacent detection zones. These zones are determined by a Fresnel lens mounted in front of an IR detector. Body heat generated by humans is usually sufficient to trigger a passive IR sensor. Using such sensors, it is usually possible to determine if one or more persons are within a room as long as at least one person does not remain stationary. If a person is seated in a high backed chair and turned away from the sensor, the sensor is not able to detect the radiated heat through the chair back. In some cases, if the person was above average height and his or her shoulders and head cleared the high chair back, then the person could be detected. Shorter people were often not detected. For the scope of this research, this problem was not satisfactorily solved.

The solution to problem #1 above, however, is an example of the advantage of the General Design Cycle: awareness, suggestion, development, evaluation, and conclusion. By evaluating the design numerous times and cycling over the steps, the design could be improved. For example, on the actuation side:

- a. The controlling application could turn the air conditioner on and off appropriately (taking into account the two problems indicated above).
- b. The controlling application could increase or decrease the output of the air conditioner appropriately (again, taking into account the two problems indicated above).

The primary scope of this research, however, was to determine if the pub-sub pattern was suitable for such an environment which attempted to control the comfort of an office meeting room while, at the same time, being energy efficient. In this respect, the pub-sub mechanism worked properly and removed the requirement of wasteful polling to obtain data from the sensors.

CONCLUSION

As more tangible objects become Internet connected, the Internet of Things grows. Mechanisms need to be put in place to be able to easily monitor the data which are being generated by this vast collection of smart objects. This paper investigates whether the pub-sub model is suitable for an Internet of Things platform which operates at four levels (sensors or actuators, Supervisor, Middleware, and application). A model is created for this interaction. The model was subsequently instantiated using HTTP with all HTTP messages being in the format of JSON messages.

Although this paper primarily investigates the use of the pub-sub pattern, it is important to note that there are two supporting mechanisms. First, there is an enrolment/unenrolment mechanism allowing subscribers to join and leave the platform. The enrolment process also provides important additional information about the object. Second, there is also a discovery mechanism which allows subscribers to look for potential publishers of information.

As the word “towards” in the title of this paper indicates, the work reported here is the first of multiple anticipated design cycles. Some of the design challenges we faced are stated in the results section, but other challenges remain. For instance, we are investigating mechanisms by which we can determine the number of persons in the room as well as get an indication of

their activities within the room. We then hope to find a correlation between the energy consumption and the activities taking place within the room.

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APPLICATION OF DESIGN THINKING IN THE DEVELOPMENT OF AN INFORMATION SYSTEM THROUGH A SCRUM METHODOLOGY

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ABSTRACT

Many studies have sought to understand the failure of Information Systems projects and factors that make other software products more successful than others. Some publications have proposed modifying project management techniques and developing ad hoc software development methodologies to address these concerns. As a result, the Information Technology industry has invested in design thinking as an alternative to market research and as a solution for developing artefacts that are likelier to be accepted by end users. However, design thinking is sometimes applied in isolation and without consideration of the teams involved and as a result its return on investment is not well understood.

The paper is based on a research that introduces design thinking to a large scale software development project for the metropolitan city of South Africa. Design thinking capabilities and its core values are introduced to the scrum team from the conceptual phase of the project to the implementation phase. The paper evaluates the role and impact of design thinking within the context of a scrum team to evaluate the various team dynamics and the artefacts produced through this intervention.

Keywords: Design thinking, Scrum

INTRODUCTION

When we hear Design Thinking, many different concepts and terms come to mind. This results in the interchangeable use of design thinking with terms and concepts such as innovation, creativity, invention and research and development (R&D). (Collopy 2009; Brown 2009a; Nassbaum 2009) debate on the different meanings of design thinking and argue that terms such as innovation and creativity can be harmful and at the same time add value to

the concept. Cross (1999) argues that design thinking is in danger of losing its meaning because the concept is misconstrued or it is simply just understood according to the school of thought that defines it. As a result, the different definitions and understandings of design thinking within literature and industry create confusion and cause detriment to the discipline. This paper does not seek to define nor discuss the origins of design thinking but to apply its applicable and relevant facets within the scope of the research.

From (Reid, 2014), the principles of design thinking are similar to agile software development, customer relationship management, business process management and many other related fields of product/service development. The multidisciplinary approach of design thinking and its application by different industries is predicated from its ability to be utilised on ad hoc needs or value to the set objectives. Within the Information System (IS) discipline, methodologies can be classified as Process-driven, Blended, Object-oriented, Rapid development, Organisational-oriented and People-oriented (Avitson & Fitzgerald 2006). The design thinking capabilities can make use of these methodologies and as a concept it can be integrated within these IS methodologies without compromising their inherent principles. The structured nature of some IS methodologies such as the Waterfall model or the Rational Unified Process (RUP) sometimes stymie ideas and new concepts to technology. In support of this notion, (Jabi et al 2007) propose the use of ubiquitous social computing technologies to enable novel, creative and richer outcomes through the architecture design approach. The application of design thinking within the context of the research is applied within the agile methodology to support the notion of creativity and adaptability.

The focus of this research is to evaluate the impact of design thinking within Agile methodologies specifically Scrum in IS projects. Scrum as the selected methodology is classified as a Process-driven methodology although some of its principles and values are incorporated from other methodologies. Scrum was developed to handle large complex projects because of its ability to handle agility and rapid changes of software development projects. According to Shwaber & Sutherland (2011), scrum is not a technique or a process for

developing products, but a framework which can be integrated with different techniques and processes. Through this notion, scrum is an ideal agile methodology to apply design thinking because of its openness and ability to be infused with other constructs of agile methodologies and its adaptability to different business contexts. Scrum embraces innovation oriented approach to software projects and a flexible project planning therefore it is anticipated that with the introduction of design thinking there will be agility.

The paper is based on the development of a large software system that is developed for the metropolitan city of South Africa. The paper is partitioned into three sections; the first section the authors study the literature of design research and scrum methodology within the scope of the IS discipline. This approach is applied within the conceptual phase of the development of the system in planning, analysis and design. Design thinking is introduced in this phase of the system development life cycle (SDLC) because of the limited risk to project failure because of the magnitude of the system that is developed. The authors evaluate the composition of the team to understand different team dynamics and influences within the development of the system that may stymie the progress of the project. The discussion of design thinking aims to identify problems with the concept and its value add to scrum teams. The ultimate objective is to develop a user centric system through the development of strong user stories inherited from the Persona Driven design. The last section is an evaluation and data analysis of results drawn from focus groups of the scrum team and observations made from users of the current and the new system. The contribution of the paper is to provide an understanding of the intangible subsets within the development of a system by making an explicit link between social science and the technical nature of IS projects. The application of design thinking will expand our notions of design thinking and maybe realise that it should not be placed in any box but rather embrace it even with its misinterpretations.

RESEARCH THEORY

Burnette (2009) discusses the need for a theory that can support different levels and objectives of complex projects. The proposed theory for the study

is Design Theory. Cross (1999) defines design theory as a tool to support the creative and tacit nature of various design processes. In addition, design thinking embraces an unstructured approach to problems and fragmented processes followed when developing conceptual ideas into meaningful artefacts, hence it has been commonly associated with 'wicked problems'. Cross (1999: 7) states that "we have come to realise that we do not have to turn design into imitation of science, nor do we have to treat design as a mysterious, ineffable art. We recognise that design has its own distinct intellectual culture; its own 'designerly' things to know, ways of knowing them and ways of finding out about them". The paper applies a qualitative research approach to underpin this notion by Cross of unpacking design thinking within the *scientific* nature. The authors introduce focus groups to the scrum team and apply action research to observe and understand users for the development of personas which will be used for user stories and the design of the system as a whole.

Within the context of the study, design thinking is applied to encourage insight, intuition, and craftiness to the designers, software developers and business analysts of the project. Buchanan (1998) rejects design as a science but rather as an art because it embraces fragmentation and does not require any formal theoretical basis from any school of thought. In contrast to this notion, Shon (1982) regards design theory as a structured process by proposing a systematic approach of framing a problem which does not necessarily require a process or a 'how' to solve a particular problem. The contrasting perspectives are used as a guideline to understanding the theoretical basis of design thinking and its applicability within the science of scrum.

METHODOLOGY

The qualitative methodology is applied in the research through the use of focus groups and literature survey on scrum, design thinking and other related fields relevant to the study. The results from the literature survey and focus groups are applied as a guide to the development of software system. On a high level, the literature is conceptually structure as follows a) discussion of

design thinking, b) discussion of scrum methodology and c) related work which merges design thinking, scrum and related subject areas.

Focus group is the primary methodology used in the research as means of evaluating the scrum team. Focus group as defined by (Kruger & Casey 2000), it promotes a comfortable and natural atmosphere in which people share their experiences, attitudes and ideas while the researcher is a listener, moderator, observer and an inductive analyst. The focus group is used in the intervention of the pre-design thinking and post implementation of design thinking. In the paper by (Williams & Katz 2005), the authors claim focus group approach must involve constant questioning of theory, politics, some skepticism and challenging traditional mediums of knowledge production. It is in the same manner focus groups are applied in the research to evaluate how the paradigm shift in developing software without the knowledge of design thinking and the differences when it is applied.

The philosophical stance of the study defines the subjective and objective approach to the research. The social constructs of the research influence on the results, interpretations and the interactions of the artefacts produced from the research. The research does not explicitly define the epistemological and ontological philosophies, but are important to understand the science of the study and the rationale of the authors.

- **Epistemology:** Knowledge, understanding – must be able to justify, logical and evidence
 - o Empiricism – empirical study
 - o Rationalism - reason
- **Ontology:** Existence, being – material objects vs immaterial
- **Power:** The software product vs the client vs the software development team

SCRUM METHODOLOGY

Scrum methodology was developed by Ken Schwaber and Jeff Sutherland (Conboy 2009). It embraces collaboration and a leadership philosophy that

encourages self-organising and cross functional teams (Heikkila Paasivaara & Lassenius 2013). Scrum is designed to deliver products fast and to handle highly volatile variants in a pressured environment (Shalaby & El-Kassas). The working products are referred to as sprints which are released within two to four weeks as working components of the software (Gerndt et al., 2014). Furthermore, (Gerndt et al., 2014), scrum allows the team to select their own practices in the development of the software. In reference to the scrum values and principles, some of the core values are team building, responding to change, transparency, quality checks and testing. The main components of scrum are:

- Artefacts: Sprint Backlog, Product Backlog and Kanban board
- Roles: Product Owner, Team and Scrum Master
- Ceremonies: Sprint Review, Daily Stand-up Meetings, Sprint Planning, Retrospective Meeting
- Time Planning: Play poker for easy estimation packages and release sprints

Traditional software development methodologies have had to evolve as the complexities of projects and technologies have had to adapt to the frequent changes of business requirements. Software methodologies such as the waterfall model are based on an assumption that project's requirements can be specified before the project starts and do not change during development (Sutherland 2001). However, the nature of businesses within the globalised economy of stock exchanges and corporations being located in multiple geographic regions means IS requirements can change rapidly without anticipation. From (Boehm 2000), 31% of software projects which include some waterfall variants have been cancelled prior to completion or delivery of the product.

The unpredictability and constant requirement changes of software development projects results in the need for tools and techniques that can handle the different degrees of IS projects complexities. According to (Lee and Xia 2005), a major challenge for software development projects is establishing 'what' the software is required to do. Often with software projects

in the initial phase of the project, requirements are not made clear to the business analyst or they change constantly as the software development lifecycle progresses. This can be referenced to lack of defined business requirements elicitation by the business analyst or the business itself does not know exactly what it requires out the system. (Maruping, Venkatesh & Agarwak 2009) claim that the inherent interdependencies of users and the system as the major challenge to an IS project. Scrum was developed in response to these challenges to handle the complexities of IS projects by not only focusing on the technical features of the project but the people involved within the projects. Culture and environment within which the system is developed can also have an impact the system especially with the multi-location in which the system is developed and diverse personnel involved in projects.

Different fields including design science and software engineering bodies proposed various techniques which included agile methodologies, iterative and incremental approaches as a response to relatively high IS projects failures ((Baskerville et al. 2002) & (Fowler & Highsmith 2001)). The key component that these methodologies sought to address within the software development is their ability to embrace flexibility in order to handle frequent requirement changes (MacCormack et al 2001). (Maruping, Venkatesh & Agarwak 2009) argue that flexibility can be costly because of its impact on the development process and on the artefacts because of the variance in the degree of complexity of the system. Conboy (2009) further elaborates on this notion of the ability for agile to be flexible and in which adaption can be a trade-off for a high likelihood of a project failure. These contrasting views of what is flexible are largely dependent on the organisation applying scrum. Within the research, this is handled by intervening design thinking predominantly in the conceptual phase of the system development.

DESIGN THINKING

When *design* is defined in isolation, it embodies a different connotation to *design thinking*. As defined in (Oxford 2014), design is an arrangement of an artefact's features produced according to a plan. Banerjee (2011) defines

design thinking as “an approach that frames problems creatively and generates innovative solutions, strategies, systems and paradigms at the nexus of domains”. According to Brown (2008), design thinking is a methodology that embraces innovative activities to advance a human centred design. The human centred design (UCD) is applied within the persona driven design and heavily focuses on the user experience. The persona driven design and user experience form part of the multidisciplinary approach of the design thinking values:

- Empathy
- Ambiguity: Embrace for new opportunities
- Fail early and often
- Less is More

Design thinking has shifted from being a specialised skill used only by professions but has grown to be a common practice in our daily lives (Kimbell 2009). Kimbell (2009) elaborates further to argue that various disciplines have taken assertive measures to describe specific activities that can only be found in their respective fields when applying design thinking. Many different variants of design thinking are applied by architectures, sculptors, film makers and many other disciplines that produce artefacts. These disciplines are expanded according to the relevancy of the respective discipline.

The design thinking process is not fixed and is not rigidly followed because of the volatile nature of projects. (Senge 1994) questions whether design thinking does vastly differ to other professionalised disciplines such as systems thinking because of its different views of problems. The argument does hold merit because design thinking applies the systems thinking approach of viewing a problem as a complete system with interacting parts. However, design thinking does also separate concerns by evaluating them in isolation without consideration of the interacting elements but this is relevant to the given perspective.

DATA RESULTS AND ANALYSIS

The user experience was tested by using two potential users who represented the personas depicted in the latter section. The authors had limited influence during the user experience test by communicating to the users only after the session. All the instructions were written on a document which users followed on their own discretion. The authors just captured the results as the users executed the various tasks as instructed on the documents.

Table 4: User experience test criteria

User Experience Test Criteria	Results
Completion Rates	
1. Complete < 5 seconds	3 tasks
2. Complete < 30 seconds	6 tasks
3. Complete < 60 seconds	1 task
4. Complete > 60 seconds	None
Usability Problem	
1. Prevent task completion	2 tasks
2. Significant delay or frustration	2 tasks
3. Minor impact on task performance	6 task
Task Level Satisfaction	
1. Poor	2
2. Satisfied	6
3. Ecstatic	2
Expectation	
Users preconception of difficulty vs actual experience	These were noted as comments and varied widely with users.
Page View Clicks	
How many clicks to complete task	Capture Project: 5 clicks
	User registration: 3 clicks
	Search for project: 4 clicks
	View work location spatially: 2 clicks

The application of design thinking is on a project for a major metropolitan city of South Africa. The first focus group was conducted to introduce the team of developers and the business analysts to design thinking concept. The second focus group session was conducted during the implementation phase to understand the impact of design thinking on the project as a whole. The design thinking process was evaluated from the team collaboration

perspective and the actual system through user experience. The focus groups were recorded over an electronic device through an approval of the participants.

Persona driven design was introduced as part of the project to understand the current and perspective users of the system. Personas are archetypal users of a system that represents a larger group of users according to their personal characteristics and goals (Calabria 2004). Main purpose of personas is to guide and act as figures for real users to aide with the design, functionality and testing of the system. In this research, personas were used throughout the development of the new system and also to test for the user experience.



Table 5: Administrator persona

Age	26
Family	Single – No family
Quotable	“I want a system that will make my life easier”
Working Experience	In IT – 3 years
Role Model	Grand mother
Home Town – Current Location	Northern Cape – Johannesburg
Education Level	B Tech IT
Marital Status	Single
Ambitions	Want to grow my career
Frustrations	When the system does not do what it is supposed to do
Likes	Being perceived as an expert
Dislikes	Not achieving my goals
System related attributes	
Training on current system	Difficult to learn the system in just a day, a user requires close to a full year to understand it fully.
Benefits of the current system	Inventory – can pull different datasets, draw reports or any information that is needed out of the system.
Objections to current system	It is difficult to manage the system. Ideally it should be upgraded to meet some of the new business needs.
Find value in current system	Yes, makes different people's lives easier

Adapted to current system	Yes, but there is still room for improvement
How much time spend on the current system	On an annual basis it is about 9 months
Is the current system a major part of your work	Yes
	Have to go through a lot of barriers to make simple changes or functionalities to the system
Technology Savvy	Adapt quite well to technology, need to use daily to adjust to it. - Facebook, whatsapp, Instagram – computer and smart phone
Solve Problems independently	60% of the time I solve problems independently.
Goals with the new system.	Achieving the goal much more easily.



Table 6: Manager Persona

Age	60 +
Family	Yes
Quotable	"Getting confused when working around complex systems"
Working Experience	Over 30 years
Role Model	Father
Home Town – Current Location	Johannesburg
Education Level	First degree – Bsc Engineering
Marital Status	Married
Ambitions	To retire without financial constraints
Frustrations	The system that is hard to work around
Likes	Understanding my colleagues and a harmonious work environment
Dislikes	Working with systems that require manuals.
System related attributes	
Training on current system	Had to receive training for ½ day
Benefits of the current system	Good database, can pull up information on project, data kept is its ■ Some parts have ease of use but there is tedious captions
Objections to current system	Difficulty working with reports, manipulating, duplication, financials – sources and budgets. Questions on the system are very vague and hard to apply to your relevant project
Find value in current system	Yes it does assist with our work
Adapted to current system	Generally, but it is hard to remember how to use the

	system if have not used it in a while
How much time spend on the current system	Cyclic. During budget time, spend fair amount of time on the current system – randomly it can be within the range of 15 percent
Is the current system a major part of your work	No major part – Sept – Feb – 15%
Technology Savvy	No smart phone – not necessarily into new technology – not exposed to a lot of social media
Solve Problems independently	Yes solve problems independently. For technical problems I consult the administrator.
Goals with the new system.	To be easy to use

The second part of the focus group was based on the parameters that are illustrated below. The focus group was composed of a team of five developers with 1 junior and 4 senior developers. The questions are evaluated as part of the study included the following:

Pre- Design Thinking

- a. What are your experiences with software projects you have been involved in?
 - o As a developer, did you have the user in mind?
 - o What has been the rate of project failure?
 - o How did the users find the system?
- b. How do you find working in Scrum?
- c. Team Dynamics – was scrum being fully applied?

Applying Design Thinking

- a. How many know about Design Thinking?
- b. What are your experiences with Design Thinking?
 - a. Any value
 - b. Does it change your software development process – design, architecture, code, team dynamics
- c. Do you think design thinking has an impact on your project
- d. What you doing differently with Design Thinking in mind?
- e. Has the team worked differently with design thinking in mind?
- f. Client interaction – has it changed and does it make any difference?
- g. How much did you consider quality?

h. How much did you consider empathy with the team?

These questions were discussed in a focus group and some were used indirectly with the development of the system. The results were used as a guideline and not necessarily as a one to one relationship to the integration of design thinking to the scrum methodology. They provide intuitive insight to the authors with the intervention of design principles and capabilities to qualitatively understand the value of design thinking and its impact on the system.

CONCLUSION

Within the study it is discovered that IS researchers have to evaluate different methodologies, models, techniques and constructs for systems to gain *insight* to manoeuvre through complex systems. Within the IS domain, there are parameters that act as constraints which typically alter the decisions of the users that interact with the system. Many factors can create constraints which can either be technological, human centred or be affected by the environment. The development of real-time IS requires high level decision automation and computer networking which can be high in capital intensiveness as stated by (Chan et al 2011). From the research, challenges identified for a usable system are not necessarily only in terms of functionality or the technological architecture but are for exceeding users' expectations and user experience.

Based on the research, design thinking is found to add greater value when it is used in conjunction with other defined techniques and methodologies. The introduction of persona driven design and testing the user experience has contributed to the system that has been developed. The scrum values and principles such as consistent client interaction and releasing working sprints were not used in isolation but coincided with design thinking. Future research will entail more design sessions which involve teams outside of the IT domain and other parameters to gain insight on the user experience. A post analysis of the system once it is released on a production environment would add value to research understand how it differs with the current system.

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CONTEXT SENSITIVITY AND PROCESS IMPROVEMENT AS INFLUENCERS TO EMR ADOPTION BY CLINICIANS: IMPLEMENTER PERSPECTIVES

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ABSTRACT

Objective: *The implementation of electronic medical records (EMR) in hospitals worldwide has had mixed success and concerns have been raised on issues of adoption by clinicians. The purpose of this initial study was to identify the factors which implementers of an EMR for public hospitals in the Western Cape Province of South Africa considered important for improving its adoption by clinicians.*

Method: *Interviews were conducted with 2 stakeholders in the implementation team to establish the factors they regarded as most beneficial to the adoption of an EMR by clinicians at public hospitals in the Western Cape Province. A change manager and an executive manager from the Western Cape Government Department of Health were interviewed determine the main elements which needed to be built into the EMR to enhance its adoption by clinicians.*

Findings: *Since doctors in South African public hospitals are overburdened and focussed on healthcare provision, the implementers developed a solution which changed the supporting administrative work practices to improve doctors' adoption of an EMR. The introduction of automation and improvements to work process timing and flow resulted in easily captured, complete and accurate patient records which linked to an existing hospital information system named Clinicom. A unique indexing system was combined with the scanned documents to provide both detailed and summary chronological patient histories which were searchable and could be*

easily accessed and navigated by clinicians. The limited changes to clinical work processes as well as the comprehensive patient records available via the EMR were key influencers to its adoption by the clinicians. The context focus and minimal change to clinician work processes were considered the most important factors to implementers for influencing the EMR adoption by clinicians.

Discussion: *Two key factors emerged as important to the implementers for developing and implementing an EMR which doctors in South African public hospitals would adopt and use. Firstly, they considered a good understanding of the challenging and complex environment presented by public hospitals in South Africa to be vital for the customized technical solution that would be developed. This approach focussed change on the supporting administrative work practices by introducing automation and improving the timing to produce accurate, complete and timely electronic records for clinical decision making. The resulting low level of change to clinical work processes combined with the availability and completeness of patient information made the EMR attractive and useful to the doctors, thereby improving their adoption and use of the EMR.*

Conclusion: *The busy complex environment of public hospitals in South Africa called for an EMR which aligned well with its context and clinical work processes to improve adoption by its overstretched doctors. The implementers of an EMR at Western Cape government hospitals addressed these constraints by focussing change on the supporting operational processes instead of on the clinical processes. Implementers viewed this context focussed systems approach to be most suited to improving EMR adoption of the EMR by the clinicians. Future research to test these implementer perceptions against those of the clinicians is planned.*

Keywords: *EMR, doctors, clinicians, adoption, South Africa*

INTRODUCTION

Electronic medical records (EMR) offer many benefits including savings in costs and time, support for decision making and improved patient care. Despite these potential advantages adoption of EMRs by clinicians has been slow (Anderson, 1997:84, Boonstra and Broekhuis, 2010:16). Research on Health information system (HIS) adoption in general indicates organizational and social factors to be the key barriers to their implementation success, and efforts to improve clinicians' adoption of EMRs require a comprehensive

understanding of several behavioural and organizational factors (Janols et al., 2013:440). Central to this poor uptake has been the concerns doctors have expressed related to changes to their work processes (Gerntholtz, van Heerden and Vine, 2005:26; Lakbala and Dindarloo, 2014:6). The clinicians' view that healthcare delivery is their primary focus combined with their increasing workloads, incomplete patient records and their conservative way of working have been identified as obstacles to their adoption of EMRs (Gerntholtz, van Heerden and Vine, 2005; Lakbala and Dindarloo, 2014:2). These challenges raised an opportunity for the development and implementation of an EMR which causes little change to the way clinicians work while still delivering the expected benefits.

The development of an EMR necessitates the involvement of a team of stakeholders whose importance to adoption success has been highlighted in research. Users have been identified as vital stakeholders, and their involvement in the development of HIS is considered critical to its adoption (Ludwick and Doucette, 2009:26; Cresswell and Sheikh, 2012:81; Najaftorkaman and Ghapanchi, 2014:9). Their inclusion allows the implementers opportunities to address issues related to design; compatibility with work processes; skills and usefulness (Gagnon et al., 2010:248; Cresswell and Sheikh, 2012:81). User involvement is also a psychological factor for boosting the perceived usefulness and perceived benefits the EMR brings (Najaftorkaman and Ghapanchi, 2014:9). Another stakeholder team participant is the implementer, whose role as change manager is vital to EMR adoption success. Ludwick and Doucette (2009:26) found that implementers were able to alter implementation outcomes since they are best placed to insulate the project from challenges and limit potential failure. Through their provision of training and support, implementers can facilitate adoption and provide feedback to other team members (Cresswell and Sheikh, 2012:81, Cresswell, Bates and Sheikh, 2013:4, Najaftorkaman and Ghapanchi, 2014:11-13). Executive management's participation in the team is equally important since they fulfil many roles during the development of the EMR. As project initiators, sponsors, policy makers and champions they have the difficult task of balancing competing demands in leadership and management,

innovation and diffusion, expected benefits and real returns on the investment (Kaye et al., 2010:167; Cresswell, Bates and Sheikh, 2013:2). Their belief in the business value of the EMR combined with their strategic leadership creates the necessary executive commitment essential for the buy-in and co-ownership by the various stakeholders (Cresswell, Bates and Sheikh, 2013:1).

METHODS

This initial study focussed on the providers' perceptions regarding the most important influencers needed to improve the adoption of the EMR by doctors at Western Cape Province public hospitals. The Western Cape Province was selected as the implementation case since it had recently introduced an EMR at some of its public hospitals. A change manager for the EMR supplier and a director of implementation at the provincial department of health were identified as fundamental stakeholders in the implementation and adoption success of the EMR. This limited population of providers made interviewing the preferred data collection method. Semi-structured interviews were conducted with these two stakeholders to gain an understanding of the different organizational contexts, the technical solution and their perceptions of the EMR adoption. Each interview lasted approximately 90 minutes. Content analysis of the transcripts was supplemented with the review of a written report provided by the change manager, and notes taken during a demonstration of the technology.

CASE OF THE WESTERN CAPE PROVINCE OF SOUTH AFRICA

As is the case in many developing countries, South African public hospitals are struggling to match constrained resources to high patient loads. The staff are overburdened and focussed on health care provision, causing few to move away from the familiar paper-based systems currently in use (Mostert-Phipps, Pottas and Korpela, 2013:550). The recently introduced National Health Insurance (NHI) policy which seeks to improve the provision of quality health services for all South African citizens has provided an impetus for change. In keeping with this policy and as part of its plans to improve service delivery in the province the Western Cape Department of Health

commissioned an EMR for use in public hospitals throughout the province. The development of the EMR was viewed as an opportunity to incorporate a number of local objectives towards realizing the province's vision of future digital hospitals. The system would manage patient admissions, link to the national Health Information Repository, assist in reducing the volume of physical documentation being produced by the existing hospital information system, integrate with other existing information systems in the hospital, be patient-centred, and be of use to both administrators and clinicians. The resulting Enterprise Content Management (ECM) system was based on providing an EMR which changed the way patient data was captured, stored, accessed and processed at public hospitals in the province. Some of the expected benefits from the implementation of this EMR were efficiencies and accuracy in data capture, shorter patient waiting times, improved access, usability, collaboration and consultation. The implementers selected a phased approach for rolling out the EMR at a variety of types and levels of hospitals across the province, enabling incremental learning from a range of organizational contexts which would inform future implementations. While EMRs have been implemented in other provinces in South Africa with varying success, the implementers for the Western Cape Province focussed on the organizational context and improving supporting non-clinical work processes to advance the potential for adoption success with doctors at the provincial hospitals.

FINDINGS

An EMR for use in public hospitals throughout the province was commissioned by the provincial department of health in 2009. Pre-implementation commenced with users and developers creating a taxonomy to gain a comprehensive understanding of the public hospital context and the development of a classification system for documents and work processes. Several non-clinical work processes were automated by means of bar coding of all documents and patient labels and a scan centre being set up at each of the test hospitals. Automation altered the way patient data was captured, stored, accessed and manipulated. In addition to the automation of

supporting non-clinical processes, implementers improved the timing and flow of these work processes. The new process required historical paper-based patient data to be scanned into the repository during the week prior to a patient's admission to hospital to produce electronic records. On admission, several barcoded labels would be printed for the patient for attachment to related forms accumulated during the hospital stay or episode, thereby linking patients to processes. The labels contained the unique patient number which linked to the existing Clinicom hospital information system. This patient number was combined with work process document numbers and process dates to create a unique indexing system to provide electronic medical records which were integrated and easy to access. Within 48 hours after a patient's discharge all patient documentation had to be scanned to update the patient's history. This approach left clinical work processes largely unchanged but the resulting comprehensive patient record availability and its search functionality provided benefits for clinical decision making. Since computers were placed in the reception stations in the wards, doctors were able to access complete chronological patient histories and summaries from the EMR during and prior to their consultations. The scanned searchable records allowed doctors to navigate the associated patient information at point of care, thereby providing support for clinical decision making, facilitating collaboration and reducing delays caused by incomplete paper-based medical records. Standardized, easy to use interfaces were created to improve adoption and limit the amount of training needed for use. Training was delivered prior to implementation in a traditional demonstration format and as a series of short videos available to users post-implementation as online help and ongoing support.

A pilot installation in a single department, the Oncology Unit at Tygerberg Hospital, a large tertiary academic hospital, was used to test the system and its adoption. Based on lessons learnt from user feedback, observation and a greater organizational understanding, refinements were made to documentation and work processes to further elevate the EMR's adoption. An enhanced version of the EMR system was rolled out to the whole large tertiary academic hospital (Tygerberg) in 2012 and at a recently modernized regional

hospital (George) in 2013. In 2014 the EMR was implemented at two new district hospitals (Khayelitsha and Mitchell's Plain) where no organizational culture existed to hamper adoption. The interviewees reported that there had been little additional change to the EMR and its related work processes post implementation.

DISCUSSION

Process Improvement

The challenging hospital setting and the way clinicians have to work at public hospitals in South Africa required careful consideration by implementers when they developed solutions which would be adopted and used. Pottas, Mostert-Phipps and Korpela (2013:553) identified a poor mapping of systems capabilities to work processes in healthcare in South Africa as a barrier to adoption and meaningful use. Cresswell, Bates and Sheikh (2013:4) motivated for understanding the work processes prior to implementation to mitigate risk and implementation failure of health information technology. With this in mind, the implementers focussed on improving the supporting non-clinical processes to provide the maximum benefits of the EMR while changing as little as possible in the way doctors worked. A technical solution linking the EMR to the existing Clinicom hospital information system, to work process documentation and to processing dates provided doctors with easy access to complete patient records for better healthcare profiling and information sharing. Administrative work processes were improved through automation of processes and scheduling to provide accurate and timeous electronic patient records for clinical use (Cline & Luiz, 2013:11; O' Malley et al., 2009:184). By carefully tailoring the technology and supporting operations to change as little as possible of the clinicians work processes, the implementers improved the fit between the tasks and the doctors (Honekamp and Ostermann, 2011:49, Cresswell and Sheikh, 2012:81), thereby improving the potential for adoption by the clinicians.

Organizational Context Sensitivity

The pressured environment of public hospitals in South Africa was an equally important consideration for implementers when preparing for installation and training. The need for a comprehensive change management strategy to adequately prepare a hospital for the change a HIS brings has been identified by Pottas, Mostert-Phipps and Korpela (2013:553) as very important for adoption and meaningful use. Implementers selected a range of different types and levels of hospitals across the province for the early rollouts to improve their understanding of the different organizational contexts and to inform future implementations.

The implementations ranged from two new district hospitals where no cultural issues existed to challenge the adoption, a smaller regional hospital where the change in hospital size and level offered new context understanding and where strong management support enhanced adoption of the EMR. The EMR was also implemented at Tygerberg which is a tertiary, academic hospital and also the largest in the province. This hospital is currently undergoing a major modernization project and this unique context has brought new organizational learning. Establishing several champions within hospitals and executive management has been fundamental to advancing the adoption (Cresswell and Sheikh, 2012:81) in earlier rollouts. The unique and complicated setting of the tertiary teaching hospital with many transient student doctors will bring new environmental learning for the change managers.

Both Southon et al. (1999:34) and Hanmer (2009:250) have cautioned to the importance of understanding the challenges of introducing HIS into complex organizations such as hospitals and Cresswell and Sheikh (2012:81-82) found this to be true even when a pilot has been implemented successfully. Equally important and challenging is the hospital's interaction with the implementation strategy (Southon al., 1999:44, Cresswell, Bates and Sheikh, 2013:3). The implementers addressed these concerns by selecting the slower incremental approach of a phased implementation to enhance the possibilities of EMR adoption by clinicians.

Adequate training has been found to be important (Ludwick and Doucette, 2009:26) for buy-in, adoption and meaningful use (Cresswell, Bates and Sheikh, 2013:1). Achieving a sufficient level of competency via standard group training sessions proved difficult to coordinate due to the high workloads and lengthy shifts of duty required of doctors in South African public hospitals (Pottas, Mostert-Phipps and Korpela, 2013:552). In response to this challenge the implementers decided to supplement the group training sessions with a series of 4 minute videos which are available to users on demand as online help and they provide ongoing individual support. While the practical group training remains fundamental to improving skills and encouraging adoption the tailoring of additional training into formats suited to realities of the working environment makes it an attractive additional and ongoing support for doctors (Cresswell, Bates and Sheikh, 2013:4).

POTENTIAL FOR FUTURE RESEARCH

This initial limited study sought to determine the factors considered most important to implementers of an EMR to improve its adoption by clinicians. The size of the sample, the exclusion of some types of stakeholders and the emphasis on the implementers' perspectives of the factors which influenced the EMR adoption call for caution when using these findings to generalize to all EMR adoptions or comparison to larger studies. Further in-depth research is planned to establish the clinicians' perspectives regarding the adoption, while later research should determine the actual use of the EMR by the clinicians. The literature revealed limited research into EMR implementation and adoption in South African hospitals, thus presenting opportunities for future research into the implementation and adoption of EMRs and other health information systems.

CONCLUSIONS

The expected healthcare benefits of an EMR are not always realized due to its slow adoption by clinicians. Poor alignment of these technologies with clinical work processes has been identified as a key barrier to its adoption. Implementers felt it important to understand the complicated environments

where South African doctors work before changing supporting operational processes to improve their adoption of the EMR. Future research will compare these implementer perceptions against those of the clinicians before establishing actual use of the EMR.

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SUSTAINING CULTURAL HERITAGE THROUGH TRADITIONAL GAME DESIGN

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ABSTRACT

Traditional games as integral part of societies are ideal for use in sustaining indigenous knowledge in African societies. It is evident that African indigenous knowledge is gradually being eroded away by the Western culture. The paper discusses one of Botswana's traditional games called Mhele. Using traditional games, as a means of cultural edutainment will empower societies with approaches at addressing various social pitfalls. Mechanics and popularity of traditional games within societies could be explored and exploited to address issues as most of them have a narrative and socializing element within them. A single-case experimental design study was conducted with people who often play the game in Botswana. The findings show the game can be used to promote diversity and unity of different tribes so as to sustain cultural heritage.

Keywords: *cultural heritage, sustainable, traditional game, design, Botswana.*

INTRODUCTION

A good game should be interesting, challenging and satisfying to the player's preferences. Ways to play the game should not be too complex rather it should challenge the player to make the best moves. Traditional games are to a large extent influenced by geographical location, norms and traditions of a particular society (Parsons, 2006). Some games are played internationally and are well recognized. For example, chess is a brain-challenging game - it is a foreign game to Botswana traditional games because it originates from India. A traditional brain challenging game in Botswana and some portions of neighboring countries is *Mhele*. The paper refers to neighbours because borders divide tribes in most African countries. For example, there is Bakgatla tribe in both South Africa and Botswana, Baherero in Namibia, Bakalanga in Zimbabwe. Traditional games have an interesting aspect that

have not been fully exploited and explored. Some of these games could be added to the international game menu and played during global activities. This game is not just a brain challenging activity , but a game for socialization as well, which tend to be the missing element in most recognized board games.

In this paper, the authors analyze the relevance of a traditional game called *Mhele* in addressing some of the societal pitfalls looking into its play mechanism and popularity. Amongst the pitfalls, is dilution of indigenous knowledge, which contributes negatively to cultural heredity and identity of societies. The game is not necessarily a new innovation, but the paper will explore ways of making it modern while maintaining its original mechanics. Fabricatore (1999) argues that, in order to enhance an already existing feature of game mechanics, it is necessary to design what is called power-up enhancement mechanics. These have the sole purpose of changing an existing feature, usually to empower the whole mechanics.

CULTURE OF BOTSWANA

Africa as a developing continent is going through different challenges economically, socially and culturally. Developed societies are in most cases used as role models by most African countries and they tend to adopt a number of socio-economic behaviours. Amongst such elements is culture, which is defined by UNESCO as ‘the set of distinctive spiritual, material, intellectual and emotional features of society or a social group, and it encompasses, in addition to art and literature, lifestyle, ways of living together, value systems, traditions and beliefs (UNESCO, cited in Zietsman, 2006). In other words, culture is made up of indigenous knowledge. This knowledge is passed from generation to generation, usually by word of mouth, entertainment and cultural events. The National Policy on Culture identifies cultural identity as one of the critical ingredients for nation building and the attainment of national sovereignty. This does not imply a homogeneous culture, but rather, the acceptance and respect of other cultures as integral parts of the national stream. It further identifies that cultural continuity and understanding depend largely on the content and the method of this process

of knowledge development and the inculcation of social and moral values (*National Policy on Culture*, 2002).

Botswana is made up of various tribes with unique traditional cultures. Some of the tribes in Botswana regions are: Balete, Bakgatla, Batlokwa, Bakwena, Bangwaketsi, Bahurutshi and Barolong in the southern region, Bangwato and Batswapong in the central region, Bakalanga, Baherero, Bayei, Bahambukushu, Bakoba and Batawana in the northern region, Bakgalagadi and Basarwa in the western region. (In Setswana, “Ba” is plural while “Mo” is singular, e.g. Motswana is one person from Botswana society while Batswana refers to more than one). The authors refer to some tribes because within these large tribes there are other tribes who are few in numbers, for example, there are Basikwa within Balete tribe.

This paper focuses on how games can be used by all to achieve equal recognition, acknowledgment and appreciation of various cultures in Botswana regardless of numbers. The paper will further pay attention to various tribes that are found in all areas within the country and some portions of neighbouring countries and use them in the game design. Cultural identity is one of the critical ingredients for nation building and the attainment of national sovereignty (*Background Note*, 2009).

ROLE OF GAMES

The authors design a game as a form of play or sport, especially in a competitive manner, played according to the rules and decided by skill, strength, or luck. This aspect puts emphasis on the player and play mechanism. Fabricatore (1999) argues that game play is the most important pillar of the game design activity. A handful of good core mechanics and some carefully thought satellite mechanics allow creating games with simple but yet rich and entailing game play, capable of providing to players the challenge, mastery and reward that they seek, without unnecessary difficulties, thus sustaining and enhancing their motivation.

Games are generally very common within young people, they serve various purposes, amongst them brain development and edutainment. Children and

young people are introduced to the virtual world via video games, and the way that they interact with technology may be changing ways of learning and the production of knowledge (Gros, 2007). It is important to note that children and young people are critical components of cultural sustainability. It is, critical to develop and use games that are at their level in terms of understanding, interpretation and interaction. Sotirova (2005) concurs by arguing that;

edutainment needs to be approached "through the eyes of the child", with sensitivity to a child's scale and how they see, interpret and use space and objects. Since much of the children's play takes place in their minds through imagination, you need to create the right space (the stage) and supply the right objects (the props) to support their play.

Hunicke, LeBlanc and Zubek (2004) developed taxonomy of aesthetics from playing games. Aesthetics describes the desirable emotional responses evoked in the player(s) and the audience, when the player interacts with the game system. They argue that games develop the following aesthetic features: sensation, fantasy, narrative, challenge, fellowship, discovery, expression and submission. At the other end of the scale, Gros (2007) advances the argument that games can assist players in the following ways: personal and social development, language and literacy, mathematical development, creative development, knowledge and understanding of the world and physical development.

It is evident that literature predominantly aligns edutainment to children and young people. However, it does not in anyway distance edutainment from adults, learning is a lifelong activity. Edutainment applications are location based and are mainly child audience oriented, but age never is a limitation for experiencing the world of playing (Sotirova, 2005).

Mhele

Mhele is a game, which is played by people of all ages, whether literate or illiterate. It is a game that is currently being played for entertainment purposes (Figure 1).



Figure 1: Men playing Mhele at a Shebeen

The game is commonly played during leisure time at the four social settings in Botswana: urban-areas, villages, lands and cattle-posts as well as in shebeens, bars, schools, and homes. Botswana tribes predominantly practice their traditions and norms at the aforementioned social settings. People plough at the lands and rear livestock at small scale for milk, ploughing, meat, transport and other conveniences. For example, selling a goat to buy school uniform for children or paying school fees. Botswana keep a large herd of animals at the cattle-post. Normally, cattle-posts are places far away from villages and lands.

There is no doubt that Mhele delivers cultural edutainment. The game play influences creativity and personal expression and it redefines reality, i.e., it does not only reflects, but also influences the surrounding culture (Sotirova, 2005).

Mhele has been identified as an element that can be used to educate societies about Botswana tribes and their names. For example, it is a brain testing game like chess, played with 24 pieces (12 per person) on a board or marked on the ground with three squares or rectangle joined together at the corners (Figure 2). Usually, small stones or pieces of different colours are used to play the game (Figure 2). Each player should use pieces of similar objects or colour. These stones in most cases are referred to as cattle. Due to

the cultural significance of cattle to the people of Botswana, probably this is the reason why the game stones are referred to as cattle.



Figure 2: Stones and bottle lids used in playing Mhele

The game is played in turns, placing the pieces on the intersection points of the shapes. Each player should block the three pieces of the opponent to be placed in a straight line (usually referred to as mhele hence the name of the game). One player will take an opponent piece if he/she fails to block three pieces in a row. The rule is; no piece should be picked from three pieces already in a line. The more the opponent pieces are taken away from the game board the weaker he/she becomes and can actually surrender from the game. This creates free intersection and after all the remaining pieces are placed in the game board. The two opponents will start moving pieces in turns to form or block any three pieces from forming a line. Usually, players make friendly mockery statements of the opponent. For example, one player can ask his/her opponent to block with his/her nose, because he is running short of pieces. In most cases, spectators are free to make suggestions on moves, while on the other hand, studying strategies of the winning player to be able to counter when their turn comes. This is where the socializing aspect of the game is displayed. The winner continues to play until defeated by a new opponent. If there is no other opponent they will keep re-starting the game, the loser trying other strategies to win.

RESEARCH METHOD

This study was based on a single-case experimental design conducted in Botswana with eight Mhele players. This approach suits this research because Botswana's heritage must be interpreted from the perspective of the participants being studied. The research seeks to develop an in-depth understanding of the research problem by collecting multiple forms of visual and textual data from participants. This helps to probe beneath the surface appearance and provides detailed information about how cultural factors can be transformed into product design features. The process enabled the researchers to assess how different elements of Botswana's social system (values, norms, beliefs, behaviour) interconnect in designing products and in terms of the context in which the research was conducted. During the design experiment, participants were observed in their natural environment in order to reflect on the process they used in playing Mhele.

New Mhele game board and pieces

Instead of playing Mhele with small stones, the playing pieces will be labelled with various tribe names (Figure 3). This flexibility, influence the design of play pieces made of small flat pieces of wood, which can be labelled in the middle, adding some popular traditional patterns for the purpose of the association. Popular traditional colours were also used to differentiate the pieces. The shape was made similar to withhold original concept of cattle. The pieces are labelled with various tribes on the two sides, which provide an opportunity for the player to choose the tribe he/she wishes to use. Furthermore, that allows coverage of different tribes as many as possible.



Figure 3 Labeled Mhele pieces

Winning and defending with a particular set of tribes indirectly elevate the tribes, as the players will praise the set and moves they have applied to defend or win. For example, if a pair of Bangwato is playing, they will be using a set of 12 pieces labelled with various tribes within Botswana including theirs. The use of tribal names does not in any manner promote inferiority of any tribe. In actual fact, it advances all tribes, as they are all important in qualifying one to play the game. In reality, all tribes also need to acknowledge this diversity and unity. The game is normally played in a passionate atmosphere; players in this game are emotionally invested in defeating each other. This is a vital element of an effective and interesting game. It is easy to see that supporting adversarial play and clear feedback about who is winning are essential to competitive games. If the player does not see a clear winning condition, or feels like he/she cannot possibly win, the game is suddenly a lot less interesting.

DISCUSSION

It is evident that the Mhele game can be used to educate societies about the existing tribes in the Botswana. Labelled pieces will provide an opportunity for players to share their knowledge on tribes' location totem and general characteristics. The mechanics of the game also, lays an appropriate platform for modifications to address an intended aspect. Fabricatore (1999) identifies modifications as a component of core game play activities, but with new semantics, and don't require any new game mechanics to be carried out. Hunicke *et al.* (2004) also concurs with the argument that adjusting the mechanics of a game helps to fine-tune the game and overall dynamics. The game can be modified to suit contemporary set-ups. The new game can be designed on a movable tabletop or fixed at a particular location, e.g. bus rank, parks etc. This will maintain the social interaction concept; the same table can be used for other purposes, for example, serving food or drinks (Figure 4). Playing pieces will be kept under the tabletop (Figure 5).



**Figure 4 Movable Mhele table
game pieces**



**Figure 5: small containers for storing
game pieces**

Mhele game provides an opportunity and spaces ripe with narrative possibilities. The game taps on players and spectators emotions. Listening to players praising their pieces provides a narrative or story. Games tell stories the same way that other media tell stories. Narratives enter such games on two levels: in terms of broadly defined goals or conflicts and on the level of localized incidents. The aspect of narratives in traditional games is a quality, which is often overlooked in modern digital games, which locks the individual away from the rest of the society. Traditional games do the opposite by inviting everyone to the game table. There are designed to encourage collectivist activities, rather than individualized ones.

CONCLUSION

Traditional games are embedded in societies. It is, therefore, ideal to use them to address some of the social issues facing the society. It is time to

explore these games in terms of sustaining the people's cultural heredity. If this aspect is not taken seriously, there is a possibility that the next generations will lose their identity. New generations use social media and technology to socialize. The Mhele game can be digitised to cater for them with their heredity implanted within it. Social media platforms can actually lead them to globalised norms and traditions and in the process loosing the cultural heritage. The first President of Botswana, Sir Seretse Khama once said, a nation without a past is a lost nation, and a people without a past is a people without a soul (Parsons, 2006). Furthermore, [Garvey](#) (n.d.), states that, a people without the knowledge of their past history, origin and culture is like a tree without roots. The re-designing of the Mhele game is one way of responding to such concerns.

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MULTIMEDIA LEARNING AND NURSING INFORMATICS EDUCATION IN SOUTH AFRICA

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ABSTRACT

This article describes Nursing Informatics as a course to be implemented as part of midwifery education in a public university in South Africa. An online learning environment is being explored to facilitate the training programme. Instructional technology and its benefits to students which include critical thinking, learner satisfaction and Nursing Informatics, are discussed in this preliminary study.

Nursing Informatics, with competencies such as computer literacy skills and E-learning, are essential for the sustenance of emerging technologies for healthcare professionals in Africa. These competencies, facilitated by instructional technology, could enable midwifery students to actively participate in an online environment by experimenting with technology and devices that will sharpen their skills in informatics.

Service design methods such as co-design were employed to develop the training programmes in collaboration with nursing educators, using the TIGER model as a foundation to develop the core competencies. A key outcome of this preliminary study is the core competencies of the Nursing Informatics programme, starting from year one through to year four, allowing midwifery students to study in a multimedia learning environment as well as a face-to-face setting. Thus, a blended learning approach is being explored in this preliminary stages to facilitate student satisfaction, making learning flexible and easier.

Keywords: *Nursing Informatics, service design, instructional design, multimedia learning, computer literacy, midwifery students.*

INTRODUCTION

Nursing informatics

Nursing Informatics (NI) has become relevant in the practice of healthcare in today's fast world of technology. It has gradually become an interesting field of study for researchers in health Information Technology (IT) and social sciences to improve healthcare. Abbott and Coenen (2008:238) explain that today's nurse does not work in isolation, but as part of a multidisciplinary team which must be recognised towards realising the effective use of ICT in Healthcare. NI is recognised as essential knowledge for the sustenance of emerging technologies in the healthcare sector, designed to improve patient care (de Gagne *et al.*, 2012:676). However, the presence of technology alone is not sufficient in healthcare. Consequently, a workforce with applicable knowledge and skill will advance the benefits of technology in healthcare systems. Informatics is gradually becoming a part of the expected competencies of nurses and every nurse/midwife must take advantage of this opportunity towards enhancing their work activities (Abbott & Coenen, 2008:245).

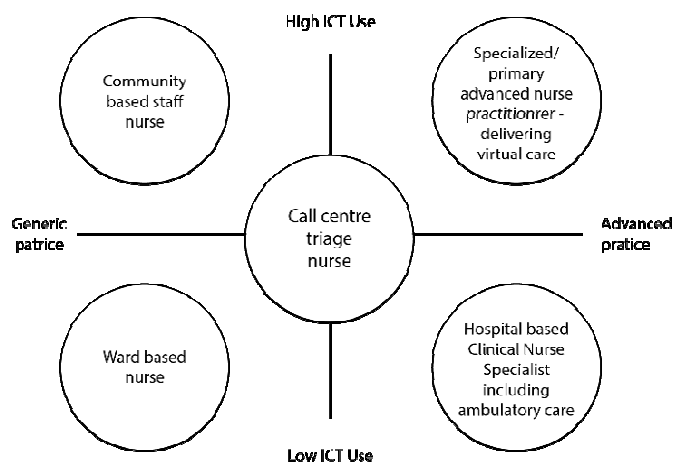
However, student nurses are introduced to technology during their practical work after school with an increasing number of new record systems and other electronic equipment to enable them do their work effectively. These Information Technologies (IT) are sometimes used to record patient data. Others include wearable technologies to monitor the blood pressure of patients, scanners, and other handheld computers. Although studies have indicated the importance of integrating IT into nursing education, educators are sometimes reluctant to incorporate technology into their curriculum. It is noted that these are sometimes due to the lack of familiarity of IT by the educators or the reluctance of institutions to accept such concepts in their training programme (de Gagne *et al.*, 2012:678). However, the study is being conducted to explore the possibility of integrating Health Informatics (HI) into the nursing and midwifery training curriculum. A Multimedia Learning (ML)

environment is considered to make learning more fun, allowing learners the flexibility to work at their own pace. Thus, “the potential for collaborative learning to break the isolation of learners is realized in E-Learning (EL) technologies” (Ruiz *et al.* 2006:211), allowing them to eventually sharpen their NI skills.

Despite the popularity of NI, very few people understand the term. Conversely, it is described as an applied branch of computer science, and information created leading to improved outcomes in healthcare service delivery (Dixon & Newlon, 2010:83). According to Coiera (2003, as cited by de Gagne *et al.*, 2012:676), HI is “the study of information and communication systems in healthcare with a focus on understanding the fundamental nature of these systems, developing interventions that can improve upon these systems, and evaluating the impact of these interventions”. The discipline does not only apply to nursing, but also to other specialised fields of study by personnel in medicine, such as physicians, pharmacist, therapist and clinicians in many other sub-disciplines in healthcare (de Gagne *et al.*, 2012:676).

Additionally, HI should be viewed as an opportunity for nurses to use ICT to assist them in their work practices to improve the quality of healthcare (as shown in figure 1). The use of ICT in their work practices could potentially minimise the challenges of geographical barriers in healthcare delivery (Abbott & Coenen, 2008:245). Edwards & O'Connor (2011:1-2) explains that the National League for Nursing (NLN) indicates that computers are all around us, therefore knowing that nurses in the digital world will practice in an informatics-healthcare system, it becomes necessary that the nursing educators master and teach informatics knowledge and skill (Dixon & Newlon, 2010:83) to prepare nurses for professional practice.

Figure 64: ICT use in nursing practice (adopted from While & Dewsbury, 2011:1308)



Professional bodies such as the Pew Health Professions Commission, International Medical Informatics Association (IMIA) in support of NI, circulated a set of regulations to health training institutions. The information placed emphasis on including NI content in all healthcare undergraduate programmes. The objective was to enable health workers to efficiently use information processing methodology and ICT (Desjardins *et al.*, 2005:1012) in their work activities.

As a result, the Institute of Medicine (IOM) report on Health Professions Education (HPE) indicated in the IOM HPE report that health professionals such as doctors, nurses and other allied health workers, lack the necessary education and training to meet the 21st century needs in healthcare. The report urged healthcare workers to develop their proficiency in the identified core competencies needed to improve their professional practice. These are: the ability to deliver patient-centred care, work as members of interdisciplinary teams, practice evidence-based medicine with a focus on improving quality in healthcare systems (IOM, 2003, as cited by Galloway, 2009:para 19-20) using Information Technology (IT).

Although, there is evidence of the use of technology in healthcare systems in South Africa, NI is not part of the nursing and midwifery training programme in tertiary institutions in South Africa. Therefore it becomes relevant to explore

possibilities of introducing NI curricula to enable healthcare professionals to use emerging technologies to aid in their professional practice.

This paper is based on the reflection of a NI workshop of which the authors were both participants and observers. It was a three-day workshop where academic presentations and discussions on NI were made. The aim of the workshop was to determine the needs for NI education in South Africa and collaboratively design appropriate curricula for the NI programme to be implemented into midwifery-education.

Members present in the workshop were mainly educators from backgrounds such as ICT, design and healthcare. Together, participants designed the courses using a co-design approach which covered both undergraduate top-up programmes and postgraduate courses. However, this article focuses on how the curriculum for the undergraduate programme was designed. It also explores how it could be integrated into the bachelors programme in nursing and midwifery education. The implementation of the NI programme and its benefits in midwifery professional practice as well as the role of Instructional Design (ID) and technology in education is discussed in this article.

BACKGROUND

The role of technology in midwifery practice

Nurses, particularly midwives, are referred to as the skilled birth attendants who are one of the key players of health workers whose collective efforts help in reducing maternal morbidity and mortality in developing regions. The appropriate use of health information in the health sector in South Africa is not only vital in improving maternal care but also largely influences the maternal and neonatal outcomes. The introduction of information and Communications Technology (ICT) brings along the challenge of training the health professionals to utilise ICT effectively in the management of women during pregnancy, birth and the postpartum periods. NI has largely been absent as a core competency in midwifery.

The introduction of technology in the professional practice for midwives requires that NI be integrated into their education to enable them to use technology as part of their professional practice. The objective is to empower them with technology to make their work much easier in today's digital world. Competence and competency are fundamental requirements in the field of midwifery education as well as employment and deployment of potential midwives (Ruiz *et al.* 2006:210). However regarding the implementation of NI as a course in midwifery, one of the core competencies that every potential midwife must have is EL.

EL competency in NI could potentially empower midwives to actively participate in an online learning environment. It offers them required skills needed to be able to access information. It can enable midwives to communicate with their patients and health workers from different parts of the world (Ruiz *et al.*, 2006:210), thus increasing the access to information and providing assistance to patients in remote areas. Additionally, healthcare providers will be able to conduct virtual tours to share information and send personalised health information to patients to improve upon their wellbeing (While & Dewsbury, 2011:1303). Also, midwives will be able to access their much needed learning and teaching aids from the internet (Ruiz *et al.*, 2006:4), making it easy for them to improve upon their professional practice.

Learning and instruction

Over the years, educational approaches to teaching and learning have been in various forms such as hands on experience, apprenticeship, role playing, demonstration, reading and digitally printed formats (Grasha & Yangarber-Hicks, 2010:5). The use of traditional forms such as chalk boards has been completely minimised in today's world of technology. Empowered by technology in today's digital world, educators use an interactive approach to teaching, whereby instructions are digitised in a step-by-step instructional format which makes teaching and learning more effective for students.

Teaching online is different to teaching face-to-face. The content is the same but the modes of delivery and platforms makes the difference (Clark & Mayer,

2008:11). Teaching online does not only demand an understanding of the content, but also how to present the content.

Therefore the blended learning approach is always preferable since it facilitates the community of enquiry in learning environments. The community provides the calming, interconnected guidance that balances the open communication and offers infinite access to information on the internet (Garrison & Kanuka, 2004:95-97), making learning easier and flexible. Thus blended learning is worth considering especially in the early stages of implementing NI into an existing midwifery training programme.

Also, as indicated by the Nursing and Midwifery Council, nursing programmes use evidence-based practice and therefore the digital environment must address the learning needs of the student to allow them to actively participate in a ML environment (Berge, 2002:183-184). The introduction of highly visual instructional media into training programmes presents both the teacher and the learner a good platform to interact and share knowledge. For instance midwifery processes such as how to record a partogram and what to do during emergency situations from the clinical guidelines can be developed in audio visual formats. This will facilitate communication between midwives as well as inform patients' means of health for self-management. These and many learning and instructional materials, either synchronous (instructor-led) or asynchronous (self-led), (Clark & Mayer, 2008:11); could be made available online for learners. With basic NI skills, these can be easily accessed by nurses online to enhance their professional practice.

In order to have an effective instructional media integrated into NI courses in an online environment, it must be thoughtfully designed and tested (Sorden, 2005:264-267). Contextualising the needs of the learners through instructional theory will make learning adoptable by educators and learners, embracing the concept of "user-designer" (Reigeluth *et al.*, 1996:3); hence the need to consider design methodologies such as co-design, to allow relevant learning instructions in the NI programme to be designed to meet the needs of potential learners who will be enrolling in the Web Based Learning (WBL) environment. Brindley *et al.*, (2004) cites Bates (2000:57) on the need to

acknowledge “educational innovation” with the inclusion of faculty members, in order to co-create learning materials from the educator’s perspective to meet the needs of learners.

Multimedia Instructions

Presenting ideas in the form of visuals has been proven to facilitate critical thinking and understanding in educational processes (Mayer, 2003:130). Thus, “Multimedia instruction (or a multimedia learning environment) involves presenting words and pictures that are intended to promote learning” Mayer (2005:3). For instance, the use of visuals such as cartoons and animations in instructional media has been noted by many writers that visual communication plays an important role in the educational practice (Dalacosta *et al.*, 2009:741). Illustrations can be used effectively in teaching when it is designed to provide concrete information regarding educational matters. For instance, studies have shown that visuals can potentially enhance the learning capabilities in children and adult learners alike. It has been proven to be very effective, allowing learners to create their own mental modelling using images as a point of reference to remember major topics discussed in a lesson. Amazingly, the most innovative use of animations in educational practice is that it captures the attention of students, allowing them to travel with their mind in a world of imagination and amusement while they learn (Dalacosta, *et al.*, 2009:741).

Additionally, Mayer (2003:125) confirms this assertion when he states that “multimedia learning occurs when students build mental representations from words and pictures that are presented to them (e.g., printed text and illustrations or narration and animation)”. His study also provides much support in the ability of students to deepen their understanding in multimedia learning through well-designed multimedia messages, consisting of words and pictures than from more traditional modes of communication involving words alone (Mayer, 2003:127). Therefore it is proposed by the researchers that multimedia learning should be considered as a means of education for midwifery-students who will be enrolling for the NI programme.

Again, studies have shown that an online learning environment is as effective as the classroom. In some studies a combination of the two is recommended

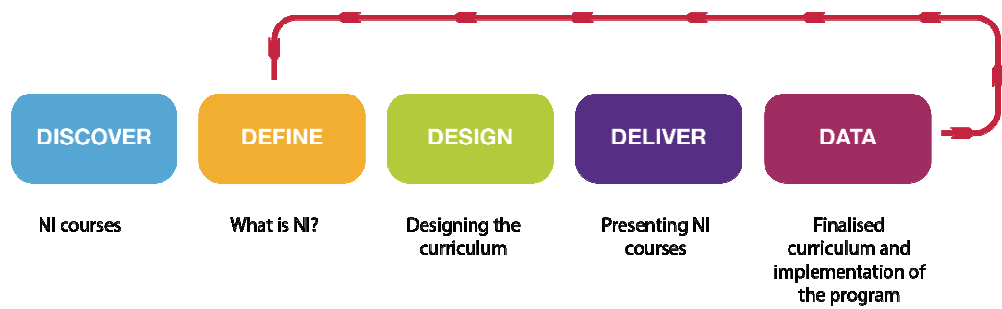
to improve learner satisfaction whereas others have shown similar results for both cases (Dankbaar, *et al.*, 2014:2). This implies that a blended learning approach can facilitate teaching and learning by future health professionals such as midwives in the 21st century. More so, Galloway (2009:para 19) indicates that a digital learning environment can enable the attainment of the outlined core competencies for the health workers as stated by the IOM HPE to enable them meet the demands of the a technology-driven healthcare practice. This learning strategy as indicated in the IOM HPE report states that “distance learning technology, standardized patients, and clinical skills testing technology also hold potential for revolutionizing HPE...offering students an opportunity to customize their learning and progress at their own pace...” (IOM, 2003:90, as cited by Galloway, 2009:para 20). However, irrespective of the mode of learning adopted, it should be supported by multimedia learning materials such as videos and PowerPoint slides to facilitate the learning process.

METHODOLOGY

Service design

A service design approach was used to design the NI curriculum (as shown in figure 2). Design trends have changed from “Design Centred Design” to “User Centred Design” over the last decade (Mager, 2009, as cited by Trischler & Zehrer, 2012:58). Traditionally design focused more on disciplines such as graphic design, product design and other design related disciplines with tangible artefacts. Design is no longer limited. The concept is used to design intangible complex experiences, processes and systems, such as healthcare. In service design, the end-user is part of the design process which is referred to as co-creation. In this process end-users are not passive consumers but rather active partners and co-creators of value (Mager, 2006:8). In this study, the users of the NI curriculum are the nursing educators. Therefore it is extremely relevant to co-create the NI curriculum with these educators in order to add value towards the implementation of NI education in South Africa.

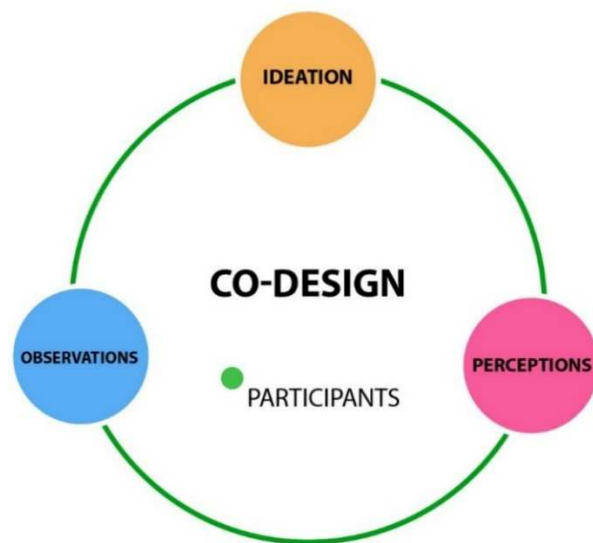
Figure 65: Mind map of the service design process



Designing the NI curricula

In this research, observation and co-design methods were used to gather data needed for the implementation of the NI curriculum. The curriculum was designed by health workers as well as IT and design professionals from both developed and developing countries. Key facilitators who have experience with NI and EL shared their knowledge and expertise with participants to facilitate the designing of the NI programme. As participants and observers, data was gathered from the workshop by the authors (as shown in figure 3). The authors engaged in informal discussions with participants to get a deeper understanding of the NI field of study. This information was integrated into the development of the NI curricula during focus group discussions at the workshop.

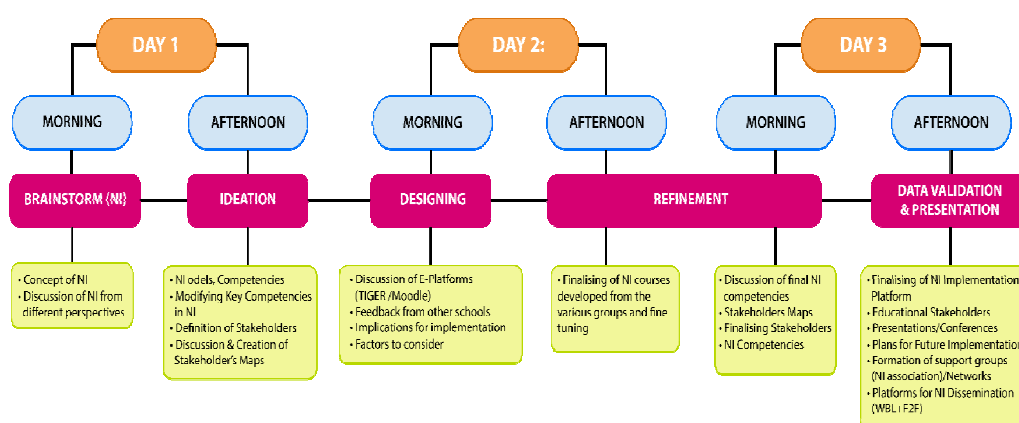
Figure 66: Observation map



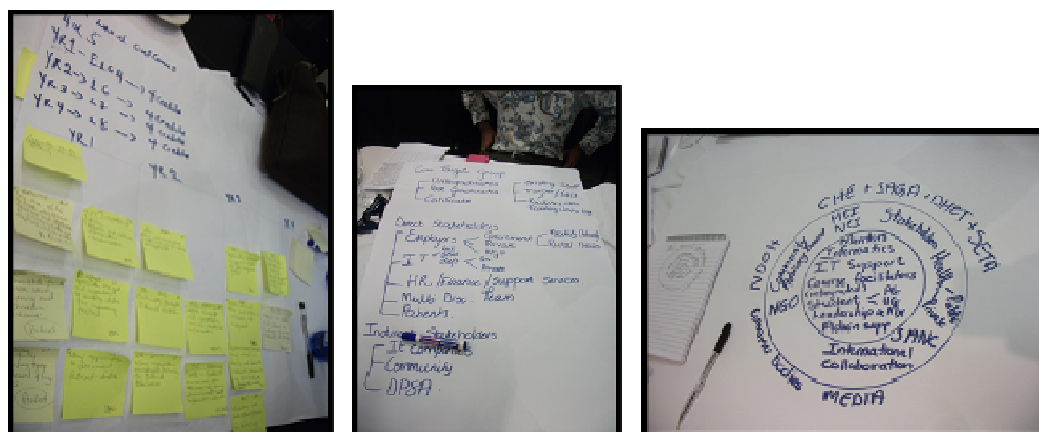
Workshop description

The three day hands-on-workshop (as indicated in figure 4) was organised based on the following anticipated outcomes with a focus on:

- Areas relevant to NI needs in South Africa
- Relevant stakeholders and special interest groups
- Potential NI courses with relevant exit outcomes
- Curriculum design plans for identified courses and the curriculum for the first course
- Potential content providers and delivery platforms
- A network of international partners

Figure 67: The structure of the workshop (designing the curriculum)

- a. Workshop day-one:** The first day of the workshop saw the introduction, discussion and presentations related to NI. It was a jointly organised workshop with partners from Finland who already had experience with NI in their university. They shared their knowledge with participants present, discussing their challenges and success with the implementation of NI. Some of the other topics discussed were mainly the core competencies of IMIA, the lessons learnt, list of needs, competencies and expectations of NI implementation. These issues were discussed and the participants worked on what was needed to overcome some of the hurdles. Also, the stakeholders required for the implementation of the NI curricula into midwifery (as shown in figure 5) and the model for NI documentation were discussed.

Figure 68: Curriculum development at the NI workshop

- b. Workshop day-two:** The next day, the discussions and activities were centred on topics such as nursing documentation competencies, the impact of nursing terminologies use for care, nursing documentation standards competencies and the list of needs building. In addition to these, participants designed the curricula for the various levels as mentioned earlier. The courses were designed in focus groups (figure 2) which were formed within the workshop setting with each group focusing on a particular level. This study primarily focuses on the undergraduate programme which was designed to suit the South African nursing education programme.

Figure 69: participants designing NI curriculum



Technology Informatics Guiding Education Reform (TIGER) initiative

TIGER is the most influential contemporary movement initiative which was formed by bringing together key stakeholders in nursing to share strategies about improving patient care using Health Information Technology (HIT). Also, the TIGER model aims at bringing nurses fully into the information age, giving key considerations to interoperability, informatics competencies and consumer empowerment (Byrne, 2014:43). This initiative is currently running online (as shown in figure 6) as a training platform, allowing nurses to develop their NI skills towards achieving the vision of the TIGER initiative by using informatics in transforming nursing.

Using the NI methodology adopted from the TIGER model, the minimum set of competencies that was required by nurses to succeed in today's digital era were discussed. These NI competencies are:

- Basic computer literacy
- Information literacy
- Information management

These competencies when acquired by nurses will allow them to improve patient care and minimise errors and delays in their work practices. In this information age it will allow them to work better in contemporary healthcare settings worldwide (Chang *et al.*, 2011: 332). Although, the TIGER Initiative (figure 7) aimed at improving the information competencies of nurses, educational programmes must work further towards improving members of faculty as well as the competencies of beginning nurses to minimise their challenges with IT in clinical settings (Fetter, 2014:47).

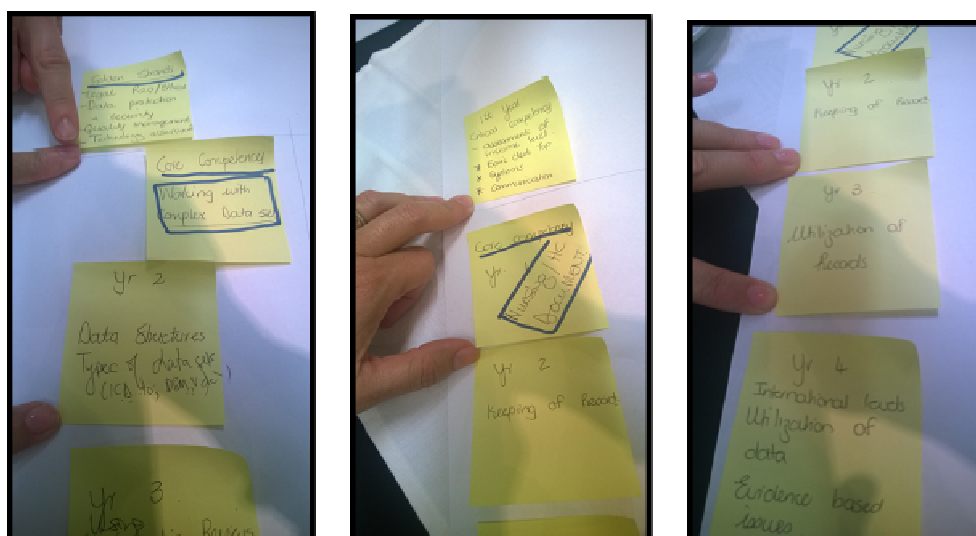
These NI competencies were further synthesised so that it can be aligned to the current curriculum in the midwifery training programme in the South African nursing educational system.

During the co-design session, the undergraduate courses were designed by participants (as shown in figure 8). This was to ensure that the related NI competencies being proposed can be integrated into the nursing training curricula to align with existing courses.

Figure 70: The graphic interface of the TIGER initiative for WBL



Figure 71: Images from a co-design session showing how NI curricula was designed



- a. Workshop day-three:** On the third day, the courses that were designed from the previous days were consolidated and the discussion of potential content providers, delivery platforms and plans on curriculum design and NI collaboration network was finalised (as shown in figure 9). Participants made their contributions and it was suggested that the NI programme be implemented using face-to-face and a WBL approach.

Figure 72: Participants finalising the NI curriculum



NI implementation in a WBL environment

Improvements in ICT (Web 2.0 technology) has created more openings for learning in a Virtual Learning Environment (VLE) through interconnectivity (Baid & Lambert, 2010, as cited by Pucer & Trobec, 2014:965) meeting the requirements of learners in the 21st century, permitting them to regulate their own learning (Pucer & Trobec, 2014:965).

The use of ICT and electronic media in a Virtual Learning Environment (VLE) is considered to be EL. EL which is synonymous with Multimedia Learning (ML), uses audio visuals, text, animation, as well as internet (local intranet/extranet) to facilitate learning in a distant environment (Clark & Mayer, 2008:10). This normally occurs both in a face-to-face situation and in an

online environment which is usually referred to as blended learning (Brindley *et al.*, 2004:18). EL, also referred to as online learning, virtual learning or WBL, creates a flexible learning environment for educators and students. Curtis and Lawson (2001:23) agrees with the inclusion of teacher and learner interaction in an online environment. This interaction through VLE has brought education to the door step of many individuals and facilitates distant learning (Anderson, 2008:55-57). However, EL also poses some challenges with learning which is not present in the face-to-face teaching (Brown *et al.*, 2013:para 1). Learning in an online environment requires much navigation and digital literacy skills. Students come from diverse backgrounds and their learning and cognitive skills differ. Therefore the differences in the learning requirements of midwives such as language, prior knowledge, gender etc. need to be considered so that all students can equally benefit from the online learning environment (Chen & Paul, 2003, as cited by Inan & Grant 2011:376) especially with the introduction of NI into midwifery programme.

The consideration of Adaptive Learning (AL) in a WBL environment allows the delivery of the instructional material to be tailored towards the needs of students, allowing for collaborative learning and interactivity between learners and instructors (Berge, 2002:186). Adaptive instruction means creating a learning environment and finding instructional approaches and techniques that conform to meet the needs of individual students (Park & Lee, 2003:651); hence the need to create a WBL environment using the instructional systems design model to build a useable system for the implementation of NI in South African universities. Also, using AL strategies, the learning environments that meet the needs of students for effective learning can be created to benefit nursing students.

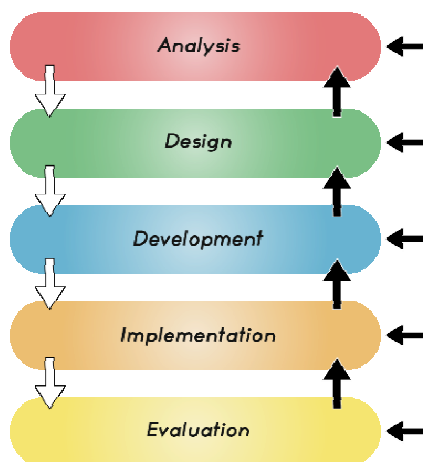
INSTRUCTIONAL DESIGN THEORY

Instructional Design (ID) can be described as the process of designing and developing instructional courses or materials that bring greater efficiency and effectiveness to acquiring knowledge or skills for learners whereas *instructions* is explained as a deliberate attempt of tailoring learning conditions to achieve stipulated learning outcomes (Smith & Ragan, 1999:2). Some

studies portray the basis and the role of educational theory for online learning and the need to understand instructional theories and strategies to facilitate the designing process towards achieving the required results (Anderson, 2004:6). Thus, ID theories provide a clear guidance on how to support people to learn and develop. The type of learning process that will occur may comprise of cognitive, emotional, social, physical and spiritual learning, occurring within a specific learning environment (Reigeluth, 1992:1) and improving learner satisfaction.

In this study, theoretical underpinnings of ID are necessary to understand in order to accomplish the intended goals. Therefore in the process of designing instructions, an ID model is an essential guide that serves as a foundation for designing the ML environments. Furthermore, it provides a bearing and creates an efficient dialogue in co-designing towards an efficient system to enhance learning (McLeod, 2001:42).

An exploratory study where the role of memory, needs analysis, and design models such as ADDIE (Gustafson & Branch, 2002:22) (*Analysis, Design, Development, Implementation and Evaluation*, as indicated in figure 10) are considered during the design process of the NI course. The researchers focused on the *Analysis* part of the ADDIE model where learning requirements and characteristics of the midwifery students were considered (Chan & Robbins, 2006:493). It was mentioned by the nursing educators that learners who enrol in the programme should be given **prior learning** for the first part of the course in order to identify their strengths and weaknesses. This is intended to give students the necessary foundation needed to make progress in their next level of training.

Figure 73: ADDIE model

RESULTS

The proposed curriculum obtained from the co-design session (as indicated in table 1) by the participants will be supported by instructional media technology. It is anticipated that the NI courses based on the preliminary data obtained will be mounted in due-time using online platforms such as Moodle (as shown in figure 11). “Moodle is a learning platform designed to provide educators, administrators and learners with a *single robust, secure* and integrated system to create personalised learning environments” (MoodleDocs, 2014:para 1).

Also, participants indicated that the participation of students can be potentially increased in a highly visual digital learning environment. This has the power to sustain the attention of learners and fill in the knowledge gap in complex subjects making learning much easier and effective in their professional practice (Mayer, 1999:622).

Additional outcomes from the workshop also suggested some core competencies of the bachelors programme (as shown in table 1-3) required for NI education in South Africa.

Figure 74: Moodle a WBL environment



Healthcare informatics: bachelor of nursing (Three core competencies and broad outcomes over four years)

Table 7: NI core competency year one

Competency: working with complex data sets			
Year One	Pretesting Use electronic devices and software to explore and communicate information Demonstrate the ability to use word processing and multimedia software Successfully navigate operation and filing systems	Explore different types of health care data sets applicable to nursing and midwifery Uses sources of data that relate to practice and care	Accesses, enter and retrieves data used locally for patient care (eg. Uses HIS,CIS for plans of care, assessments, interventions, notes, discharge planning Uses database applications to enter and retrieve information Conducts on-line literature searches
Year two	Use applications for structured data entry, interpretation and reflection	x	x
Year three-four	Year 3-4 (dealt with across two years)	Advocate for the use of quality nursing data sets to improve nursing and midwifery practice, inclusive of data integrity	Use systematic review data for patient care enhancement

Table 8: NI core competency 2

Competency: Nursing and Health Care Documentation (Patient Documentation)			
Year One	Access and retrieve information	Appreciate the use and importance of nursing data for improving practice	Use a relevant application to document patient data
Year two	Use administrative applications to document and review relevant patient data	Critically analyze patient data	Use information management technology for patient education
Year three	Appreciate the realities of electronic communication and data management systems	Explore the ethical issues and solving of such around data utilization and management	X
Year four	Explore evidence based practice in terms of data use management nationally and internationally	x	X

Table 9: NI core competency 3

Competency: Health Care Informatics Advocacy			
Year One	N/A	N/A	N/A
Year two	Explore language and current conversations around healthcare informatics	Create a conducive environment for the teaching and learning of health care informatics	X
Year three and four	Launch a nursing informatics group project to develop and sensitize relevant communities of practice	Collaborate with stakeholders/ peers for advocacy	Reflect on realities and issues on healthcare informatics nationally and globally (year four)

CONCLUSIONS

HI as indicated in this article has enormous benefits for nurses. For instance, it makes their work much easier and helps in reducing enormous paper-based record systems. NI on the other hand potentially empowers the nurses to use technology in their day-to-day practice. Also, evidence from other studies indicates that multimedia learning can facilitate learner satisfaction. Students can learn while they interact with instructors, making it easy for people to learn from remote areas. Therefore implementing NI courses facilitated through ML could potentially empower midwifery trainees to effectively use technology to aid in their professional practice.

The authors suggest that the NI courses can be extended as top-up programmes and it could also be offered at master's degree levels for

practicing midwifery professionals. This is possible using ML which allows education to take place without geographical barriers, bringing education to the door step of learners.

Further studies will be conducted to complete the remainder of the processes in the ADDIE model to facilitate the actual implementation of the NI informatics programme when accepted by interested midwifery training universities in South Africa. It is the impression of the authors that the introduction of NI in an EL platform will make learning easier for midwifery students to acquire the necessary competencies needed for their professional practice in a technologically empowered healthcare system.

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A RHIZOANALYSIS OF LEARNING CONNECTIONS AMONG HIGHER EDUCATION LEARNERS

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ABSTRACT

This study is part of an ongoing doctoral study that seeks to explore the learning connections of higher education learners. Based on the first principle of Deleuze and Guattari's (1987) Rhizome Theory, connection, the study was motivated by what learners connect to and how they connect in the construction of their learning in an ever growing technological environment. Actor Network Theory and the Rhizome Theory formed the theoretical framework that underpinned the study. Two questions that drove this paper were: what the connectors in learners' learning network are and how these connectors emerge to support learning. The study was a qualitative one which involved six participants who were by then higher education learners of different levels. Participants were selected using snowball sampling technique. Data collection methods included a focus group interview, observations and artefacts. The study revealed that learners were connected to very complex networks which continually multiplied through three basic rhizonomies that all behave as actors and actants; learners, machine(s) and technology. It was again found that apart from the learner-learner and learner-machine(s) connections; there also existed machine(s)-to-machine(s) and learner-technology connections in the personal learning networks of learners. Learners get connected to learning networks based on need, properties and nature of course studied. The research at this preliminary stage recommended an in-depth study to find out about characteristics of self-directed learners and how they construct meaning in a rhizomatic environment as opposed to existing industrial batch processing system that does not take individual differences into account.

Keywords: *connection, heterogeneity, learner, learning technology, rhizome and rhizomatic learning.*

INTRODUCTION

This study was conceived from two French theorists, Deleuze and Guattari's (1987) Rhizome Theory as part of ongoing research that is exploring learning patterns that emerge from self-directed learners in a ubiquitous and technology-rich higher education environment. In their book, *A Thousand Plateaus*, Rhizome Theory (RT) is made up of six principles that describe a "rhizome" plant which can be likened to a network without start and end points. The six principles are connection and heterogeneity, multiplicity, a signifying rupture, cartography and decalcomania. Etymologically, RT was based on the notion that the "rhizome" plant which is a "creeping rootstalk" multiplies from no one specific node (Cormier, 2008:1). "Rhizomatic learning" which was further developed from the RT describes learning that does not follow traditional and linear structures where learners are passive contributors to their own learning (Wheeler, 2012; Cormier, 2008).

In support of the RT, Actor Network Theory (ANT) was used to achieve the aim of the study. The two theories formed the conceptual framework of the study. ANT allows for exploration into socio-technical structures of humans and non-humans in a connected and technological environment (Latour, 1992). One common thing that exists between these two theories is negotiation. In RT, nodes or learners are connected and must be connected to other nodes. In a similar situation actors and actants who are also nodes do not work in isolation. Actors can only perform when there are actants. This is where negotiation comes in. Furthermore, activities of actants are usually triggered by their actors (Law, 2007:8). Learners today negotiate their learning in a community (Cormier, 2008).

This paper explores the first two principles of RT, connections and heterogeneity of learners in a higher education milieu. Learners have kept up the pace with the changing learning landscape due to the high-speed and condensed technological advancements. Heterogeneity is established once there is a connection (Law & Hassard, 1999) since learners extend to interact

with the socio (other learners, lectures, family) and technical (mobile phones, computer, apps, other platforms) parts of the environment. When heterogeneity of a network becomes very concentrated, it creates stronger tension which then causes dependency and mutuality of actors and their actants. Learners (actors) today get so dependent on certain apps and social media platforms (actants) in constructing learning. There is a growing trend in which learners' connections are defined by technology. Where learners are connected to humans, there are sometimes, elements of non-human agents such as the internet, apps, mobile phone and other gadgets in the connection.

Earlier paragraphs support the fact that one of the greatest opportunities we have today as stakeholders in the educational industry is the proliferation and advancement of Information, Communication and Technology (ICT) (Attwell & Hughes, 2010:1; Leye, 2007: 984). The opportunities offered by ICTs have amended to a great extent how learners construct their learning (Lindorth & Bergquist, 2010; Finn & Inman, 2004). However, the authors, who are educational practitioners, have observed that the batch-processing methods of training learners which was inherited from the Industrial Age continue to take a centre stage in the teaching delivery systems in higher learning environments. Apart from the will and itemised policies of integrating technology into pedagogical processes by educational authorities, designers of modern learning content and infrastructure have barely integrated technology into the pedagogical processes, even with new programmes (Kinash *et al.*, 2012).

The aim of this paper is to advance an understanding of the connections that emerge when learners engage in self-directed learning and in a networked environment. To achieve this aim, the paper focused on two questions: What are the connectors in learners' learning network? How do these connectors emerge to support learning?

LITERATURE REVIEW

Digital Generation

Research shows that technology integration has become a “free for all” resource in all disciplines including pedagogy. Cloud computing, access to internet and WIFI connections are not new things in the educational landscape, rather, they have become integral part of pedagogical processes. Due to the “universality” and fast pace of technology, educational stakeholders have in various ways worked to integrate these technologies into the curriculum. Nevertheless, the pace of improving teaching and learning through technology integration in higher education institutions is far slower than its usage by learners (Jones *et al.*, 2010). In addition, most institutions continue to maintain very archaic methods of pedagogies despite the fact that technology integration allows active learner engagement and output (Shelly *et al.*, 2012:280).

By their immersed engagement with digital media, Prensky (2005) describes present day learners as digital learners. Trilling and Fadel (2009), further expanded Prensky’s description of the current generation of learners as learners who have been “*bathed in bits*”. Obviously, technology makes learners of today far different from learners of previous generations (Shelly *et al.*, 2012:16). But the digital divide is glaringly expanding to the extent that learners are always confronted with the old fashioned Industrial Age educational practices which include teaching and infrastructural development.

“Most of the schools today were designed for the Industrial Age and yet, the learners attending schools today are living in the digital age. The world in which digital learners live has changed drastically and it continues to change in a techno fast-paced manner. Unfortunately, many school environments have not kept up with that change” (Shelly et al., 2012:16).

Table 1 gives a snapshot of the characteristics of how different current learners are from past generations.

Table 10: Understanding Today's Digital Generation (Adapted from Shelly et al. (2012:16))

Learners from Previous Generations	Today's Digital Learners
Passive communicators	Hypercommunicators
Single taskers	Multitaskers
Work oriented	Play oriented
Linear thinking	Random access
Non relevancy learning – relevancy was not critical to learning	Learning has to be relevant and fun
Single sensory input	Multisensory input
Text-based first	Digital and graphics first
Reality-based	Fantasy-based learning
Conventional speed	Twitch speed

Table 1 is very explicit on the switch of focus and skills by current learners as opposed to learners of previous generations. Learners today are much more connected and heterogeneously networked through ubiquitous access to technology. Unlike learners from previous generations, today's digital learners see learning extremely important to them only when it is relevant and fun loving. According to Papastergiou (2009), digital games as *"new modes of learning based on Information and Communication Technologies (ICT) have emerged in recent years and become increasingly used in schools."* This answers why learners can engage so much in playful activities yet connect their play to learning. Some of these activities embedded in games are highly educational.

As cited in Shelly et al. (2012:15), Apple Computers identified learners of today as digital learners who are usually multitasking in terms of communication goal orientation. Oftentimes, learners are very comfortable in parallel activities during learning (Eton, 2011; Prensky, 2001:2). With the earphones plugged in the ear, mobile phone in the hands, the thumbs very busy on the screen or keypad, learners are comfortable and respond to other

needs in real time where necessary to them (Prensky, 2005). In contrast to parallel processes and multitasking by learners, a number of researchers have identified parallel processes and multitasking as very injurious to learners' abilities to stretch their learning limits (Sana *et al.*, 2013:29; Wood *et al.*, 2012; Barak *et al.* 2006). The argument here is that, multitasking is a source of distraction since learning time and concentration are distorted and shared among a number of activities (Kraushaar & Novak, 2010).

The Changing Learning landscape

Technology adoption and use is far more advanced in the social and corporate world which learners are ultimately being prepared for. In spite of the "*evolution of modern technologies starting over 100 years ago*", current digital technologies have changed learners' approach to learning over the last decade (Shelly *et al.*, 2012: 280). Earlier before the last decade, learners relied mostly on "authorities" like teachers, parents and the library for answers to their questions as opposed to current trends when learners rather resort to technologies for their learning. This wave shows how learners have become highly adaptable in integrating technology in their personal and network learning environments. The connections that exist between learners and other elements affect their learning outputs. Learners are connected to either humans or things which then reshape their learning processes.

Learners are more connected than ever before. The connections account for the rapid information flow and thousands of virtual and physical networks of learners. Most of these learning networks are highly fluid and very informal. According to Wheeler (2012:2) informal learning forms about seventy percent of what learners learn. The seventy percent could be accounted for through the various connections of learners' learning networks. Though the current crop of learners are "*native speakers of the digital language*" (Prensky, 2001:1), a lot of their learning are negotiated through "*trial and error*" (Eton, 2011). Even, for older people today, a lot of what is learnt is than through "*trial and error*" where new apps and technology are explored based on some previous assumptions or past experiences with similar technologies. Eton's assertion defies earlier suggestions by Farrant (1980:120) about the efficacy

of the “*trial and error*” method in learning. Connecting to a learning network to a large extent is based on risks and “*trial and error*” because associating with a network can never guarantee successful learning outcomes of a learner.

Siemens (2008) espoused that learners learn through a community of network(s). These connections are based on so many factors which describe the degree and strength of closeness. According to Trilling and Fadel (2009) learners get connected through tools such as communication and collaboration. While collaboration speaks to interests and needs of learners, communication also speaks to the interaction between the nodes (actors and actants) which include learners, machines and technology in a learning network.

The “*Learning Grid*” of Wheeler (2012) shows the transition of learning from the industrial (learning 1.0) through to knowledge (learning 3.0) ages. Pedagogies of the industrial age were motivated by Behaviourist and Cognitivist theories. The common denominator of Behaviourism and Cognitivism is the use and emphasis of scientific experiments on animals to describe human behaviour. Unfortunately, their *modus operandi* have seriously been attacked by authorities such as humanist psychologists, Freud (1961) and Rogers (1951).

The current trends of technology influx, innovation and adoption by learners under very limited control of our schools and educators support the viewpoint of Freud (1961) who opposes Behaviourist and Cognitivist theorists that, learners are not *tabula rasa* (blank slates). Learning 2.0 which is the beginning of social media describes how learners get more engaged in their learning compared to learning 1.0. Many have associated Learning 3.0 to 21st Century learning (Eton, 2011; Partnership for 21st Century Skills, 2011). Eton and the Partnership for 21st Century Skills described learning 3.0 to what they called “characteristics of 21st Century skills”. Learning has travelled through the era where learners were classified as *tabula rasa* (blank slate) to a negotiated and self directed learning environment. Through technology, the mass of learners no longer learn following traditional passive and taxonomic structure (Wheeler, 2012). The current paradigm of rhizonomy describes how

learners construct their own learning through a community where they are actively involved and connected (Cormier, 2008). Like the rhizome, it is very difficult to pin down the exact sources of how learners get to learn. As opposed to the “*batch-processing*” era of learners where knowledge was only vested in the lecturer, learners today are diverse (Eton, 2011) and validate information they receive from their lecturers through the internet. A ‘simple’ description for the structure of ‘modern’ learning is that learning today is complex. Table 2 summarises the characteristics of learning from the industrial to knowledge ages.

Table 11: “The Learning Grid” (Adapted from Wheeler (2012))

Dimension	Learning 1.0	Learning 2.0	Learning 3.0
Learning modes	Passive, Individual	Active, Social, Collaborative	Participatory, Social, Community
Content Organisation	Hierarchy, Top Down	Heterarchy, Bottom up	Networked, Multi-Nodal, Multi-Directional
Classification Mode	Taxonomy	Folksonomy	Rhizonomy
Content Provenance	Expert Generated Content	User Generated Content	User and Machine Generated Content
Dominant Interfaces	Keyboard, Mouse	Keyboard/Mouse, Touch Screen, Voice/Gesture	Voice/Gesture, Direct Implants, Biometrics, Context Aware Systems
Construct	Content is King	Context is King	Community is the curriculum
Theories	Behaviourist, Cognitivist	Social Constructivist	Connectivist, Rhizomatic
Data Capture	1 D Barcodes	2D Quick Response Tags, Marker Technologies	3D Holographics, Extended Marker Technologies

Deep understanding of how higher education learners construct their learning through various connections is essential in improving pedagogical processes. The apparent gap between curriculum developers, lecturers on the one side

and learners on the other side seems not to be bridging anytime soon. Learners are still taught through behaviourists' and cognitivists' theories of learning 1.0. New curricula are also developed in that manner while the actors (learners) in the learning network clearly subscribe to principles of connectivist and rhizomatic theories.

RESEARCH DESIGN AND METHODS

The research is philosophically aligned to the stance of critical realists. Since learners' connections are associated with complexities, the researchers perceive no single reality in achieving the aim of this research. Exploring the learners' learning connections in their natural world by engaging with them will reveal varied patterns and interpretations.

A focus group interview which involved six participants who were each university learners in South Africa formed the sample. One participant who had majority of the attributes found in the initial literature was purposively sampled after which he assisted us in identifying all other five participants who related to him in his learning network and also possessed his kind of attributes. Researchers will be seeking to find resonance between existing data and available literature rather than generalising the outcomes and results at the end of the main study.

RESULTS

Table 3 gives an overview of the profile of participants. Details about gender, age, the course offered and year of study of participants are given in Table 3.

Table 12: Profile of Participants

Participant	Gender	Age (years)	Details of university studies	
			Course	Year/Level
A	Male	22	Interactive media	3 rd
B	Male	19	Medicine	2 nd
C	Female	22	Information Design	4 th
D	Male	20	Sound Engineering	2 nd

E	Male	21	Mechanical Engineering	3 rd
F	Male	19	Actuarial Science	2 nd

Participants were each enrolled as learners in a South African university. In all, the six participants came from three different universities. The age range according to Table 3 is from 19 to 22 years. There were two 19 year old males and two 22 year old male or female. With the exception of one female, all participants were males. By the nature of their courses they were all affected by technology in their learning. They all applied the use of technology in their field of studies to support their learning.

Fig. 1 is a basic Rhizomatic Map of participants about the learning connections in their learning network. Fig. 1 gives the pictorial representation of how participants themselves saw their learning connections in their learning network. Furthermore, it shows what the nodes or connectors (actors and actants) in their learning networks are. The connectors were identified to be learners themselves, their peers, other people which included lecturers and parents. Some web platforms and apps were also identified as connectors. According to participants, these platforms were used as general and specific tools for their learning. The specific learning tools (See Table 5) are those that touched directly on their academic lives.

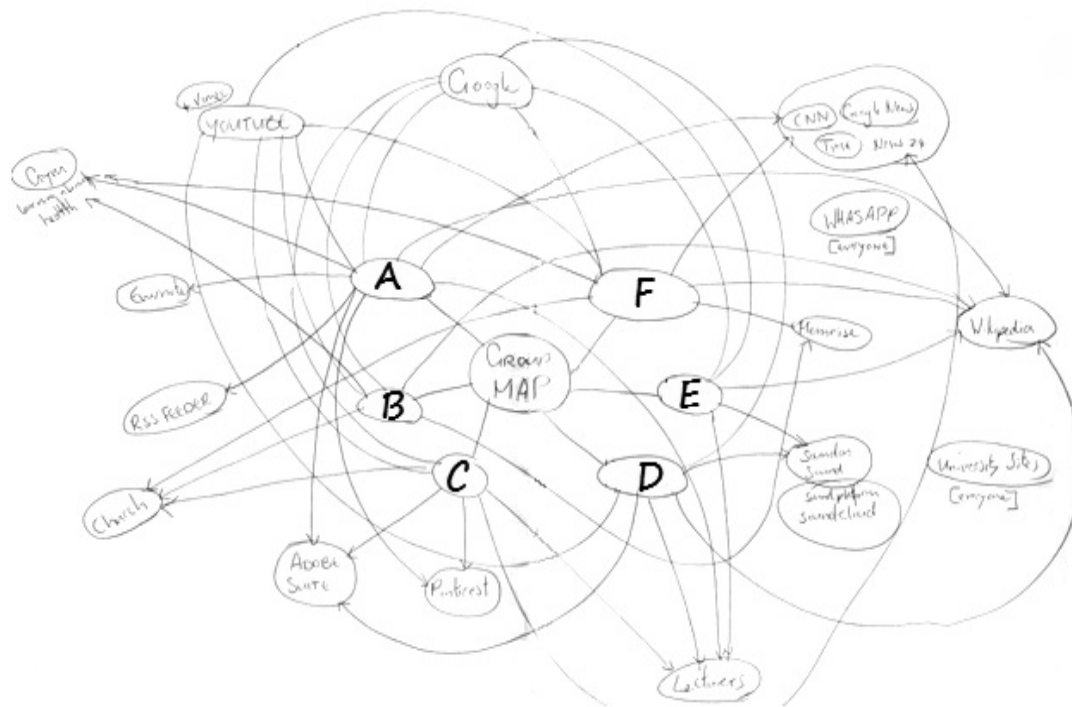


Fig. 1: Group Rhizomatic Map of participants

From Fig. 1, participants are seen to be both actors and actants. They derived learning support from their peers, apps, softwares and certain important websites. Table 4 is further analysis of the Group Rhizomatic Map of participants in Fig. 1.

Table 13: Heterogeneity of learners' connections

Participant	Lectures	CNN	TIME	News 24	Google News	Evernote	RSS Feeder	Church	Pinterest	Memorise	Gym	Adobe Suite	Wikipedia	Soundas	Sound	Sound platform	Soundcloud	Total
A	√	√	√	√	√	√	√		√		√	√	√					11
B								√		√	√		√					4
C	√	√	√	√	√			√	√			√						8
D	√							√				√	√	√	√	√	√	8
E	√												√	√	√	√	√	6
F		√	√	√	√					√	√		√					7

Key: √ = Participant is a user of item (e.g. app or platform)

Table 4 gave a total of 17 actants and actors that participants depended on for their learning as a group. The 17 matches are only exclusive to learners' as a group. The most connected learner in the group is Participant A.

Tables 5 and 6 identify how the various connectors support participants' learning. Table 5 presents 15 tools identified by participants which are useful platforms and applications to their learning networks.

Table 14: Web Platforms and other Applications

S/N	Tool	Use(s)
1	Video copilot	Used as a collaborative resource for training, design tools and artist work. Allows learners to learn how possible effects can be created so that they can apply the techniques on their own.
2	Evernote	Allows for note taking of important activities. Allows for phone and laptop synchronization.
3	learning.com	Provides digital literacy and project based learning
4	Code academy	Free coding lessons
5	Wolframe alpha	For Mathematics
6	Free sound.org	Free sound sharing platform
7	Youtube	Supports audio-visual learning, supports sharing.
8	Web clipper	Allows for saving documents online, annotations, visual and audio manipulations
9	Wikipedia	For general information
10	Memorize	For creating learning materials, learning new language, general educational website
11	Sun learn	Learning management platform
12	JSTOR	Digital library of academic journals, books, and primary sources
13	EBSCOHOST	Digital library of academic journals, books, and primary sources
14	Physics games	For Physics tutorials in the form of games. Example is the mini train.

15	Sound on sound	Mixing of sounds, used for background sounds, for creating sounds especially those that are difficult to record in their natural settings

Table 6 presents 10 tools identified by participants which are useful platforms and applications used for academic purposes to their learning networks.

Table 15: Web Platforms and Applications used for academic purposes

S/N	Tool	Use(s)
1	JSTOR	Digital library of academic journals, books, and primary sources
2	EBSCOHOST	Digital library of academic journals, books, and primary sources
4	Physics games (Mini train)	For Physics tutorials in the form of games. Example is the mini train
5	Vula	Allows for temporary or specific project based activities
6	Wordpress	For creating website or blog
7	Behance	Portfolio platform
8	Wiki news	For news, assignments
9	Khan academy	Open source educational website
10	Facebook	Socialising, calls, collaboration, sharing, class announcements, for official and emergency information from the university

Though some tools identified in Table 6 can be found in some Table 5, participants noted that their universities depended on some of the applications such as vula, JSTOR, EBSCOHOST that supported their learning so much. According to Participant E, “...thanks to Khan academy for helping me pass my metric”. Participant E continues to heavily use this platform, years after his high school.

DISCUSSION

From Tables 5 and 6, it was observed that participants made good use of open source applications as tools for learning. The most connected learner in the group was Participant A. This may be because this group was one of Participant A's main networks. Again, on the contrary, Participant B whose

connections in this network were the least may be as a result of his field of study, medicine. Perhaps, he may have stronger learning connections elsewhere which will be more biased towards the sciences. The participants by their nature are very heterogeneous from the perspective of the courses they all offered in the university. No two of the participants offered the same course. From a very diverse background of Interactive Media, Medicine, Information Design, Sound Engineering and Mechanical Engineering it is interesting to map how learners converge as far as certain apps and platforms are concerned. However, Fig. 1 and Table 4 show very strong convergence between Participants D and E in the use of sound related platforms. From Table 3, Participants D and E all come from engineering backgrounds and perhaps this may be one way to identify how the connectors bring learners together or keep them apart. Another interesting pattern that emerged from Fig. 1 which can easily be seen in Table 3 is the convergence between Participants A and C. Table 4 shows commonalities between these two participants which includes news channels like CNN and News 24. Apart from Participants A and C, none of the other participants used Pinterest which is a free social media that allows subscribers to manage videos and images. Again, this pattern may be emerging from the course backgrounds, Interactive media and Information Design respectively.

The interview confirmed that participants were all affected by technology in their learning. From Fig. 1, and the observations, participants were all connected to humans and non-humans who acted as agents (actors and actants) in a network. Their connection describes the first two principles of the RT which suggests that learners at any point can be connected to and must be connected to an actor or actant in a network (Deleuze & Guattari, 1987). All participants were strongly connected to non-human actants such as the devices like the mobile phone, computer and tablet than humans. In most cases, connections with humans were than through a non-human actant. Furthermore, non-human connections which also acted as technical parts of the network included internet and apps. Participants discussed their motivation in a learning network. For instance, the choice of a mobile phone largely depended on the functionalities that supported learning. The choice of

phones by participants can be supported by statements of Prensky (2005) who said that

“...today's high-end cell phones have the computing power of a mid-1990s personal computer (PC)—while consuming only one one-hundredth of the energy.”

Participants were internationally connected via virtual networks through social networks over the internet. Within the group map, very interesting inter and intra-connections were discovered.

According to Participant A, “I get connected to my learning network either through machines like mobile phone, computer, tablet or personal contacts with people like friends, lectures and others.”

Interviewer: How close are you to your lecturers?

Participant B: “Our lectures are closer to us based on how they adopt technology.”

Interviewer: How do your lecturers encourage you to use technology for learning?

Participant D: “They do depending on their age.”

Interviewer: What do you mean by age?

Participant D: *“Lecturers who are less than 40 years accept and use the technology for teaching, those between 40 and 55 years do not really care about technology, they still teach with or without it. But from 55 years upwards, it is difficult for them to adopt technology for teaching and learning. Some lecturers in this category can sack you from lectures when you are seen pressing your keypad.”*

The most prominent connection of participants in their personal and group learning network were in the following order; internet, machines, peers and lecturers. The connection was usually based on the skills, age of peers, nature of platform in terms of usability, applications (games, social media) and the promotion of learning. Participants' global connections were basically coming from online friends through social networks and their university learning platforms. Participants derived a great sense of belongingness and confidence each time they had internet connectivity.

Despite arguments against utilising multitasking for learning by some authorities like Sana *et al.* (2013) and Wood *et al.* (2012), Fig. 1 shows traces of how learners exhibit a lot of multitasking in a complex learning environment. Participant B is a true heterogeneous participant in the network as evident in the limited number of connections in Table 4 and Fig. 1 and during the focus group interview where his contributions sometimes differed from that of the group. This apparently shows that Participant B may be having other links to other networks apart from this. Participant A's connections in the network are also an example of heterogeneity since his connections go beyond the group (see Evernote and RSS Feeder in Fig. 1). These mappings confirm examples of connection and heterogeneity (Cormier, 2008).

From Fig. 1 participants learn through their connections with people, phones, computer, internet and their university websites. Other platforms also include whatsapp, google, vimeo and youtube. All participants found all the aforementioned as important actants to their learning, hence their connection with them. Apart from the negotiated platforms shared by all participants such as whatsapp, university websites and youtube, only two learners used memorise for their learning. Table 4 shows details of connectors where participants converge and subscribe to.

CONCLUSION

In conclusion, this paper found that learners were connected in a complex learning environment. Learners' connections included inter and intra connections with humans (actors) and nonhumans (actants) that also covered the socio-technical parts in the environment such as mobile phones, computers, internet and apps. According to participants, youtube was the most highly rated, based on its use. It was rated the mostly used because of its audio visual nature. However, participants said that the nature of the youtube interface caused a lot of distractions to their learning. This assertion is supported by Sana *et al.* (2013) who aver that multitasking is not an efficient way to support learning. University websites were also seen to be a very useful part of the higher education learning environment of learners. One

participant was the only person who used some other platforms that were not used by all other participants in the network. Evernote and RSS Feeder were only used by one participant, meaning that, that participant may have other actors and actants in different groups utilising Evernote and RSS Feeder. The connectors emerge to support learning based on the functions of the connector or actant, nature of network and course studied among others. Further studies into characteristics of learners in a technology-rich environment for the doctoral study will unearth and contribute a lot more coherent discourse.

RECOMMENDATIONS

Recommendations from this paper feed into the main research which will be expanding to look at the characteristics of self-directed learners in a connected environment. Furthermore, to go in-depth to find out how these connected learners construct meaning in a rhizomatic environment. Elaborate recommendations are expected at the end of the doctoral study since this research is still in progress.

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STAFF TURNOVER WITHIN THE MICRO RETAIL SECTOR TRACK: BUSINESS DESIGN

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ABSTRACT

Staff turnover is one of the leading challenges facing business owners and managers other than factors such as sales and marketing. Current literature focuses on driving factors of staff turnover for large retail businesses, but lacks appropriate guidelines or principles to assist micro businesses to deal with this matter. Therefore, there is a need to provide micro retail business owners or managers with appropriate key principles to address the high staff turnover phenomenon. In this paper, the authors combined three theoretical frameworks, namely; the universal turnover theory, limited modal representation theory and the sub population theory to guide the underlying quantitative research approach. The findings suggest that there are specific internal and external factors which predominantly contribute to high staff turnover in the micro retail sector. The paper concludes by providing some recommendations to assist micro retail businesses on how to reduce high staff turnover. The paper contributes to literature of staff turnover with a specific focus on the micro retail sector.

Keywords: *Staff turnover, micro retail sector, micro businesses, South Africa.*

INTRODUCTION

The role of human resources (HR) in business potentially provides the most prominent source of sustaining competitive advantage for organisations

(Kochan & Dyer, 1993:569; Pfefer, 1994:15). Human capital is identified as a key factor to enhance business competitiveness, particularly in the service sector of which retail, is an iconic example (Barcala, Perez & Cutierrez, 1999:335). According to Huselid (1995:635), human resource management practices can contribute to organisational business outcomes by shaping employee behaviour and attitudes. Maximising employee performance while at the same time, gaining staff loyalty is an objective most employers aspire to achieve. Experience shows however, the contrary. Camps and Luna-Arocas (2008:26) for example, find that most research activity is conducted on large retail business organisations, making staff turnover issues one of the leading challenges facing many human resource departments. According to the United States Bureau of Labor Statistics (2010), an increasing number of employers are finding that employees stay employed for only about 24 months. In Hong Kong, the retail sector is at the top of the list regarding high levels of staff turnover where in 2008 for example, the retail business recorded its highest annual turnover rate of 36.7%. In the case of South Africa, the retail business sector has an average staff turnover rate of between 20% and 25% (Shoprite Holdings annual report, 2010, as cited by Han, 2013). The questions then arise; could human resource management practices or direct management intervention, influence employees to stay employed for longer periods? Furthermore, to what extent would job satisfaction alleviate this phenomenon?

Using the above background, this paper focusses on the micro retail sector which is very different to medium and large sized organisations. More specifically, this research is conducted in Cape Town, South Africa, where the category of small medium and micro enterprises (SMMEs) is widely deployed (South Africa, 2003). Moreover, the focus of this paper is on the micro retail sector.

THEORETICAL BACKGROUND

Researchers have developed frameworks which are routinely constructed around the same three core turnover mechanisms; *attitudinal variables* (job satisfaction, organisational commitment) (March & Simon, 1958; Lee &

Michell, 1994), *job-search mechanisms* (whether perceptual or market-based) (Steers & Mowday, 1981; Hom & Kinicki, 2001), and *turnover intentions* (stay-quite intentions) (Mobley, 1977; Steel, 2002). It could be argued that these mechanisms form the backbone of contemporary staff turnover theory. However, the focus is more on large retail businesses where staff turnover literature is limited in micro retail businesses. Factors driving high level of staff turnover could be internal or external. Factors controlled by employers are deemed as internal, whereas factors or reasons that are not controlled by employers are deemed external (Karakowsky & Mcbey, 2000:137; Gustafson, 2002:107; Hendrie, 2004:434). The internal and external driving factors in the retail sector fall under these three turnover core mechanisms and these factors are summarised in Table 1.

Table 1: Factors driving staff turnover in the retail sector (Han, 2013)

Internal factors	Poor training Working conditions Management practices Rate of pay Recruitment process
External factors	Unemployment rate Employee personal interest

Furthermore, literature on staff turnover suggests that most staff turnover models are probably following one of three conceptual policies. Models may be intended to support the **universal turnover frameworks** (Hausknecht & Trevor, 2011) or seek to provide a more **limited modal representation** of staff turnover processes (Hom *et al.*, 2012). Finally, there are attempts to specify unique staff turnover paths of various **Subpopulations** (Allen *et al.*, 2012). Universal staff turnover models describe processes that may be appropriated to explain the staff turnover of individuals. This kind of model provides an overarching framework that is intended to apply to some degree, to the turnover decisions of all workers without regard to an individual's unique circumstances or situation. Instead of being broadly inclusive, a modal-theory approach would attempt to describe a 'most typical' or 'most frequently-occurring' staff turnover process. This conceptual policy acknowledges the

fundamental diversity among individual decision processes. However, commonalities across employees may be identified by focusing on recurrent patterns or searching for the existence of predominant decision styles. Finally, Subpopulational staff turnover frameworks are predicated on a belief that staff turnover processes are qualitatively different for employees in different situations. Situational differences may result from personal factors, contextual factors, or a combination of these two (Steel & Lounsbury, 2009).

Three theoretical models (universal turnover model, limited modal representation model and subpopulations model) are combined and constitute the framework for this research. The framework assisted the researchers to gain a more comprehensive understanding of the turnover phenomenon especially, in the micro retail sector. The following factors are identified:

- driving factors of turnover amongst all employees in the micro retail sector,
- typical patterns of staff turnover process for individual employees and commonalities among entire workforce within the micro retail sector,
- driving factors of turnover of individual employee according their situations in the micro retail sector.

RESEARCH METHODOLOGY

Research approach

Quantitative research is concerned with the collection and analysis of data in numeric form. This type of research tends to emphasise large data sets. In a quantitative approach the use of variables is critical in describing social phenomena, with a central role being the handling of potential sources of error either through experimental or statistical control (Mouton, 2006:38). A quantitative approach was selected for this research using questionnaires.

Selection of participants

Collis and Hussey (2003:55) define a target population as a set of people or a collection of items which is under consideration that researchers ideally would like to use to interpret their results. For this research, the micro retail

businesses in Cape Town, South Africa, are the population of the research. The retail employees as well as owner managers were approached to be the participants. This is in accordance with McMillan (2000:103) stating a population is the study object consisting of elements such as groups, organisations, human products and events, or the conditions under which they are exposed.

Sample method selected

According to Watkins (2010:56), purposive sampling is used for a specific *purpose* for instance, choosing participants who represent diverse perspectives on a problem. For example, Bruwer (2010:30) applied purposive sampling for retail businesses where the author aimed to establish financial performance measures from accounting resources in Cape Town, South Africa. For this research, purposive sampling is selected as the research focuses on the groups of people (unit of analysis) who are employed and involved in some way, in staff turnover within micro retail businesses.

Questionnaire

The questionnaire used is a list of carefully selected and structured questions with the aim to establish what the target group of participants do or think (Watkins, 2010:67). Furthermore, the researchers summarised the responses with statistical indices to draw conclusions. Leedy & Ormond (2005:196) express the opinion that a questionnaire should have a simple design and pose a series of questions to participants. A structured questionnaire used for this research did ensure consistency when asking participants questions, all participants being employed in micro retail businesses and performing similar jobs.

The questionnaire used a five-point Likert scale (Likert, 1932:55). According to Emory and Cooper (1995:180-181) the advantages of using a Likert scale includes easy and quick construction where each item meets and empirically test for discriminating ability.

The questionnaire consists of 9 main questions with the majority of questions broken down into a number of sub-questions. Question 1 is a table to record employee working hours and questions 2 to 8 are related to gender, recruitment, management, training, working conditions, remuneration and staff turnover. Question 9 is a general open ended question on staff turnover. Specifically, questions 2.2 to 6.5 are five point Likert scale questions. For these questions, participants were asked to rank one of the five choices presented.

Selection of samples

The delineation of this research called for micro retail businesses to be informants for this research in the Cape Town area. According to Bhoola (2008:25), shopping centres can be classified as either, regional shopping centres or convenience shopping centres. Regional shopping centres provide shopping goods such as general merchandise, apparel, furniture, and home furnishings in full depth and variety. Furthermore, regional shopping centres are built around main-line department stores and cover between 6 000 and 8 000 square meters.

In contrast, convenience shopping centres provide customers with convenience goods and services. These shopping centres cater for busy one-stop shoppers and provide services needed by consumers who are normally from the immediate area or neighbourhood. Convenience shopping centres are built around supermarkets and cover between 1 000 and 5 000 square meters. Samples have been chosen from different shopping centres, where micro retail outlets are concentrated, according to the rules categorising micro businesses.

Data collection process

The researchers attempted to find a population of micro retail businesses in Cape Town, from which a sample could be selected. This included contacting or referring to sources such as the Cape Chamber of Commerce, Department of Trade and Industry (DTI), Statistics South Africa and local business publications. Exhaustive investigation by the researcher did not reveal any

meaningful population. Due to the unknown population of the micro retail business sector in Cape Town, the researchers could not guarantee that each member of the population will be represented for the research. Therefore, non-probability sampling was applied (Leedy & Ormrod, 2005:206, Emory & Cooper, 1995:274).

There are six municipalities in Cape Town. They are: Blaauwberg Municipality, Cape Town City Council, City of Tygerberg, Helderberg Municipality, Oostenberg Municipality and South Peninsula Municipality (City of Cape Town, 2011). Although the researcher used non probability sampling, a fair representation of the different areas needed to be sought. According to the purposive sampling method, the researcher could choose three distributed geographic areas. These areas that were chosen were: City of Tygerberg, South Peninsula Municipality and Blaauwberg Municipality. In each area, the researcher selected one regional shopping centre and one convenience shopping centre. These are listed in Table 2.

Table 2: Target shopping centres for research empirical study

Municipality	Regional shopping centre	Convenience shopping centre
City of Tygerberg	Canal walk	Brighton Square
South Peninsula Municipality	Cavendish	Stadium on Main
Blaauwberg Municipality	Bayside Mall	Flamingo Square

All the retail businesses in these shopping centres which fall within the category of micro retail businesses were selected as research subjects. A business directory was used to compile a list of micro retail businesses, excluding for example, restaurants within the respective shopping centres. This list also excluded all supermarkets (e.g. Pick 'n Pay, Checkers, Spar etc) and department stores (e.g. Edgars, Clicks, Foschini, Mr Price and others). Also excluded, were chain stores (e.g. The Crazy Store, Accessorize, Shymansky) among others. Lastly, the researcher made contact with every shop owner or manager of the remaining lists of businesses to ascertain if their business falls within the category of a micro retail business. Over the four month period, 83 responses were received. During the data collection process, the researcher translated the responses from the completed

questionnaire into raw data by logging the data from questionnaires to a set of raw data sheets, depending on the questionnaire questions.

DATA ANALYSIS TECHNIQUES

Various methods were used for the analysis for the responses of questionnaire. A simple summary analysis was used to analyse the working hours within micro retail businesses in Cape Town. Mean confidence interval analysis was used to analyse the female employees' impact to the staff turnover issue within micro retail businesses. A statistical software package NCSS version 07.1.21 was used for the data analysis of the responses of remuneration, training, recruitment, working condition and management issues.

RESULTS

Most (89.16%) of micro retail businesses in Cape Town are working on Saturdays. More than half (53.01%) of micro retail businesses in Cape Town, work later than 17:00 during week days. Most (83.13%) of the micro retail businesses in Cape Town only have a one shift working hour pattern. Female employees are the majority of the employees (80.72%) within micro retail businesses; however only 49.39% responses agree or strongly agree that female employee's family responsibility could result negatively in work attendance.

Majority (more than 80%) of respondents apply recruitment processes, namely:

- Formal interviews (87.96% respondents agree or strongly agree)
- Interview result notification (81.93% respondents agree or strongly agree)
- Formal employment engagement process/ signed employment contract (81.92% respondents agree or strongly agree).

Most (more than 65% and less than 80%) of respondents apply the following recruitment processes:

- Make use of a scanning process (69.88% respondents agree or strongly agree)
- Have pre-defined questions for the interview (73.49% respondents agree or strongly agree)

Formal advertisements of vacancies are seldom posted on the internet or in newspapers, nor are recruitment agencies commonly used. Only 45.69% respondents agree that they apply this practice.

Most (more than 65% and less than 80%) of respondents applied the following management practices:

- They have clear job descriptions (71.8% respondents agree or strongly agree)
- They have clear defined disciplinary processes (75.91% respondents agree or strongly agree)
- They have clear probation periods (66.30% respondents agree or strongly agree)
- More than half (more than 50% less than 65%) of the respondents apply the following management practices:
- They have performance management processes (62.65% respondents agree or strongly agree)
- They have employee development programs (56.62% respondents agree or strongly agree).

Most (more than 65% and less than 80%) of respondents apply employee training, namely:

- New employee induction (68.76%)
- Initial job training (77.11%)

Only 57.83% of respondents apply updating employee training on new processes or responsibilities.

Most (more than 65% and less than 80%) of respondents have working conditions, as follows:

- They have clearly defined break times (65.06%)
- They have air conditioning (67.47%)
- They have security (77.10%)
- Employees are entitled to leaves (sick, annual, maternity etc) (75.90%)

60.24% of respondents answered that basic equipment are provided by the employer in the canteen.

Most applied remuneration benefits are: overtime pay (78.31%) and annual bonus (62.65%). Sales commission is by about half of the respondents (49.4%). The other benefits are supplied by fewer small businesses: Study bursaries (18.07%); company share option (16.87%); medical aid (19.28%); cell phone allowance (15.66%) and pension fund (26.51%). Some employers give travel allowance to their employees (33.73%).

Table 3 depicts remuneration as the biggest cause of staff turnover (ranked 1). It appears that in micro retail businesses, only minimal remuneration benefits are applied most of time. Physical and employment working conditions and working hours are both ranked as the second biggest cause of staff turnover in micro retail businesses in Cape Town.

Table 3: Ranking of possible causes of staff turnover

Possible causes of staff turnover	Ranking
Remuneration	1
Working conditions	2
Working hours	2
Management	3
Recruitment	5
Training	5
Gender	7

DISCUSSION

Remuneration

The findings of this research revealed that to retain staff, businesses should offer relevant and competitive salary rates compared to similar micro retail businesses within the industry. The employer can benchmark similar micro retail businesses wage levels to offer competitive wages to their employees.

Due to the low average remuneration rate in the micro retail environment (identified throughout the literature), weekly wages might assist employees more than monthly salaries in terms of the financial implications of employees for example, relieving cash flow problems. Commission on sales is another important remuneration component. It influences the total remuneration package of employees significantly but will also motivate them. Therefore, the micro retail businesses have to review their business scenarios and determine for example, a feasible sales target level for commission to be paid, which employees are able to achieve. This would not only benefit employees, but the businesses as well.

Working conditions

Within working conditions, safety and security are essential aspects to consider. If employees go to work without the assurance that they are safe and secure in their working environment, then the motivation to go to work is notably reduced. Employees will resign as soon as an alternative is available. Unfortunately in South Africa, safety and security is a pressing matter for everyone and everywhere they go. This is a particular challenge in the retail environment, both for employees and employers who need to provide a safe shopping and working environment. Employers should aspire to provide safety and security solutions in their shops such as armed response, closed circuit television (CCTV), drop safes and on-site security. The researchers are aware that these matters also increase costs, thus affecting the whole business profit cycle. Besides safety and security, other basic working conditions are also important to retain staff in micro retail businesses.

Defined break time for tea and lunch

In retail environments, closing the shop for tea and lunch during trading hours could result in the loss of sales and customers. Customers want to be able to visit shops anytime within trading hours. However, everyone has the basic need for refreshments. In micro retail businesses that have more than one shop assistant, rotating break times for tea and lunch needs to be considered. During busy seasons, the rotation time slot might be subject to change, depending on business requirements.

For micro retail businesses which often only have one shop assistant this is more difficult. These micro businesses have to face loss of trading time which may result in losing customers. Alternatively, shop owners or managers could stand in while the shop assistant takes a break. The conclusion is that micro retail businesses have to provide break times for employees for example, tea and lunch breaks.

Canteen facility

In addition to break times for tea and lunch, canteen facilities are also important aspects of working conditions. Cold food, especially in winter is neither good for health nor enjoyable. Hot water is mandatory for making hot refreshments such as tea and coffee. Taking tea and lunch breaks are not only to satisfy body requirement for food and drink, but also serves as a physical break from the working environment. Good canteen facilities would support the quality of break times. On the other hand, if there is no canteen facility, rooms or space, then employees have to take breaks elsewhere which may not be comfortable or safe. If there is no equipment to provide hot water and warming food, then employees may need to do this elsewhere, or incur additional expense. This could pose serious problems to employees in terms of providing basic human needs.

The researchers recommend micro retail businesses need to try their best to provide basic canteen facilities. It may not even be too costly for example; an electric kettle and a microwave oven would suffice in most cases. Though, this provision will assist in vastly improving the physical working conditions, meeting basic human needs.

Office ambient temperature

Although Cape Town is known to have a mild climate²¹, on average, Cape Town receives about 788 mm of rain per year and has a Mediterranean climate due to winter rainfall. The highest rainfall is in June which is in winter

²¹<http://www.worldweatheronline.com/Cape-Town-weather/Western-Cape/ZA.aspx#HolidayGuideworldweatheronline.com> [7 May 2014].

with wet, cold and often dark days. Temperatures may vary between 20 to 25 degrees Celsius during the day and between -5 to 10 degrees Celsius at night. In contrast, summer days are hot and dry and temperatures vary between 25 to 35 degrees Celsius with occasional summer showers. This is compounded by excessively windy conditions. Compared to the rest of South Africa, the climate has therefore, severe implications for micro businesses, shops and office conditions. Furthermore, the micro retail businesses that were used as participants are scattered all over Cape Town and usually far from residential areas. This forces employees to travel great distances. They mainly use public transport but are often forced to use costly private transport (taxi services). All this travelling exposes them to external climatic conditions, early in the morning and late at night. This situation is in contrast to many international country or town conditions, which have an underground or sophisticated travel infrastructure. Also, detailing working hours. It is recommended that employers of micro retail businesses in Cape Town are made aware of these basic working conditions, which are part of an employee's needs.

Working hours

To achieve maximum sales value, long working hours are the norm in the retail businesses. This also applies to micro retail businesses. Long working hours impact on an individual's private life in terms of work, life balance and social status.

To retain staff within micro retail business in Cape Town, it is recommended that employers schedule shift patterns for employees to provide them with the best possible option to achieve a balance of work and life. An example could be, equally rotating employees on Sundays, public holidays and late hour shifts. As a cross reference, this must also be considered in terms of Cape Town weather.

The empirical evidence in this research reveals that most driving factors of staff turnover in large retail businesses also apply in the micro retail sector. Furthermore, evidence also suggests that there are specific driving forces of

staff turnover in the micro retail sector. The combination of these factors provides a holistic view of different causes of high staff turnover in the micro retail sector.

CONCLUSION

Within micro retail businesses in Cape Town, South Africa, low wages, long working hours, unsafe and insecure working environments and informal management practices are challenges for micro retail businesses to retain their staff. The results shows that factors driving staff turnover within the retail sector also apply to the micro retail sector. Furthermore, specific factors such as remuneration, working conditions, defined break time, canteen facility, office ambient temperature and working hours are predominant contributors to high staff turnover within the micro retail sector.

The research findings suggest that businesses should offer relevant competitive remuneration packages, provide safe and secure environments, arrange fair shift patterns and establishes formal management practices. These would assist micro retail businesses to prevent, or at least reduce staff turnover.

This research also provides a more comprehensive understanding of factors driving staff turnover in the micro retail business sector. This is done by drawing from three theoretical models identify in the literature. The findings and recommendations will assist micro retail businesses to establish clear strategy to reduce staff turnover in their respective businesses and in the industry as a whole.

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TOWARD A CONCEPTUAL MODEL OF PARTICIPATORY ASSESSMENT IN PROBLEM-BASED LEARNING (PAPBLE) IN GRAPHIC DESIGN EDUCATION

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ABSTRACT

The educational pedagogy in most Ghanaian higher education is lecturer-centered with lecturers as storehouse and providers of information and students as passive recipients of information. This approach has impacted negatively on student's learning process. A collaborative learning approach that promotes students process of inquiry, critical thinking and skill development thus lacks in the context. To this end, to educate students to compete and become active participants in society to meet global competition requires teaching and learning processes that is underpinned by relevant theories and models. In this paper, I introduce a studio-based application, called Participatory Assessment in Problem-Based Studio Learning (PAPBLE), to support assessing students' development in professional skills in graphic design within large class-size situation. The model is based on using students to pedagogically support each other's learning through four creative process stages: research, concept development, prototyping and feedback. PAPBLE intends to rationalize the processes of peer assessments within the creative process. PAPBLE has been designed based on the theory of Model of Participatory Evaluation (PE), and thus can help describe the complex interactions among parties, knowledge, interest level, and strategies with which knowledge is gained and shared. I illustrate the workflow of PAPBLE and how PE is integrated into the peer assessment process. I also discuss the advantages of the PE-based assessment framework paralleled to a traditional assessment model.

Keywords: *Peer assessment, participatory assessment, design process, graphic design education*

INTRODUCTION

In the past few decades, enormous pressure has been placed on institutions of higher learning to churn out individuals who can contribute more meaningfully to the development of their societies. According to Obadiogwu (2012), this is the main reason for the shift from teaching methods that take

the student for a mere receiver of knowledge to methods that seek to actively involve the student in the creation of what he/she comes to know.

In an attempt to achieve this, many teaching pedagogies which tend to focus more on the student than the teacher have been developed. These teaching methods usually aim at ensuring that the student plays an active role in his/her learning; and not just serve as a passive receptor of knowledge. One of the popular teaching pedagogies that try to make the student the creator of what they know is the participatory assessment for learning.

THEORETICAL AND PHILOSOPHICAL FOUNDATIONS

The approach underpinning the Participatory Assessment in Problem-Based Studio Learning (PAPBLE) Model is, as far as I am aware, an original approach to assessment and outcomes in graphic design studio which draws on the core principles of Participatory Evaluation as acknowledged by Cousins and Earl (1992) and Ainsworth & Viegut (2006) and extends to include other dimensions such as constructivist learning theory, the design process and reflective practice.

Participatory Evaluation

According to Cousins and Chouinard (2012) participatory evaluation is the “applied systematic inquiry for the purposes of making judgments about the merit and worth of programmes or supporting programme decision making.” In participatory evaluation stakeholders could either be trained evaluators or otherwise (Cullen and Coryn, 2011). Cousins and Chouinard reckon that participatory evaluation is a bottom-up approach to evaluation with participants’ interest at its core. Participants play active roles at every stage: plan the evaluation design, gather and analyse data, and determine actions to take based on the results (Zukoski and Lulaquisen, 2002).

Participatory evaluation has proven to be a useful teaching and learning approach. Campilan (2000) enumerated five advantages of using a participatory evaluation approach in learning as: “it derives support from a broader base of knowledge, expertise and resources”. It enhances the validity

of the evaluation and makes the evaluation more inclusive since it accommodates the views and interests of all those involved in the programme. For Zukoski and Luluquisen (2002), participatory evaluation has three main advantages: it builds knowledge, skills, and relationships among the stakeholders; it ensures the needs of the local community are addressed with the inclusion of local knowledge; and finally, it ensures responsibility is shared between evaluators and stakeholders. The major challenge they identified with the concept is its time consuming nature, usually borne out of the fact that stakeholders have to be trained.

Cousins and Earl (1992) again asserted that participatory evaluation is best suited to formative evaluation projects. Formative evaluation, which is also known as “assessment for learning” (Ainsworth & Viegut, 2006) is a concept which demands that assessment not be seen as the ultimate goal of learning but rather as an aid to learning.

Constructivist learning theory practice

This model is built on the belief that knowledge is constructed by learners and is influenced by experiences, social values and several identifies. It is rooted in Dewey’s progressive educational philosophy, established on the learning theories of Piaget and Vygotsky, and progressively researched on current leaders as Darling-Hammond (2001) and Shulman (2005). This perspective pushes me to place the previous knowledge and experiences of students at the centre of my studio practice and facilitate the students’ development through meaningful exploration. Constructivist practice calls on students to be active participants and learners in their own development and to view knowledge - in theory and in practice - as dynamic social constructions that are made and re-made through reflective interactions with social, cultural and natural phenomena (Marlowe & Page, 1998; Foote, Vermette, & Battaglia, 2001; Dansforth & Smith, 2005; Ladson-Billings, 2009; Vermette, 2009).

It is also hinged on participatory learning theory. According to Weaver and Cousins (2004), participatory learning/evaluation theory has three main goals: pragmatic justification (when the intended result is to be used in solving a

problem or making a decision), political (to foster the idea of fairness to everyone involved in the process), and lastly, epistemological (for the sake of knowledge production/construction). It is also partly based on the practical participatory framework developed by Smits and Champagne (2008) which focused basically on the use of knowledge created or the results of a practical participatory evaluation.

The aim of this study is to develop a model for participatory assessment for problem-based learning in design education. First, the model aims to provide the platform for design instructors to situate assessment within design pedagogy to increase the student's understanding of course content presented. Second, the proposed model is implemented through a live design project that was utilized in the tertiary-level graphic design course (N = 132). This paper describes the model, its theoretical underpinnings and how it was developed. Finally, the conclusions are presented.

Reflective practice

Palmer (1983) opines that reflective practice can be taught within the context of design courses which view knowledge and artefact production as by product of students' search of meaning. Miller (1993) argues that pedagogy that "poses problems rather than transmits content encourages reflective thinking and doing". It is believed that reflection and metacognition enrich professional practice. (Henderson, 1996; Zemelman, Daniels & Hyde, 1998; Eby, Herrell & Hicks, 2002). The model thus focuses more on the student to ensure that he/she becomes the creator of his/her knowledge rather than a passive receiver of knowledge from the instructor. It ensured that new learning is based on a previous learning or knowledge and also took into consideration the need for students to work in groups and share ideas in an attempt to find solutions to problems, thereby learning from others. And since constructivism also fosters a situation where the answer is not the same in all situations, it is best suited theory for a model to be used in a graphic design studio.

The Design Process

Grobler (2006) notes that within design education, the design process and assessment are inseparable. The design process provides the designer a realistic approach and process for problem-based learning. In design process, the students can apply their schooled knowledge and skills to the problems and situations semblance of real-life working contexts. The design process provides a realistic and complex model of creative functions that are constructed. An essential characteristic of the design process is its lateral nature, which replicates realistic time-dependent decision making in the creative world. Such continuous processing offers reliable tasks rather than abstract instructions. Grobler is of the view that the process should not be 'prescriptive or repetitive' rather the student be allowed and guided to initiate his/her style and sequence at arriving at a design solution.

During the graphic design studio project, graphic designers make different kinds of decisions within the design process. This means that they manage the material flows, follow the clients and anticipated consumer inputs, and attempt to respond to audience actions and so on. For example, designers can make decisions on themes for communication, typography, colour, photography/graphics and layout development. Working on the graphic design project is challenging as the designers also have to manage the materials process (culture, demographic variables of target audience, the production process, deliveries and budget). Figure 1 shows a typical creative problem solving process in graphic design studio.

Creative Problem-Solving

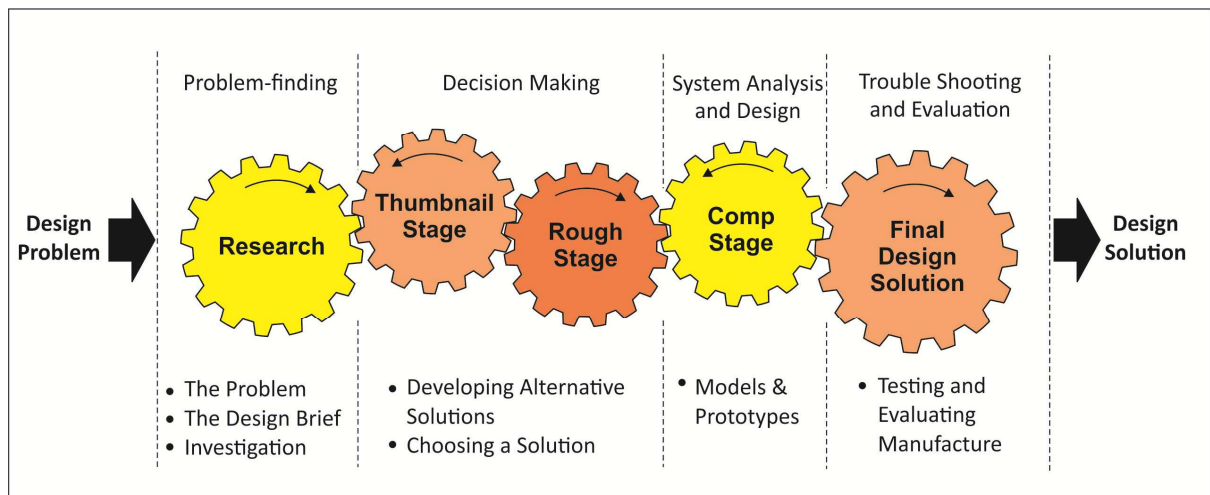


Figure 1: Diagram showing the creative design process utilized in graphic design project

PARTICIPATORY ASSESSMENT IN PROBLEM-BASED STUDIO LEARNING (PAPBLE)

There exists a lot of evidence to back the concepts on which the model is grounded. Gray (2007) posits that learning occurs when the learner is actively involved in a process of meaning and knowledge construction; as opposed to passively receiving information. Further, Christie (2005) believe learning is an active process, that knowledge is constructed and shaped by experience stressing that an educational approach should be designed towards the needs and purposes of individual learners. Schell & Janicki (2012) claimed constructivist learning theory is ideal for use in the higher education. It offers students a way of solving problems that would be very useful to them after leaving the university. For Steakley (2008), the greatest benefits of constructivism include the involvement of students in their own education, making learning relevant to real life situations, a means of encouraging unity between students regardless of their age, sex, race, wealth, et cetera, and prevention of indiscipline in the classrooms. All the above are just a few of the evidence that supports the constructivist learning theory on which the model is based.

Evidence exist that supports the use of problem-based learning (PBL) approaches in classrooms. One of the major features of PBL is its focus on

students; the fact that it is student-centred (Wilkerson and Gijsselaers, 1996). In an age and era where students are increasingly becoming the focus of educational pedagogies, it is a laudable idea that the model employs an approach that is grounded on PBL theory. Aside the above, team work is a prominent feature of PBL (Allen, Duch, & Groh, 1996; Cohen, 1994). In addition to its tendency to improve the communication skills of the students, it also sustains their interest and motivates the students since they are actively involved in the work and are held accountable for actions by other group members (Cohen, 1994).

The PAPBLE Process

The model has four (4P) main parts: the problem, the process, the participants and the product as illustrated in Figure 2. The model starts with a graphic design problem as the trigger. This part of the model conforms to the assertion by Cousins and Whitmore (1998) who insisted that participatory evaluation needs a trigger to start. It also deals with the relevant previous knowledge the participants in the process need to have. This knowledge is what the participants need to make meaningful contributions to the process.

The Process Schema

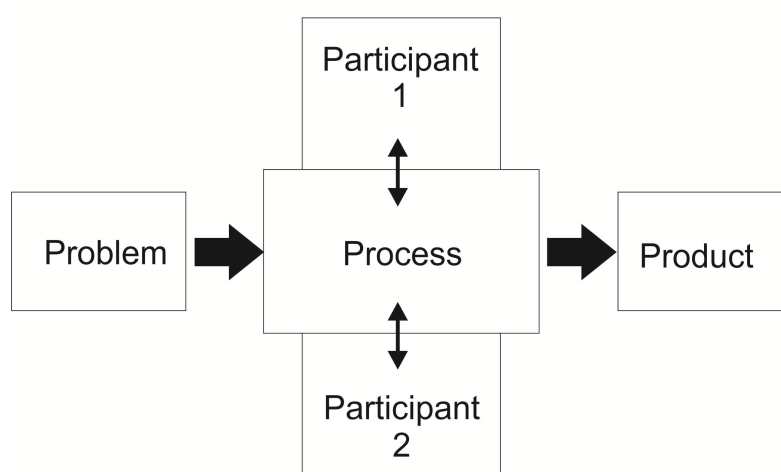


Figure 2: The Project process schema

The second part of the model details the participants in the process and the specific qualities they needed to meaningfully contribute to the process. It also specifies the duties of the participants and the interactions that must occur

between them. The third component is the creative/evaluation process which involves three phases: a) research/data collection about the problem/project, b) discussions with group members about the problem and the eventual finding of a solution (knowledge construction), and c) the prototyping phase the problem is actually solved (Eca, 2002). All these three phases are subjected to rigorous multiple-levels of assessment by both the students themselves and their peer evaluators.

Within this space, is the confluence of all of concepts and learning theories utilized in the model. It is the phase in which the students co-construct their knowledge/learning by sharing and discussing their ideas with their peers based on the problem at stake. At the end of the process, all that were involved in solving the problem could claim their success or failure for themselves. By encouraging the students to learn through “doing”, (that is, solving real life problems, something which is characteristic of graphic design projects), the model is employing the problem-based learning theory, which requires that learners gain knowledge from actually tackling and solving real life problems (Gijsselaers, 1996).

Another key concept employed in this phase is peer assessment. The students, while attending to their own projects, also act as the evaluators/assessors of other students. This helps the students to take advantage of the many benefits of peer assessment. The last part of the model shows the results of the participatory process: the co-creation of knowledge that would become the previous knowledge of a new problem/project, and also the solution to the initial problem that triggered the process.

PAPBLE Conceptual Model Workflow

PAPBLE exemplifies a planned creative process situated within constructivist learning environment. In the model, students work independently work at each stage of the design process. Thereafter, collaborative teams would perform the assessment tasks as part of the critique stage, to enhance learning. All stages of the process are stringed, monitored and moderated. Figure 3

illustrates the Project process. The solid arrows show the continuous process flow. The dashed arrows show students' previous knowledge. The reversed arrows emphasize that students also learn by observing what their peers do. The support manual will guide students and instructors, as well as assist with the administration, such as allocating students to assessors.

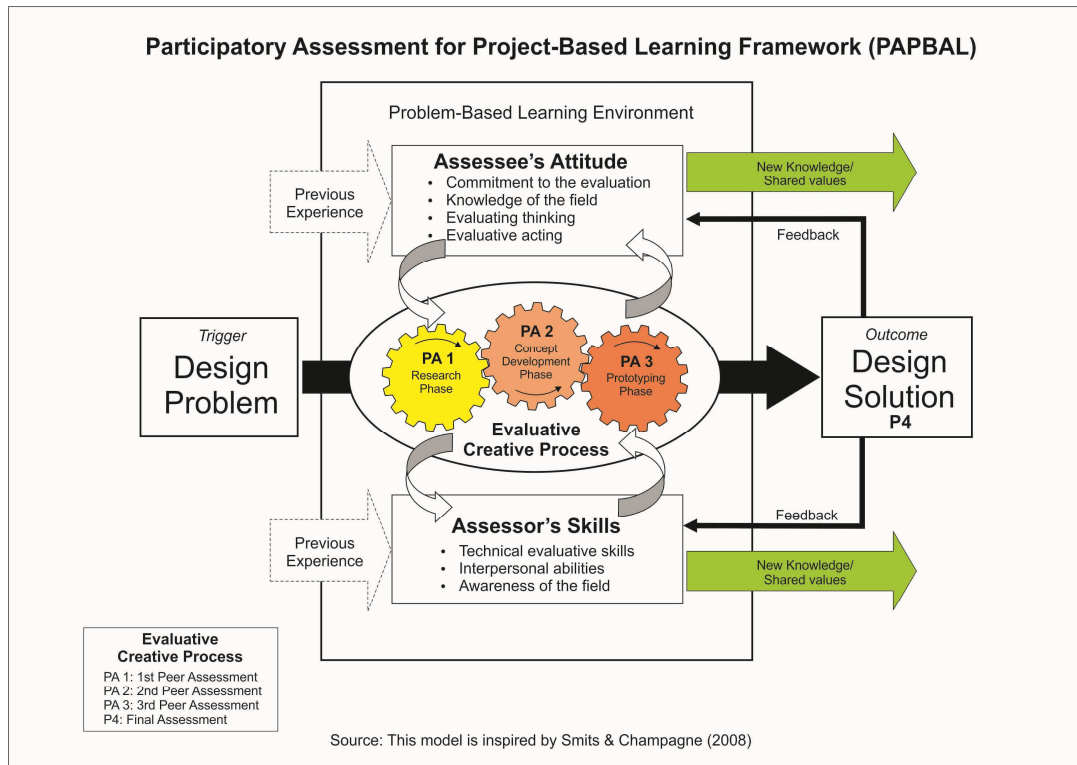


Figure 3: The Proposed Model for Participatory Assessment for Project-Based Learning (PAPBLE)

Assessment and Report Process

Pre-assessment activities

- Students are taken through orientation on peer assessment and intervention briefing.
- Students with instructor develop assessment criteria and rubric for graphic design project and work on exemplars.
- Students are randomly paired as assessee/assessors (ratio 1:2).

Assessment for Learning Process

- Students were given graphic design a problem, according to course outline and learning objectives and guidelines provided by the instructor.
- Students did presentations of the synopsis of problem, selection the best solutions from a set of options, and then appraising, justifying and communicating the decisions, for the first level of multiple peer assessments.
- The instructor reviewed the problem description and definition, corrections if necessary were made. The assessee –presented the synopsis to a panel of two student assessors in conference at the first level of assessment.
- Assessee reviews assessors' joint feedback.
- Student assessors scored the design solution using previously developed assessment rubric. At any point the feedback, a detailed written feedback — positive or negative — was a key aspect of studio learning, especially how to critique.
- Three levels of peer assessments – research, knowledge construction and prototyping occurred within the creative process for a project.
- A student may challenge his/her grade and request for instructor moderation. Disputes were a common feature and it helped in deepening students' learning. They also helped ensure the fairness of the PAPBLE approach, especially when the instructor did not have the time to review each student's design solution within the studio time for large class-size situation. If a student doubted the peers' grading, the instructor's moderation focused attention on the specific problem.
- The instructor moderation helped in the determination of the final grade for the disputed design solution.

- Using the three peer evaluations as input, instructor assigns a final grade to the final design solution. The final mark for each project was summative and calculated by the instructor.

Assessment tasks

Each participatory assessment session lasted for approximately 90 minutes. In each assessment session, there were two assessors assess the assessee together and provide written feedback. Once assessment is completed the assessee joins a new team becoming an assessor to a different assessee. The assessees were given time to analyse and review the design and to create plans for their future studio activities. The studio session ends with a general critique and verbal feedback by the instructor. Students were given criteria for success (exemplars), rubrics etc., before the schedule task is completed.

A PILOT STUDY

Participants

All second year students from Department of Communication Design, Kwame Nkrumah University of Science & Technology in Ghana who had registered the course were used in developing the model. The assessment activities were integrated in the DAD 252: Graphic Design II studio. The class numbered 132 (71 males and 61 females) students. Permission was sought from the Department Board before the introduction of the study.

DAD 252: Graphic Design II

This is Graphic Design course module which focuses more on practice (studio). The assessment requires team work of 2-3 students (1 assessee and 2 assessors). The assessment strategy comprise of a combination of formative assessment (peer assessment) via visual presentations in week 8 (weighting 35%), and final summative assessment (portfolio) due in week 12 which includes a process book – containing documentation of research activities on graphic design project(s), a sketchbook – showing the ideation process and containing visual commentaries; self- assessment (weighting

5%); peer-assessment (weighting 15%) and a final project (weighting 45%). The importance placed on the design process, which provides the students the opportunities to investigate design problems, examine and apply the techniques and skills discussed in the module in relation to concept development, contemporary media and cultural context. Students are required to come up with original ideas starting in week 4 schedule, present their work in progress (prototype) in every week and develop meaningful projects over the semester.

To successfully complete the course students need the skills that academics have identified as creativity or being creative and reflection. The assessment criteria include indicators for creativity such as 'critical thinking', 'imagination' and the 'ability to produce creative outcomes'

Consideration about reliability and validity

I consider that the materials, process journal, portfolio and the graphic design solutions therein that my design students and I have produced will offer a worthy arrangement of both reliability and validity. Am confident that the assessment strategies will be continuously evolving; there are countless revisions I have already made to the rubrics, assessment procedures, feedback mechanism and continue to count.

Reliability: Reliability is the major disapproval of participative assessment. I am confident that through the peer-assessment, student-participated assessment tasks and teacher assessments, I have considerably ensured that reliability is enriched. I reviewed my studio pedagogy to accommodate the alternative assessment strategy. Although, there were initial challenges in our studio practices, procedures and student numbers: I am equally certain that with my new innovative assessment strategy, the reliability risks are weakened notable among them are quality of feedback, students' expertise levels, fairness and student apathy. Although each stage of the process had some obvious administrative challenges that had to be dealt with as they surfaced to ensure reliability of the assessment process. Again each stage required unique rubric to ensure the learning expectations of the stage were

adequately catered for in the assessment process. Each assessor had his/her understanding and appreciation of the design theories and visual outcomes produced by the assessee, and the situations offered students opportunities to dialogue and reflect critically about their practices, thereby improving on their knowledge construction. I am much aware of the potential trouble points when introducing this alternative assessment strategy in a traditionally subjective area. Constant reflection on my practice and revision to the process ensured that students' fears were professionally dealt with.

Validity: To the extent that validity is concerned, I consider the assessment strategy that I have developed as an improved way to evaluate my design students and their creative products. Grobler cautions that the integrity and validity of assessment is compromised when assessment criteria and aims and outcomes of a design brief are not aligned. She emphasizes the need to define the assessment criteria within the project brief. I am aware of the imperfections and the difficulty of using multiple rubrics, etc., I will be continuously review the process and procedure with the view of improving the model, nonetheless I am content with the outcome, the enthusiasm I observed from the students and their interaction; and the quality of their creative output showed that the new participatory assessment approach better meets the desires of my students, and that the content of the rubric, studio critiques and feedback portions of the validity have been duly dealt with.

CONCLUSIONS AND FURTHER WORK

The integration of participatory evaluation, peer review and assessment features in a Problem-Based Learning Environment in design education was quite promising. Although, there may be some hidden weaknesses both in the concept that PAPBLE can enhance design studio practices and in the belief that the use of PAPBLE can foster participatory learning experiences, it would be a question of choosing the best means to reach a given end. While I strongly suggest that the new PAPBLE model offer tremendous possibilities for transforming learning in art and design education, these potentials do not in themselves promise that more uses of PAPBLE will improve schooling or that these uses will foster the kind of democratic school culture. However, if

teachers and their institutions are more focused on assessment for learning, then, students are likely to deepen their potential of life-long learning skills. Design studio environments could be—and indeed have been—designed to support any kind of values, including fairness, socialization, reflection, and critical thinking. Overuse of sophisticated and high-handed studio environments also has the danger of taking creative–challenged students out of appropriate contexts and problems in favour of completely decontextualized or hypothetical situations not similar to professional environment.

To conclude, PAPBLE focuses on the process rather than the product. Consequently, PAPBLE can help construct engaging and effective participatory learning activities in the studio or problem-based learning. The implementation of PAPBLE offers meaningful pedagogically practices that facilitates deep learning in design education. However, it is worth noting that the PAPBLE model only describes the learning process within the creative process and do not prescribe ways to engage and motivate students. Additionally, the use of PAPBLE would offer design educators and practitioners ample opportunities to effectively assess the creative process as well as to develop students' abilities to make better decisions during the process.

Teachers and institutions adopting such model should also closely monitor the model's impact on group processes and group member relations, as well as its implications on both individual and group performance. In the near future I plan to apply the model to more complex projects on a larger sample of students in order to examine the effectiveness of the participatory and peer review features. Furthermore, I plan to revise PAPBLE in order to provide the additional functionalities for supporting communication and assessment to meet the requirements that arose from the discussion with the students that participated in the study for the evaluation of the model.

Implications for policy and practice

Although the experiences from this study suggest that art and design students could be highly motivated by their experience of participatory assessment,

however, they did not always experience teaching approaches which best foster their creativity through the design process. Reflection on the experiences has led to the following conclusions with implications for policy and practice.

- a. Fostering creativity through participatory assessment could increase students' interest in the participatory assessment process.
- b. To ensure maximum students' sense of ownership and control, instructors would require a higher level of expertise, support and confidence in participatory assessment than is currently the case.
- c. The design studio environment should be student-centered which implements participatory approach to teaching and learning.
- d. To foster of creativity through the assessment process requires for space and time.
- e. The bond of friendships among the students in the class could jeopardize the process, since the two main concerns of peer assessment are validity and reliability which not be compromised.

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EMPOWERING AND REWARDING INNOVATION IN THE MANUFACTURING INDUSTRY: MANAGERS' PERSPECTIVES

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ABSTRACT

Orientation and motivation for the study: *With rapid changes in technology and global competition, the success of many organisations had become increasingly dependent on the ability of launching innovative products and services. Croatian organisations are lacking a specific framework to guide the innovative knowledge exchange and sustainable rewarding systems.*

Research purpose: *The purpose was to examine current practices and innovative systems for stimulating and rewarding innovation in Croatian manufacturing companies.*

Research approach and method: *The study sample consisted of three manufacturing firms: a company A is involved in manufacturing components for the automobile industry, a company B is involved in manufacturing machinery parts, a company C is involved in manufacturing tools. This study demanded a qualitative approach and individual interviews to collect data from senior managers who were responsible for the implementation of incentives to reward innovative ideas of employees. The aim was to investigate experience of managers in terms of the stimulation and rewarding of innovation processes and outcomes.*

Main findings: *Findings highlighted a range of approaches for rewarding employees and management recommendations to improve the current reward system. A need existed to establish professional bodies to assist in managing innovations and developing a sustainable framework that empower employees' innovative engagements.*

Keywords: *innovation, managing innovation, entrepreneurship, rewarding system, knowledge sharing*

INTRODUCTION

The problem of retaining a nucleus of high-quality personnel over the long term and motivating all employees to ensure maximum involvement, identification with the company and constant creative contribution, includes the question of how to reward their work. The transformational nature of companies and the constant need for managing changes affect employees that demand an urgent answer to the question of how to structure and sustain the innovation systems.

The key to future competitiveness in high technology is the ability to innovate. A turbulent environment encourages organisations to improve their innovative competitive advantages and quickly respond to new technologies and changing markets. While it seems that many companies develop successful innovation only by chance, a few companies experience consistently rewarding innovation.

Most successful Croatian companies rely on a model of corporate culture that is based on a hierarchical organisation guided by the principles of authority of managers or owners. Very few of them have a flexible model of corporate culture guided by the principles of an innovative culture including teams as the fundamental wealth of the company. Only the deployment of innovation can provide economic growth and the growth of employment in Croatia (Antoljak, 2011).

Based on the perceived problem that only few companies stimulate and reward innovation, the interest and attention of researchers of this study focused on manufacturing companies in the metal industry in Croatia. Thus, the purpose of this paper is to show how innovation is stimulated, rewarded and sustained in various manufacturing companies in Croatia. Furthermore, the purpose is to determine specific approaches of stimulating and rewarding innovation, and their implementation in the business context.

To this end it is necessary to examine the opinions of managers on innovation and the problems relating to rewarding innovation. How the existing reward systems could be improved and what are the experiences of managers with regard to innovation in the business environment? Based on the aforementioned problem of rewarding innovation and the purpose of the study, this study raises the following research questions:

- f. *What approaches of stimulating and rewarding innovation are currently used in manufacturing firms?*
- g. *What are the problems of rewarding innovation?*
- h. *How can rewarding innovation in the organization contribute to its sustainability?*

The next section describes the theoretical framework in order to understand, stimulate and reward innovation in the manufacturing organizational environment.

FRAMEWORK TO STIMULATE AND REWARD INNOVATION IN THE MANUFACTURING ORGANISATIONAL ENVIRONMENT

Creativity and innovation in the global environment

With rapid changes in technology and global competition, the success of many organisations has become progressively more dependent on their ability to bring innovative products to market (Mumford, 2000). Talent is the bedrock of a creative society (Yusuf, 2009). According to Howkins (2001) development and commercialisation call for expertise, ingenuity, and entrepreneurial creativity in order to achieve success.

Open innovation is currently one of the most debated topics in management literature (Gumuslouglu & Ilsev, 2009; Chiaroni, Chiesa & Frattini, 2011). In recent years, many companies have shifted from so-called closed innovation processes toward a more open way of innovating, for instance through cooperation with suppliers and competitors or through active searches for new technologies and ideas outside the firm (Rost, 2011).

Many established corporations make equity investments in young technological start-ups to enhance their innovation effectiveness (Anokhin, Örtqvist, Thorgren & Wincent, 2011). How companies can simultaneously achieve both exploration of new knowledge for radical innovations and exploitation of existing knowledge for incremental innovations is still one of the key dilemmas in organisational learning research (Dobre, 2005; Un, 2010). The next section will discuss the importance of innovation as a competitive advantage.

Innovation as a competitive advantage

The effect of today's turbulent environment means that organisations need to improve their competitive advantage and respond swiftly to changing technology and markets (Brennan & Dooley, 2005; Mishra & Sahay, 2010; Govindarajan & Gupta, 2001). If a company is unable to continue to innovate, it risks falling behind competitors who aim to take the lead by changing their products, refining their manufacturing processes or applying innovation in their business models (Prester, 2010). It should be noted that regardless of the technology, social and market conditions, the key to creating and maintaining a competitive advantage is in continuous innovation. The owner of the rights of one technology could benefit from the existence of complementary technologies (West, 2009).

The process of innovation

The literature on systems of innovation conceptualises innovation as an evolutionary and social process of collective learning. But three main questions remain open: Is this learning process internal or external? What are the boundaries of this process? Is this social process voluntary or rather unintended? In their paper Ronde & Hussler (2005) strives to answer those questions by analysing the determinants of regional innovative levels in French manufacturing industries. It is suggested that regional innovative policies should be focused on welcoming different sectorial activities and on supporting networks among regional actors. Unlike product replacement planning, innovation performance requires planning that is more strategic, proactive, a long-term oriented and development-focused (Terziovski &

Morgan, 2006; Langerak & Hultink, 2008). Organisations recognise that knowledge workers with the requisite skills and expertise are critical to improving innovation performance.

Managing the processes of innovation

The use of research and development expenditure or more direct measures of innovative output, such as productivity growth, might prove useful for a more complete assessment of the contribution that investors make to an acquired firms' innovation activity (Ughetto, 2010).

According to Prester (2010) the construction of external interactions is more important than development of internal innovative capabilities. Managers need to ensure a strategic approach to management of the innovation cycle and to identify critical success factors that are intrinsic to the achievement of corporate goals (Umesh, Lawrence & Lowe, 2010). Furthermore, development of evaluation systems and data connectivity would greatly facilitate monitoring and commercialisation of this process, by identifying where in the innovation cycle improvements is needed.

Teamwork and innovation

Although much has been written about the benefits of teamwork in innovation, it should be borne in mind that teams are not always the solution. Hoegl and Parboteeah (2007) observe teamwork in different contexts and emphasise the importance of proper selection of the members and of the development of a team for a specific and straightforward task. The reason for organising the work in teams is the complexity of the work that exceeds the cognitive capabilities of individuals. Multidisciplinary teams have been on the rise, which can solve problems from different perspectives (Svoboda, 2006).

Knowledge sharing and an innovative climate

Knowledge creation is a process of communications between explicit and tacit knowledge (Evans, 2003). Knowledge is explicit (that exists typically in documents, databases and as part of processes) and tacit (embedded in people and their experience). The companies should secure knowledge

exchange and innovative environments where the biggest enemies to creativity (fear of critics, ridicule and retrenchment) have been removed (Evans, 2003). Thus, good communication, risk-taking and a free inspirational atmosphere that includes trial-and-error brainstorming can stimulate the development of innovative products. It is necessary to pay attention to key elements to unlock creative inspiration, such as: discipline, routine for creative work, one's own efficiency/construction system and spontaneity (McGuinness, 2011; Apostolou & Mentzas, 2003). Allowing individuals to self-select projects they see as opportunities either to accumulate or to create knowledge is vital for the knowledge enrichment (Felin, Zenger & Tomsik, 2009).

The impact of transformational leadership on innovation

Jung (2008) considers transformational leadership as encompassing five theoretically distinct components: charisma, idealised influence, inspirational motivation, intellectual stimulation and individualised consideration. His study seeks to advance understanding of how transformational leadership by top managers (CEOs) can affect their companies' innovativeness, so he proposes a model that includes both direct effects and indirect effects, moderated by aspects of organisational culture, structure and the external environment. A leader's behaviour may be perceived as an organisational endorsement of promotion-focused or prevention-focused concerns and this perception will influence employee behaviour by eliciting a congruent state of regulatory focus (Wu, 2008).

In his study Gumusloulglu, and others, (2009) propose a model of the impact of transformational leadership both on followers' creativity at the individual level and on innovation at the organisational level. Makri & Scandura (2010) introduces two dimensions of strategic leadership, termed operational and creative, specifically developed for top executives of high-technology firms. Makri et al. (2010) confirm the expectation that there is a positive relationship between transformational leadership and organisational innovation. The next section deals with stimulating and rewarding innovation.

Stimulating and Rewarding innovation in financial terms: models and project financing

Leenders & Corne (2007), in their study, signal detection theory, shows that it may be less important to improve innovation practices in companies than it is to change the nature of the projects that enter the corporate innovation funnel. Financial reward is an essential element in fostering innovation. Systems of incentive pay for performance are shaped by the established activities of the company, strategy, organisational culture, management style and model of corporate governance. Models form a stimulative element in wages: a stimulus for increased performance on the basis of experience, a stimulus for daily output – project work, a stimulus for monthly effect, a stimulus for results, sharing of the profits of innovation and rationalisation in the business, premiums and bonuses for the achievement of annual goals and stimulating reward for overtime work (Tadin, 2007).

There are many good ways and methods for forming a model to stimulate work performance through payment (Tadin, 2007; Čurčija, 2007; Bis, 2009). Additionally, top managers are expected to propose a concept for a system of incentive rewarding for performance and to adapt it to the specific conditions in which the company operates (Tadin, 2007). According to Bis (2009), project finance has never been applied to an entity engaged in the production, acquisition, and monetisation of patent assets.

Stimulating entrepreneurship as a way of rewarding innovation

Subramanian (2005) presents a model of an employee–firm interaction in which a private intrapreneurial activity competes with the basic activity of the firm. The parent firm lacks ownership of any new asset created through intrapreneurial activity, but asset complementarity gives it an advantage over outsiders. Menzel, Aaltio and Ulijn (2007) describe how to make engineers active in the field of intrapreneurship within large firms.

There is an emerging stream that positive emotion may enhance entrepreneurial creativity, which can aid in the recognition of new opportunities. The entrepreneurs who are passionate about their ventures

may be more creative and persistent, and may become more absorbed in venture-related activities, which should enhance key venture outcomes (Cardon, 2008).

According to Goodale, Kuratko, Hornsby & Covin (2011), research on the topic of corporate entrepreneurship has expanded steadily over the last few decades, in large part owing to the increasingly recognised linkages between product–market and technological innovation (i.e. the consequences of corporate entrepreneurial activity) and firms' success. An entrepreneurial work environment is characteristic of small, emerging private enterprises in which "everyone does everything" and where everybody feels equally responsible for the efficient functioning of the organisation. The entrepreneurial approach is particularly advantageous in conditions of mutual dependency in respect of tasks (Srića, 1997).

Motivational aspects for non-financial stimulation and rewarding of innovative activities

According to Sladoljev (2007), financial rewarding is a necessary but insufficient condition for developing a broad base of diverse motivational behaviours within a company. The motivational basis is extended by group reward systems that, apart from material rewarding, include a participation in a goal setting and decision-making, autonomy and responsibility, shaping operations, collaboration and flexible working hours (e.g. Wei & Kwaku, 2009).

There are numerous techniques for developing creative skills, such as the analytical technique, which includes listings, the input–output technique, "for" and "against" technique, technique of free flow of associations, brainstorming techniques and Gordon's method (Sladoljev, 2007). Motivation, creativity and performance evaluation play an important role in a work success process (Sladoljev, 2007).

Current innovative activities within Croatian manufacturing companies

Croatian manufacturing companies consider the most important innovative activities as those that form part of the management vision of the enterprise, personnel and research potential of the company and market information. Various incentives for innovative activity are relatively low-ranking. Barriers to innovative activities for Croatian companies are lack of funding, too long a period of return and the innovation potential of small businesses (Andrijević-Matovac, 2005).

The main obstacle to innovative activity of the average enterprise in the Croatian economy is resistance to introducing changes in the company. Also, through evaluation and benchmarking, there should be a mutual learning process involving the state administration in order to support the development of more effective innovation (Švarc & Lažnjak, 2008). For example, the Japanese government has started to use a systemic approach to reforming the national science and technology innovation system of Japan, that it is geared toward reinforcing policies to stimulate innovation in corporate sectors (Motohashi, 2003).

RESEARCH METHODOLOGY

This research can be described as a qualitative multiple case study, which is the result of research in a closed context (Creswell, 1994; Merriam, 1998; Yin, 1994).

Sample, intervention and methods of data collection

The study sample consisted of three manufacturing firms: a company A is involved in manufacturing components for the automobile industry, a company B is involved in manufacturing machinery parts, a company C is involved in manufacturing tools. The firms were located in Zadar, Croatia. All three companies were of small to medium size with 30 to 100 people employed. The participants were managers in companies responsible for the implementation of rewarding innovation systems.

Data were collected using semi-structured individual interviews. A trained researcher conducted the interviews in the three manufacturing companies in the managers' offices. The aim was to investigate experience of managers in terms of the stimulation and rewarding of innovation processes and outcomes. The individual interview method involved an innovation manager in a company A, a director in a company B and a head of production in a company C. The individual interviews lasted an average of 30 minutes each.

The researcher manually recorded the answers of the participants. The researchers of this study used a broad set of ideas, theoretical frameworks and different paradigms by which the interview questions were created in the interview protocol. The researchers established contact with the companies via e-mails.

Data analysis and assessment of trustworthiness

Analysis of the interviews entailed the studying, categorising and tabulation of data in order to focus on the initial hypothesis/research questions (Yin, 1994). Themes that were described through the analysis of the data were segmented into categories and subcategories in alignment with Creswell's guidelines, (1994) which were described and supported by evidence. The constant comparative method (Merriam, 1998) was applied to the data gathered during the interviews.

The main procedures that could provide scientific correctness (rigor) to the study were closely connected with the basic metric characteristics of qualitative studies such as validity, reliability, objectivity and standardisation (Cresswell, 1994; Yin, 1994; Merriam, 1998). All information collected in the interviews was strictly confidential and was available exclusively for research purposes. Strategies proposed by Merriam (1998) and the concept of internal validity (Yin, 1994) were applied in order to improve the internal validity of the study. An in-depth description of the research phenomenon that was embedded in a theoretical framework contributed to the external validity (Merriam 1998) of this study. Researchers carried out the necessary preparations in order to prove the essential competencies in the activities,

including clarification of prejudices and assumptions, and exploring the social context of the entire cases (LeCompte, Preissle & Renata, 1993).). Instead of the limited generalizability of findings from the qualitative study, the intention was to form an interpretation of events (Merriam 1998), based on uniqueness of the business environment. This should increase the validity and reliability of the results.

RESULTS: EVIDENCE IN TERMS OF STIMULATING AND REWARDING INNOVATION IN MANUFACTURING COMPANIES

This section presents the findings of the qualitative data analysis of interview data in three Croatian manufacturing companies regarding stimulation and rewarding of innovation. For the purpose of this study, the researchers named companies as A, B, and C.

Based on the interview statements of the participants the data were analysed using methods of comparison, which led to the derivation of categories that are shown in Figure 1. Thus, specified symbols for categories **a–k** for companies **A**, **B** and **C** are presented in Figure 1, followed by interview reports of the participants.

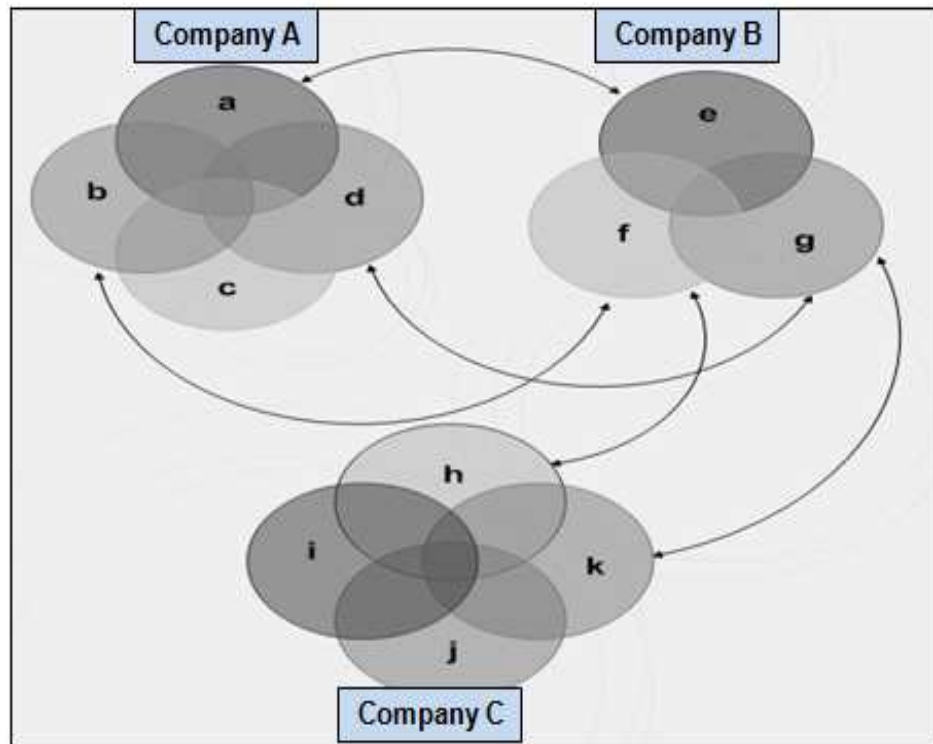


Figure 1: Categories in terms of stimulating and rewarding innovation

Figure 1 shows the logical sequence and coherence of categories in all three cases examined. The categories are described in the following section:

Company A: Case 1

- a. There is no developed industrial infrastructure that would encourage innovation.
- b. Inadequate innovative culture and political will at national level do not induce rewarding innovation at existing industrial platform.
- c. There is a need to establish a unit for the financial support of innovators in order to improve sustainability of innovative outputs.
- d. Weekly review of innovation proposals should be undertaken by a commission for the monthly rewarding of adopted innovative ideas.

Company B: Case 2

- e. There are no examples of good practice to organise innovative projects at the national level that would serve as a model for innovators.
- f. The business environment is poor and lacks a technological innovation centre to sustain innovation.
- g. It is necessary to introduce new mechanisms for rewarding innovation.

Company C: Case 3

- h. Marketing of innovation in national, regional and global markets is insufficient.
- i. Lack of motivation for employees' innovation and outdated technology causes a low innovative culture.
- j. Management is not sufficiently active regarding policies of rewarding innovation.
- k. Financial rewarding of innovation on a monthly basis causes conflict among employees.

Using comparative analysis (Merriam, 1998; Konsa, 2007), the researchers chose the relevant answers relating to the categories derived from each of the interview transcripts and these were discussed in the following sections as evidence.

Evidence: Company A

Categories a–d showed the experience of the innovation manager in respect of rewarding innovation in the company A.

a. There is no developed industrial infrastructure that would encourage innovation.

The innovation manager of company A stated that “...here is no developed industrial infrastructure that would encourage innovation...Innovations implies strong industrial production, which, in Croatia, is not the case because of the

tendency of declining industrial production and extinction of large factories ... It is important that the innovation has an economic aspect and that it is financially viable.. Croatia does not have developed industrial infrastructure and very little attention is still paid to innovations at national level."

b. Inadequate innovative culture and political will at national level do not induce rewarding innovation at existing industrial platform.

The innovation manager further reported that, "... in the last two decades we were witnesses of a process of decline of the entire industry ... the key problem is political will at national level, which should stimulate industrial production and reward innovations... These are some reasons why rewarding innovations is not sustainable within the company..."

c. There is a need to establish a unit for the financial support of innovators in order to improve sustainability of innovative outputs.

Furthermore, the innovation manager pointed out: "Any innovation should have a specific speed. The path from concept to construction and finally placement on the market should be as short as possible. These can be achieved through a unit for the financial support to carry out the innovation; the ultimate goal of innovation is its application in practice. There are various positive examples of innovation activities, but innovations are often poorly recognized and state policies do not encourage production sufficiently. "

d. Weekly review of innovation propositions is undertaken by a commission for the monthly rewarding of adopted innovative ideas.

The innovation manager said: "A reward system in which a committee reviews proposals for innovation on a weekly basis and provide rewards once a month is suitable in our company which produce a large range of products, where each small saving in production can lead to significant reductions in production costs. In our example, where the company produces different components for the automobile industry and the manufacturing is cost-effective, the reward system mentioned is a logical choice... "

Evidence: Company B

Categories e-g indicated the opinion of a director in the second company.

e. There are no examples of good practice to organise innovative projects at the national level that would serve as a model for innovators.

The director in the company B commented that: "*There is no organized management of state projects and examples of good practice ... The actual value of projects is difficult to define and even harder to measure ... Projects in companies are conducted in phases and that is the way they should be conducted by the government at national level...*"

f. The business environment is poor and lacks a technological innovation centre to sustain innovation.

The director further commented: "The business environment is in poor condition and the innovation infrastructure is inadequate to sustain innovation." Every major city in Croatia should have a technological innovation centre, which Zadar still doesn't have, even though much has already been done in this respect. It should work continuously on improving innovation. The construction of such a centre would help to set up mechanisms for the improvement of existing technologically innovative companies and would help to improve knowledge transfer from the university and innovation centre into the community."

g. It is necessary to introduce new mechanisms for rewarding innovation.

The director said that "... It is necessary to introduce new mechanisms of rewarding employees. An employee's salary depends on the tariff groups, payment factors, salary increments and gross increments from the employer. Gross increments depend on motivation, knowledge, skills, expertise, human relations, cooperation and teamwork, as well as on ethics and collegiality ... Stimulus is given to an employee once or twice a year as a reward for innovation ... That kind of stimulus is an open category of the salary and the manager decides on it according to his own opinion".

An inadequate innovation infrastructure was an aggravating circumstance, but there were positive examples of stimulation and rewarding of innovation in companies.

Evidence: Company C

Categories labelled h–k represent the responses of a head of production in the third company.

h. Marketing of innovation at the national, regional and global markets is insufficient.

The head of production revealed that "the problem is the placement of innovations on the market ... Many innovations do not reach the last stage, i.e. the marketing stage. Innovation is not successful if you do not achieve market success, therefore it should be applied in practice ... Innovations should have a clear timeframe from an idea to the market realization."

i. Lack of motivation for employees' innovation and the outdated technology causes a low innovative culture.

The head of production commented: "In many companies there is no reward for innovation. Employees are not trying enough because they are not motivated ... It is common for the notion of rewarding innovation not to exist in many manufacturing companies. Employees only carry out current operations and are not motivated to refine or improve anything. Another problem is the outdated technology. The current recession has further exacerbated the existing poor state of the industry ... "

j. Management is not sufficiently active regarding policies on rewarding innovation.

The head of production further elaborated: "Management is not sufficiently active regarding policies on rewarding innovation ... management is responsible for introducing the policy of rewarding innovation. Inactive management and a poor business climate in the company result in the absence of rewards... An absence of rewards shows that the company has no long-term strategy for employee development".

k. Financial rewarding of innovation on a monthly basis causes conflicts among employees.

The comments of the head of production were: " Financial incentives are given on a monthly basis to employees in manufacturing...Financial incentives caused conflict among employees...Rewarding in this case creates just the opposite effect from the one desired. ... The company produces a variety of machine tools according to customer specifications, so it is challenging to introduce innovations in the manufacturing process because they do contribute significantly to savings. Another problem is outdated machines because the company does not invest in new technology.

It was important that innovations passed through all stages, from prototype through to mass production. The business environment and inadequate innovation infrastructure aggravated the sustainability of empowering innovation. Management is inactive and in the third case studied, rewarding innovation simply does not happen. Positive examples of rewards related to incentives, where the stimulative parts of the salary were dependant on the innovativeness of employees. It should be further noted that awarding financial incentives on a monthly basis sometimes caused conflict among employees rather than motivating them. The next section gives answers to the research questions and interpretation of the results obtained.

DISCUSSION

The first research question sought to determine *the approaches of stimulating and rewarding innovations* in the companies that were analysed in the study. Of the three companies in the sample, two applied a reward system and stimulated innovations of employees.

Systematic management of vital knowledge exchange and the associated processes of creation, organisation and dissemination of innovation were perceived as necessary approaches for the company's success. However, comprehensive communication and a support of management were missing. A technological innovation centre could inspire the development of new ideas, technologies and practices through a community of employees. Many

innovations were also the result of teamwork. It sought to improve understanding of how the leadership style of top management affected the company's innovativeness.

Evidence indicated that a financial stimulus is used to encourage employees once or twice a year as a reward for innovation. The study had shown different perceptions of rewarding innovation through financial incentives (case 2).

In Croatia little attention was still paid to industrial production. Companies were differentiated by the type of production, so the same approach of rewarding, for example providing incentives for innovative ideas could not have been applied in the production of machine tools and in the production of a series of the same components. In the production of pre-ordered machine tools, the selection of appropriate approaches of rewarding was not an easy task, because there were different stages in production and it was not easy to determine which was of greater importance. Understanding the mechanisms through which firms created knowledge showed that appropriate approaches of rewarding innovation were only at its beginning (*in response to question 1*).

In answer to the second question '*what are the problems of rewarding innovation?*' it could be understood that many problems were evidenced in rewarding innovation, for example: inadequate innovation infrastructures, lack of an appropriate innovative culture, political will at national level, poor business environments, irregular reviews and financial incentives. A further problem is the placement of innovations on the market. Outdated machines and incompetent managements are additional problems. For a company that produced a product series, innovations could result in reduced costs. A commission that would examine innovative proposals on a weekly basis seemed like a logical choice (case 1). The company management was an important factor in the ability to innovate because the director had a great influence on the development of organisational vision and strategy to achieve it. The theoretical part was reflected in case studies where the management was inactive with regard to rewarding innovation.

In answer to the third question *'how can rewarding innovation in the organization contribute to its sustainability?'* it could be said that every company required a special model of rewarding innovation through which employees' innovativeness could have been motivated. The model should be adapted to particular production environments and cultural traditions of each company. Evidence indicated that innovative practice could be sustainable through many ways, for example: introducing new mechanisms, providing examples of a good practice at the national level, marketing innovative products and establishing a unit for financial supports. It was possible to create stimulative models of payment for an innovative work performance, but usually there was only one optimal model that was quantitatively and qualitatively effective in every company, taking into account the existing competencies of employees. Monthly stimulation was not always the solution and it could be harmful and cause conflict among employees. The successful development of innovation and its sustainability required a technological innovation centre. The next section presents some conclusions and recommendations of this paper and areas for further research.

CONCLUSIONS AND RECOMMENDATIONS

Technologically oriented organisations need to be creative and innovative to be able to survive, compete, grow and lead innovations that bring social and environmental benefits. Business organisations are becoming increasingly dependent on creativity that requires a sustainable innovation framework. It is important to assess the position of the organisation, to identify areas of improvement compared to global benchmarks and then to work on a plan for transition to the global level, including the development of sustainable rewarding systems.

There is growing awareness among regional authorities that the economic growth and competitiveness of the region largely depends on the capacity of local companies to innovate. Providing adequate support to local companies to become more competitive through innovation is of increasing importance in the regional political agenda. Technological innovation centres are opening in major cities to encourage innovation development and its sustainability.

Rewarding systems of paying incentives for innovative performance are shaped to accommodate the established activities of the company, its strategy, organisational culture, management style and business enterprises. A system for rewarding experts' innovative performance involves determining a strategy of financial and non-financial rewards that will enable achievement of the defined innovative plans, as well as annual and strategic goals.

A recommendation for future research is to explore the attitudes of employees in companies that reward innovation with the objective of determining the extent to which the reward system is applied. Furthermore, it should be analysed how effective are financial incentives in practice.

Practical and managerial implications: Developing an innovative environment required a range of management measures. A technological centre could help innovators through project funding and monitoring of the innovation process.

Contribution and value-add: This research had predominantly been in small and medium manufacturing enterprises in Croatia. The study suggested the ways to improve their innovation potential by emphasising the need for a sustainable reward system relevant to global demands for innovative outputs and competitiveness.

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FINDING ERRORS CAUSATION IN DESIGN BY STUDYING OBSOLETE ENGINEERING DRAWINGS

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ABSTRACT

Ideally, information communicated by engineering drawings must be complete and precise to prevent the making of bad parts in machine shops. That notwithstanding, errors and mistakes do occur. In an active design environment the result, invariably, is a massive collection of obsolete and superseded drawings. This paper shares preliminary findings of an investigation of the contents of one such copious collection of superseded engineering drawings from the product design office of the Rural Industries Promotions Company-Botswana. The collection was collated, inventoried and categorised according to what caused the changes thus rendering the initial drawings obsolete. Simultaneously, engineering change management literature (e.g. design and engineering change notes) was combed for concepts and causes of errors in engineering drawings. Finally, by integrating contributions from the survey with scholarly articles, a thesaurus of drawings-based engineering change management principles was built. It is hoped that from the nomenclature, a pattern would emerge from which future efforts in the reduction of design and drawing errors could be based.

Keywords: Drawings, Design Errors, Engineering Graphics, Obsolete Drawings, Superseded Drawings, Engineering Change Management

INTRODUCTION

The emergence of engineering drawings came to draw a line between design and manufacturing as two distinct areas. Consequently, before a design can be manufactured it must be captured and communicated to the shop floor using drawings. Between the two areas, errors and mistakes get noticed and changes have to be made to the design.

These changes, termed **design change**²² (DC) in this paper, can take many forms. At one end, changes may be steady and continuous, whereby the main features of the component remain so intact that in some sources (e.g. Deb, 2008: 267-271) the term *evolutionary design* is preferred. In other instances, the change could be so radical leading to a complete redesign of a new product and its downstream processes that the term *design overhaul* would be an apt description.

Any of the above changes can happen at any time during the life cycle of the artefact and for whatever reason. It could be due to an engineering or design error. For instance, mating or interconnected parts could be experiencing interferences or collision. Sometimes the change is a result of difficulties experienced elsewhere in the production value chain. For example, a change in the material specification of a component or feature can lead to breakage of the cutting tool in the machine shop hence a redesign of the component or feature becomes necessary. It may well be that the length of a component has altered, leading to a change in the dimensions of the packaging box; a classical example of engineering change propagation (see Shankar et al., 2012: 292). The converse is equally true. Acquisition of a new production technology by the machine shop can bring about a new drawing culture and style (Tjiparuro, 2012: 104). Whenever a design change occurs, and for whatever reason, current engineering drawings are often rendered obsolete and they are superseded. For this reason, obsolete drawings become a necessary repository of past mistakes; pitfalls and lessons that must be learned and avoided in future.

Mistakes are known to contribute to loss of profit, reduced productivity, cost and time overruns as well as contractual disputes in the engineering service industry. It is estimated that as much as 60% of variations in projects are a result of errors and omissions in engineering drawings (Love and Zhou, 2013: 448). In engineering, investigating errors causation falls into that domain

²² In literature various terms are used such as: engineering changes, product changes, technical changes, prototype changes, or design changes. In this paper, which investigates engineering graphics, the term design change (DC) is preferred because of the close affinity between design and drawings.

popularly referred to as engineering change management, an area that has been studied enthusiastically generating various perspectives (refer to Jaratti et al., 2011: 103-124 for a comprehensive review).

By and large, the perspectives can be put into three neat categories, namely, case studies, industrial surveys and reviews (Langer et al, 2012: 223). The investigation carried out in this paper belongs to the two domains of industrial surveys and literature review. It delves into a copious collection of obsolete engineering drawings to glean important archival information concerning design errors and supplements the findings with the latest scholarly contributions in the field. By doing this, the paper hopes to bring to the fore important information toward the development of an error-free design protocol. From the analysis a pattern should emerge from which future efforts in the reduction of design and drawing errors could be based.

Admittedly errors and mistakes, as noted by amongst others (Magi, 2006: 387, Hanifan, 2010: 5), are impossible to eliminate. In fact, in product development as noted by (Fricke et al., 2000: 170), errors, mistakes and changes are the rule and not the exception. That notwithstanding, research into design errors causation is very important even if it only means revealing the areas where most errors occur. The work described in this paper approaches design change management from the perspective of obsolete drawings, an approach never before attempted. Partly this is due to, and as noted by (Love and Zhou, 2012: 7), the fact that design companies are often reluctant to allow research into their design documentations as that tends to put intellectual property into public domain prematurely.

The rest of the paper is organized as follows. The company where the study reported in this paper was undertaken will be introduced first. Then literature will be reviewed followed by presentation of the methodology used. Discussions and conclusions and future research directions will bring the paper to a close in that order.

RURAL INDUSTRIES PROMOTIONS COMPANY-BOTSWANA

The Rural Industries Promotions Company - Botswana (RIPCO-B) was established in 1975 as a public company owned by the Botswana government and a centre for technology research and entrepreneurship. Until cessation of its operation and closure in 2013, RIPCO-B had registered a large product portfolio, amongst others, the world renowned PRL/RIIC sorghum dehuller and many other products and technologies in the market. Juxtaposed against the development has been an accumulation of a copious collection of current and obsolete engineering drawings as a result of design changes. This paper investigates the two collections; answering these two basic questions: *How was it Before?*, and *Why was it Changed?*

LITERATURE REVIEW

In engineering change management literature, drawings which are no longer in use as a result of them having been replaced by newer versions are referred to by the triad terms: ***superseded drawings, obsolete drawings or voided drawings***. The newer versions replacing the old become known as ***revised drawings*** or just ***current drawings***. In this paper only superseded and obsolete will be used interchangeably as they are more common compared to voided.

Literature dealing with superseded drawings can be put into two categories, viz., literature against and literature in favour of the retention of obsolete drawings.

In the first category is literature which when the words “superseded” and “drawings” appear strung together to form one word, is always followed by such words as: delete, remove or destroy. This is literature that decries obsolete drawings as sources of some of the commonest mistakes that occur during construction of projects (see amongst others; Schwartz, 1976: 248-253, Naha et al., 2010: 290-298). Accordingly, obsolete drawings are viewed as militants against efficiency (Panchyk and Panchyk, 1998: 69-92). The category is also replete with methodologies and registered patents on how to remove, delete or destroy obsolete drawings (e.g. Brown and Rich 1994).

On the other side of the divide sits the school of thought that views marked-paper as an indispensable holder-of-human-thought. A classic example of this is encapsulated in ***The Paper and The Ink*** fable of Leonardo da Vinci (see Robitaille, 2005: ix), whose nub is that once a paper has been marked (by ink) it ceases to be just a paper but it becomes a document, which, as compared to its plain counterpart, cannot be dispensed and destroyed easily. Accordingly, literature for the retention of drawings does not only hold that a complete paper library of drawings be maintained by design and manufacturing firms, but that there should further be an archive section of all obsolete drawings if only to allow research on engineering changes of any particular part (Floyd, 2003: 12). This is because as documents, obsolete drawings are a significant component of knowledge retention structure (see O'toole, 2010: 1-6) or what in modern-speak is called institutional memory. Thus obsolete drawings can be used to reconstruct old technologies (Popplow, 2008: 51) or for purposes of manufacturing replacement parts for older technologies. For instance, much of the historical infrastructure of the British canals network is still in use more than two centuries after its construction (Sillitoe, 2014: 127). There is also a legal reason why superseded drawings must be retained and this is as documentary evidence in case of future disputes (Schwartz, 1976: 248-253).

Errors causation in design can be instantaneous. For instance, at the height of Nazism in 1940, Britain desperately needing replacement of their carriers sinking at the hands of Germany U-Boats, and engaged an American ship builder, only for work to halt instantly because the English supplied drawings did not make sense to the makers and had to be redrafted to American national style (Brown, 2000: 195).

Notwithstanding the fact that research on engineering changes has been identified as one of the key reasons why obsolete drawings are retained, little research has been done in the extant literature on errors and mistakes which render drawings obsolete. For the first time, this paper navigates this maze, collates and presents a thesaurus of drawings errors causation.

METHODOLOGY

A two-pronged approach was used.

Firstly published scholarly literature (journal articles, conference papers and books) in the areas of: engineering change management, document control and engineering graphics was searched by using appropriate keywords such as: obsolete drawings, superseded drawings, voided drawings, current drawings, drawing changes, etc. The search was done using electronic databases such as Scopus, Engineering Village, IEEE Xplore etc. Once the literature was found it was combed for terminology and nomenclature on drawing mistakes.

Secondly, current drawings of RIPCO-B technologies were retrieved from drawing cabinets and studied. In particular, the revision tables of the title blocks were perused for information on revisions. Where revisions were noted, obsolete drawings were accessed and the current drawings compared to their previous forms to recreate the situation as it was at a certain stage of the project in order to establish the reasons behind the changes. This is more important because as it can be seen from Figures 1, reasons for some of the revisions were accurately spelt out while it was not the case in other instances.

The revisions were critically reviewed to establish their nature. These and the results of the literary review were collated to come up with a scholarly taxonomy of engineering drawing mistakes. Where the extant literature did not contain the right terms, new ones were created. By and large, the approach followed is similar that followed by, amongst others (see Tjiparuro and Thompson, 2004: 105-106), and illustrated in Figure 1. Once the classification was done, the changes noted from the drawings were then categorised according to the classification generated and the statistics of their occurrences tallied. This methodology is illustrated in Figure 2 below.

					SCALE	1:2 & 1:5			
					PROJECTION				
					DESIGN	AGAS GROTH			
						W. M. MASIBI			
					DRAWN	W. M. MASIBI			
						20/01/13/9/91			
2	#12,14,17,18	K. RANKALA		12/07/01	CHECKED				
1	#18	F. MPYAN		24/03/98					
REVISION	DESCRIPTION	DRAWN	APPROVED	DATE	APPROVED		 RURAL INDUSTRIES INNOVATION CENTRE P.O. BOX 11, KANYE, BOTSWANA (P.O. BOX 11) 561-03 7/16		

					SCALE	1:5	SHELLING CHAMBER SUB-ASSEMBLY		
					PROJECTION	3rd angle			
					DESIGN	T.Z.	MAIZE SHELTER		
					DRAWN	F.M.			
					CHECKED	JAN. 2001	RURAL INDUSTRIES INNOVATION CENTRE JOS II KANYE, BOTSWANA PH340448/9		
					APPROVED	S. K. LABORDINE			
1	824 notocutted, dms added	Deseng	Notokwane	18/04/08	24/01/2003	E. E. MASHAMBO	138-02	4/	
REVISION	DESCRIPTION	DRAWN	APPROVED	DATE	APPROVED	DATE			

Figure 1: Title block revision information

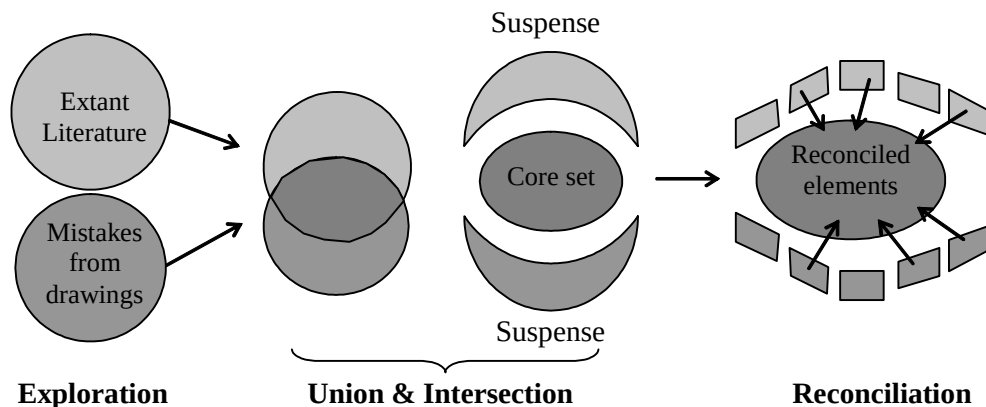


Figure 2: Building the taxonomy

FINDINGS

From Literature

At the highest level, research into design errors causation factors (e.g. Eckert et al., 2004: 2, Ahmed and Kanike, 2007: 2, Jarratt et al., 2011: 108, to name a few) agrees that changes can either be emergent (e.g. changes correcting errors, etc., within the product) or initiated from outside the product (e.g. through customer, legislation, production etc.). In both situations, and as noted by Jarratt et al. (2006: 6), three sources could trigger the changes, namely: (1) suppliers, (2) customers and (3) internal departments. And generally the purpose as noted by Ahmed and Kanike (2007: 2) is either to remove/avoid errors or to improve/enhance the product. And of course all the above do not answer the question: what caused the error but rather speak to the nature of the errors, the direction from which the error can come from and what benefits does correcting the errors deliver.

The work of Fricke et al., (2000: 170-172) fits into the error causation category. This work identified and divided causes of changes into eight

different categories, namely, Needs and Requirements, Feedbacks and Complaints, Complexity, Degree of Innovation, Change Impacts, Communication and Coordination, Time, and Decision Discipline. Similar effort was to be undertaken by Ahmed and Kanike (2007: 3-4) who after surveying 1510 engineering change notes identified six errors causation factors (see Figure 3). Another work worth mentioning was done by Hsu (1999: 44) also given in Figure 3.

Analysis of the four groups of causation factors given in Figure 3 reveals that by and large the factors have categorised into thematic areas. In fact the size of possible themes may seem to be inexhaustible. For instance, what about dimensions based mistakes due to either poor style, omissions or insufficiency (tolerance zones) as expounded in Hanifan (2010: 8-18). What about the lack of commonality between national styles as illustrated in Brown (2000: 195-238), alluded to under literature review above? Perhaps a better option would be to refer to what drawings themselves say. This is the purpose of the next subsection which reports on preliminary results of an ongoing investigation.

Fidei et al., (2000)	Ahmed and Kanike	Jaratt et al (2000)	Hsu (1999)
- Needs and Requirements - Unstable: Evolving at a faster rate than the product development time - Stable but not well understood or documented - Moving targets due to competition, sophisticated customers or technological evolution - Customer's complaints and feedback - Removing complexity in design - Degree of innovation? - Change Impact - Communication and Coordination or Information exchange - Time (in this paper this does not lead to change in drawing documents as it relates to work still in progress) - Decision discipline, either - the decision is delayed - or taken without basis	- Product Improvement: Changes that are made to improve the product, a solution may exist but an improved solution may be offered - Satisfaction: Changes made to increase satisfaction of a solution, including customer satisfaction and to avoid suspected failures based on the previous experience - Cost reduction: Changes made as a result of an opportunity to reduce costs - Performance, Reliability: Changes to increase the performance or long life reliability - Durability, life, Warranty, Guarantee: Changes to enhance the product's durability, the length of warranty and guarantee - Maintainability: Changes made to improve the maintainability of a product or attempts to design for ease of maintenance	Suppliers induced - Current supplier changing manufacturing processes - New supplier engaged - Obsolescence of components Customer induced - Customer changing options on an order Internally induced - Quality and reliability improvements - Cost savings - Changes to a manufacturing process - Improve servicing - Reduce weight, bulkiness Impact based change or Change propagation Legislation compliance	Requirements definition issues - Traceable to program initiation - Traceable to a previous change Changes in needs - New needs identified - Needs defunct Need to fix deficiencies - Modify design or product Government-prime interactions - Contracting/program arrangement - Overly stringent specifications Program-program interactions - Design baseline shift in a predecessor program - Program reprioritization Technology changes - Taking advantages of advances in a certain area - React to unfeasibility/obsolescence - Change requirement to acknowledge capabilities/feasibility Need to change documentation - Synchronise paperwork - Rescheduling tests

Figure 3: Comparing different taxonomies

From RIPCO drawing cabinets (preliminary results)

Preliminary results identified a mix of different drawing errors causation factors. The following are the main areas into which the observed errors can be categorised.

Parts Misidentification: under this category, parts identification numbers in the title block did not match what the balloon '*pointed to*' in the drawing.

Parts Renaming: it was observed that some corrections sought to give part and components more descriptive names with respect to either their location within an assembly or their design intent.

Design Intent Conflict: this category relates to instances where location of parts and components or features contained within such parts and components present functional problems such as collision or interference. Corrections to the above necessitated repositioning of parts and features.

Missing Information: some drawings were found not to be providing sufficient and accurate information as to the exact location of parts. Such missing information was found to be in respect of exact dimensions, tolerances, development of processed parts.

Robust Design: some features and dimensions in some drawings were changed to allow for a more robust configuration during assembling. For instance, an assembly can be improved to make for a more fool proof mating of parts during assembling.

New Technology Induced Drawing Change: these are changes that come about because the downstream value chain functions have adopted new technologies thus necessitating a change in the design of some features and components.

CONCLUSIONS

This paper gives a synopsis of drawings errors causation factors. The findings are preliminary and part of a much larger study that looks into a huge archive of engineering drawings which when complete will deliver the envisaged taxonomy. What the preliminary findings seem to point to is that some errors causation factors are of the type that can only be gleaned from drawings. What the paper hopes to achieve at this juncture is to bring to the attention of research community the value of obsolete engineering drawings over and above their conventional value.

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INFORMATION SHARING IMPEDIMENTS IN GOVERNMENT DEPARTMENTS: A LITERATURE REVIEW

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ABSTRACT:

This paper discusses information sharing impediments in government departments. Information sharing is a core component of the e-administration part of e-government. The rationale of this paper is to discuss contexts influencing information sharing processes in government departments at different government levels. Contexts can be used to describe the efficacy of sharing information within government departments at different administrative levels, to indicate the level of information sharing needs in government departments. E-government in a Government to Government (G2G) component contributes immensely to information flows in and between government departments. The suggested conceptual model in this paper is based on a literature review of the papers and documents relating to e-government and investigates benefits and impediments to a successful implementation of e-government in developing countries. Technological, organisational, environmental and people are the main impediments that hinder effectiveness and efficiency of e-government in developing countries. The study suggests that, the model can be used to identify information sharing needs in government departments across different governing levels.

Keywords: *information distribution, e-government, Technology, Organisation, environment and people*

INTRODUCTION

The main objective of e-government is to provide efficient and convenient access to information and services to government stakeholders. E-government is a broad concept referring to the use of ICTs to maintain and improve government functions and services, to link government and citizens (G2C), government and businesses (G2B), government and government (G2G). Ochara (2009) referred to e-government as an internet-based innovation for the transformation of government service delivery. This paper focuses on the G2G component of e-government. Literature shows that developing countries are facing numerous challenges when they attempt to implement e-government projects targeting G2G part of e-government (ITU, 2009; Hossan et al (n.d); InfoDev, 2002; Gichoya, 2005; Narayan, 2007). It can be argued that, for developing countries a comprehensive e-government is not a dream that can be achieved any time soon. A lot of issues need to be addressed before embarking on a journey/programme to achieve a connected government. For example, ICT adoption and infrastructures, skills development etc.

Discussion presented in this paper offers a possible approach to establishing information sharing needs. The paper points out benefits and impediments of effective and efficient information sharing in government departments.

LITERATURE REVIEW

Literature on information sharing in the public sector at national levels has proliferated in the past decades. However, literature targeting administrative processes and service delivery information sharing in the field of e-government has not been so prolific. According to the United Nations (UN) (2008) e-government can contribute significantly to the process of transformation of a government, by making it leaner, and more cost effective. E-government can also facilitate communication and improve the coordination of authorities at different tiers of government, and within the organisation's departmental levels. Efficient information sharing is one of the G2G targets through e-government. Literature shows that developing countries are still in the early stages of e-government adoption and are facing numerous challenges when they attempt to implement e-government projects (ITU, 2010; Hossan et al (n.d); InfoDev, 2002; Gichoya, 2005; Narayan, 2007; Beynon-Davies, 2007). Since developing countries are struggling with the initial stages of e-government, it can be argued that, for developing countries a comprehensive e-government is not a dream that can be achieved any time soon. A lot of issues need to be addressed before embarking on a journey or programme to achieve a connected government. In the context of e-government and information sharing, ICT initiatives such as information systems are required to enable information sharing. According to Ebrahim&Irin (2005), e-government information sharing depends to a significant degree on existing government data and existing processes. Therefore, governments integrate information systems and web application to share information within and between departments. Information sharing is facilitated by IS. Government departments need Information Systems (IS) to be able to share information.

The Internet is a sought-after ICT tool in information sharing phenomenon, which enables networks of computers to share information and related groups to collaborate. Ebrahim & Irani (2005) applaud the presence of the Internet in the e-government adoption process by stating that “e-government provides a wide variety of information to government agencies, citizens and businesses through the Internet” (Ebrahim&Irani, 2005). The formation of IS such as electronic data interchange and enterprise resource planning, relies on the availability of the internet. Applications such as e-mails, instant messaging, electronic

white boards, and other tools that support communication also require the existence of a functional network.

Information sharing in governments serves different purposes. One, the sharing of data and information enables the achievement of improved policy coordination between governmental agencies on a more timely and effective manner (UN, 2008). Thus, governments around the world are progressively turning to information sharing and integration, for solving problems in an extensive range of programs and policy developments (Headayetullah and Pradhan, 2009). Government reports, documents and studies also indicate that information sharing is a requirement if public benefits are to be achieved (UN, 2008; Caffrey, 1998; Australian Government, 2009; OPM, 2005; Ruhode & Owei, 2010). One public benefit that is discussed among others is accessing governmental information and services on a 24/7 basis, in the comfort of the user's home or at any public office. With the emergence of the e-government phenomenon, governments can expect to share information electronically. Therefore, e-government is driven by intra-governmental and intergovernmental need for information sharing. Gichoya (2005) asserts that in developing countries, ICT inhibitors do not prevent the implementation of ICT projects but they do prevent advancement and restrict implementation and sustainability. Heeks (2008) expresses the opinion that *"in developing countries government ICT projects fail; either a total failure where by a system is never implemented or implemented and immediately abandoned"*. Failure of IS or ICT projects in governments leads to inefficiency of information sharing processes. This paper categorised the impediments and benefitts into four categories in the table provided. Impediments in this paper referred to the factors that do not completely prevent the implementation of e-government but, they do prevent advancement and slows down implementation of e-government.

Perceived benefits of e-government

Gil-Gracia et al (2007) affirm Dawes (1996) three categories of information sharing perceived benefits; technical, organizational and political. Technical flexibility includes, but is not restricted to, reduction of data duplication, processing, storing and presentation of information. According to Gil-Gracia (2007) the benefits of electronic information sharing to government agencies range from data processing and information management, improved decision making processes, better coordination of the activities, to high quality services (Gil-Gracia, 2007). Politics plays a role in the implementation of information sharing projects [in government]. Enhanced dissemination and understanding of government ICT

policy goals increases public accountability, promotes ICT integrating planning (Gil-Gracia, 2007) and improves ICT project(s) management that leads to successful implementation of the projects.

Apart from all the benefits and opportunities that e-government can offer to government agencies, major impediments to the adoption of e-government such as the digital divide, organizational structure and poor information sharing infrastructure between departments, are exposed in literature (Karokola and Yngstrom, 2009; Weerakkody, 2011; Gil-Gracia, 2007; UN 2008). Impediments to information sharing differ from government to government, however impediments can still be grouped into similar categories as are used for benefits, or Gil-Gracia's (2007) group of ICT initiative impediments can be used. The following barriers emerge from e-government studies in developing countries, many inhibitors can be divulged based on the focus of the study; hence only inhibitors that are common in the literature are listed in the following table.

Table 2.1 Information sharing influential dimensions

Information sharing influential dimensions	Technological	Organizational	Environmental	People
benefits of e-government	Flexible sharing of data & information	Reduced costs, timely decision making	Improved communication and information dissemination	Skills/ realizing ICT value
	Eliminates duplication of data	Better data management, accurate planning	Increased public accountability	culture
	Processing, storing and presenting	Improved coordination of activities, high quality service	Integration planning,	
impediments of e-government	Poor ICT infrastructure	Organization structure lack of organizational policies and legal frameworks	Digital divide	Perception towards ICT

	ICT capability and availability	Fund & budget allocated to ICT, ICT acquiring process(Namibia, tender board)	Availability of ICT vendors	Literacy, beurocracy
	ICT compatibility	Shortage of skills among employees	Lack of legislative policies at agency level	

Technological impediment

The technological impediments covers problems associated with hardware, software, presence of ICT infrastructure, and communication networks (Gil-Gracia et al, 2007). Technology availability, the digital divide and compatibility significantly influence the sharing of information in and between agencies. An example of e-government impediments is incompatibility of ICT tools and systems in governments; this is a technological barrier that government agencies are experiencing this result from a variety of ICT standards followed by departments. The absence of common ICT standards as guidelines for information systems development, results in disjointed information systems which cannot enable information transfer within and between government departments. Weerakkody et al (2011) expresses the opinion that e-government is expected to provide access to citizens and other users from a single integrated gateway, which also requires participating agencies to share data to serve and achieve citizen's needs. Due to a lack of common ICT standards, information systems integration in governments is difficult to achieve, therefore common ICT standards should be considered the prerequisite factor from an e-government implementation perspective (Weerakkody et al, 2011). Fan & Zhang (2007) assert that ICT capability and availability influences information sharing at intra organizational level. IT capability refers to the availability of technology and expertise within the agency to enable participation in G2G information sharing (Fan & Zhang, 2007). ICT infrastructures are made up of hardware, software, communication facilities and ICT knowledge and skills, available to the organization. Fixed wired Internet technology infrastructures are not as omnipresent in developing countries as they are in developed countries; instead, mobile technology infrastructures are omnipresent in most developing countries (ITU, 2010). However, most e-government initiatives do not support mobile applications. The lack of Internet infrastructure in developing countries contributes to low implementation and usage of ICT tools and projects. A Government's lack of information systems infrastructures to support organizational activities in the areas of information collection, storage dissemination and use, in growth and rural areas is a result of the digital divide in developing countries. ICT standards and infrastructure impediments discussed are linked to other barriers, discussed under the organisational theme such as the budgets associated with any e-government projects.

Organizational impediments

The organisational impediments relate to organizational culture, such as the management support on ICT projects, structure, skills within the organization, and characteristics of

project implementations, project champions, organizational needs, project management and budget allocation (Gil-Gracia et al, 2007). Top management support and championing – the absence of top management support or an ICT project champion, can result in the failure of ICT initiatives. Researchers comment that the support and commitment of top management to provide a positive environment that encourages participation in information sharing and implementation of ICT initiatives is vital. (Heeks, 2008; Akbult, 2003). The agency needs to appoint a responsible individual to lead and introduce ICT initiatives in the agency. At national level, the government as an organization needs a responsible department to oversee the implementation of e-government. In spite of being sound technically, most e-government initiatives do not achieve their desired success (Hossan et al (n.d)). Initiatives fail due to a lack of skills to design, implement and use the information system (Ndou, 2004; Nkohkwo & Islam, 2013). Lack of skills in developing countries is influenced by numerous factors such as ICT education not being compulsory in developing countries (Tembo, 2008). Such lack of skills to design, implement and use ICTs contributes to ineffective information sharing within and between government departments. As a result, government departments in developing countries rely on off-the-shelf ICT products. Heeks (2008) points out that, governments need skilled developers and project managers to lead these implementations and manage their ICT projects. Organizational structure – The allocation of duties and the reporting channels within the organization determines how information should be communicated. Traditionally, organizations have a top-down-bottom-up delegating and reporting route. This makes it difficult for employees to share information.

Funding and budgeting for ICT initiatives -Although the UN report (2008) indicates that the cost of ICT has reduced drastically and has therefore become more affordable than before, several researchers indicate that ICTs required to effectively implement and enable information sharing are expensive (Tembo, 2008; Narayan, 2007; Gichoya, 2005; Caffrey, 1998). The cost of ICT services remains a major barrier in Africa (ITU, 2010). The costs of ICT being a concern, in developing countries, fiscal resources are a definite inhibitor to intra and intergovernmental information sharing. Authors criticize donor funded projects stating that, some projects are carried out without a prior needs analysis (Gichoya, 2005); as a result each department takes its turn to seek for funds in isolation to implement its own ICT projects. The downfall of a donor funded project can often be attributed to the fact that the feasibility study conducted is mainly focused on a specific community and its

needs; and that the feasibility study does not include any aspects of intergovernmental agencies (Gichoya, 2005).

Policies/legal factors can contribute negatively to the use and implementation of ICT initiatives in government. Examples of legal barriers in an information sharing project are restrictive laws and regulations, and the confidentiality of important data and information (Gil-Gracia et al, 2007).

People

Tembo (2008) pointed out that, people's perception of technology in developing countries is a challenge. Users' perception of ICT as complicated tools impacts negatively on information sharing within government departments. Government employees are included in this group of users. If people perceive that ICTs are complicated, or have been invented to take over their jobs, the result is that ICTs are neither adopted nor utilized in the organization (Julibert, 2008:195). Negative perception towards ICT results from lack of ICT literacy and skills, poor training or lack of exposure to ICTs. Therefore, governments need to focus on training to motivate workforces.

Environmental factors

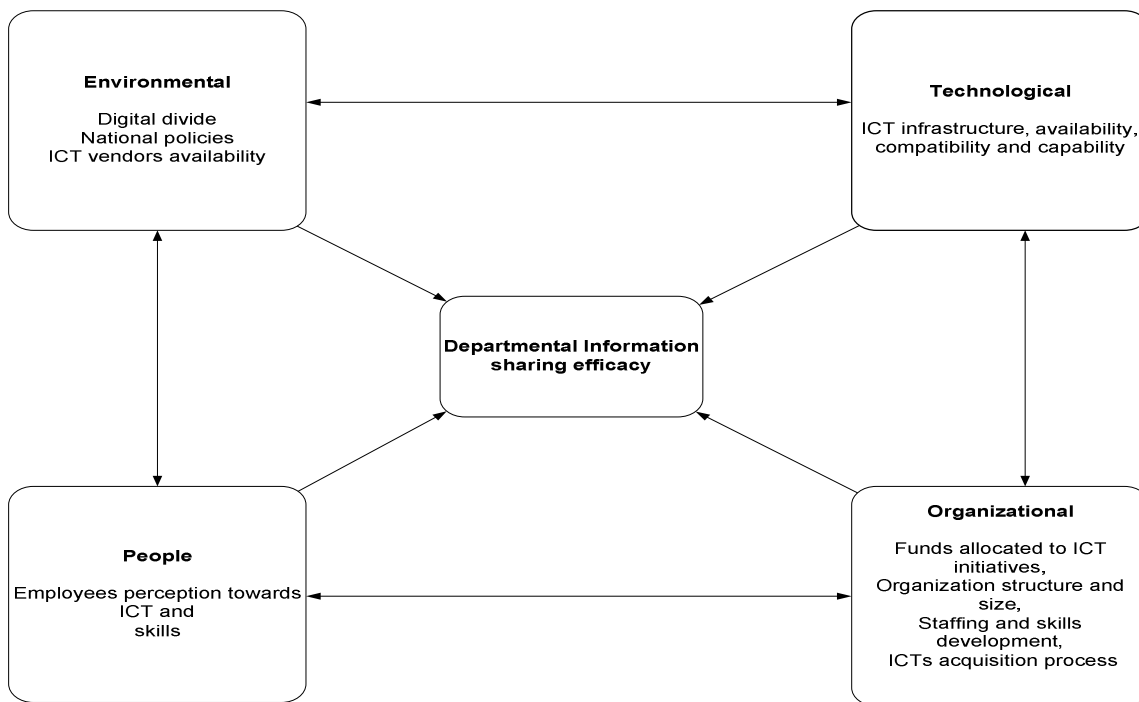
Consist of external factors and pressure from external entities (Akbulut, 2003) such as the availability of ICT vendors at a local level, support from public and private partners and the digital coverage in the country.

The digital divide is the gap between people who have access to the internet and those who do not (infoDev, 2002). Globally, the digital divide between the sub-Saharan African region and the rest of the world is much more pronounced than the divide within the region (ITU, 2010). Africa as a continent consists of developing and least developing countries. Developing and least developing countries are struggling with the problem of the digital divide more than developed countries. The problem is even extensive internally, given that large parts of developing countries are rural areas. The diffusion of ICT to such places in developing and least developing countries is very low. As a result, access to ICT within and between government departments remains a challenge. The inaccessibility of ICT makes it difficult to share information across traditional barriers and to give a voice to traditionally unheard government stakeholders (Tembo, 2008). Researchers' discourses emphasize how important it is for governments to implement policies that address the digital divide within their own countries (Ochara-Mugandu & van Belle, 2010).

More barriers to intergovernmental information sharing can be listed. Barriers are consequences of one another, for example; because of budget constraints for ICTs in developing and least developing countries, the digital divide exists, and user skills remain under developed. Individuals continue to think ICTs are difficult. Governments as organizations need to overcome ICT implementation impediments as discussed above under the five themes (technological, organizational, policies/legal, people and environmental). However, policies framework can be discussed under organisational theme. Government organizations need proper ICT infrastructure, more investment/budget allocation to ICT innovations, policies, skills development and training, hardware and software availability and compatibility through implementation of common ICT standards throughout government departments, project champions and support from top management, and a clearly defined implementation strategy for each department that includes a needs analysis and the identification of stakeholders.

THE INFORMATION SHARING EFFICACY CONCEPTUAL MODEL

Many authors overlooked the important concepts of governments such as the structure and environment in terms of locality. The derived model in this paper includes the environmental factors that could contribute significantly on departmental information sharing process. The context is significant because it describes the environmental settings. It can further be applied to identifying information sharing needs for government departments, once the elements of each contexts are analysed and proven that there is a need for improvement or not. Figure 1 present the unified contexts for information sharing effectiveness and identified characteristics under each context. Under each context are contributing factors to efficiency of information sharing in government departments. The combination of contexts leads to the effectiveness of information sharing in government organizations. The connections between the square boxes indicate dependencies of context. The logic is that, investigating the four contexts for the purpose of identifying information sharing needs for improvement may lead to electronic information sharing effectiveness and efficiency.

Figure 1: A conceptual model for information sharing efficacy (Hamunyela, S. 2014)

The purpose of information sharing through e- government initiatives implementation is to revitalize government processes and to achieve information sharing benefits. Intra information sharing leads to effective and timely service delivery and eliminates duplication of data while realizing ICT value. Factors under the technological, organizational, environmental and people contexts contribute positively and negatively to information sharing processes. These factors could positively impact information sharing if well thought-out and tackled by governments. Failure to consider such factors or partial consideration of the four related factors leads to duplication of efforts, and inflexibility of data management and information sharing within and between departments. This paper suggests that the influential contexts are inter linked and should be used as suggested. In the discussions policy factors are closely allied to the organizational context.

The technological context focuses on factors that influence information-sharing in government organizations such as ICT infrastructures, capability, availability and compatibility of ICTs. The organizational context refers to characteristics of the agency influencing information sharing processes within the organization such as organization size, funds allocated to ICT initiatives, information sharing practices and skills in the organization. The environmental context describes the organizational surroundings and internal and external factors influencing electronic information sharing such as availability of required infrastructures to enable ICT use. Environmental factors include, and are not

limited to, location of the organization, the digital divide, and distribution of electricity and availability of ICT vendors. The people context describes the society / citizens and employees involved in the information sharing system. Significant factors influencing the people context are perceptions, skills and attitudes towards ICTs and information sharing concepts. The combination and acknowledgement of all contexts in ICTs implementation processes for information sharing purposes in an organization could lead to accomplishing electronic information sharing effectiveness and efficiency

CONCLUSION

Information sharing is an important component of e-government. Government departments are expected to share information for effective and efficient decision making. However, literature indicates that information sharing is hampered by numerous impediments. This paper categorises the impediments in four contexts, Technology, Organisation, Environment and people related impediments. The conceptual model derived in this paper can be used to describe electronic information sharing influential factors in listed contexts. It can further be applied to identifying information sharing needs for government departments, once the elements of each contexts are analysed and proven that there is a need for improvement or not.

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E-SKILLS FOR SUCCESSFUL M-GOVERNMENT IN THE WESTERN CAPE

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ABSTRACT

The main objective of any government is to successfully deliver services and improve the well-being of its citizens. In this era of the pervasiveness of information and communication technologies (ICT), governments use the notion of e-government over an Internet connection to accomplish this. In South Africa, this is seen as a problem as not many South Africans have access to the Internet either at home or through public access centres; hence the majority of citizens are inclined to use their mobile phones to access government services. However, there is no evidence that the citizens of the Western Cape, the empirical setting of this study, possess relevant ICT skills (e-skills) to effectively use mobile devices to benefit from government-supplied electronic services. Besides, there is no clear understanding on what e-skills government officials should have for successful delivery of m-government services or what e-skills WC citizens should possess in order to access and utilise these services and achieve benefits. This study, hence, identifies e-skills necessary for effective delivery and use of m-government and maps these e-skills to the potential benefits of these services.

Keywords: M-government, E-skills, benefits, government employees, citizens.

INTRODUCTION

There is a common agreement that the main objective of any government is to successfully deliver services and improve the well-being of its citizens. In this era of the pervasiveness of the information and communication technologies (ICT), governments use the notion of e-government over an Internet connection to accomplish this. In South Africa, this is seen as a problem as not many South Africans have access to the Internet either at

home or through public access centres. In the Western Cape, the empirical setting of this research, only 24% of the population use the Internet as opposed to a high mobile phone penetration rate of approximately over 90% (ResearchICT Africa, 2011). Due to the fact that there is a higher mobile penetration rate than internet penetration rate in the Western Cape Province (WCG), many citizens are deprived of using e-government services.

This was not surprising as in many developing countries the expectations that e-government would bridge the gap between citizens and government has not been fully realised, but there is a *“technological hinterland (such as mobile technology) that is still largely unexplored by governments and could potentially deliver benefits previously inaccessible to many”* (Somani, 2012). Indeed, a recent study by Munyoka et al (2014) suggest three reasons for making mobile communication an integral part of sub-Saharan Africa's m-Government delivery platform: (i) the continued growth in wireless access ensures a wide audience reach, (ii) messaging and data usage shows consumers are savvy enough to recognize mobile as a potential delivery arm for public services and (iii) the mobile device market is maturing and smart-phone penetration accelerating.

The available evidence discloses a number of possible benefits that might come from using m-government, i.e. using government electronic services supplied through mobile devices. The identified benefits range from mobility and ubiquity of m-government to the increased service accessibility, ease of use and efficiency of these services. Recent studies have confirmed that citizens and also government officials in the Western Cape perceive introduction of m-government services as rather beneficial and are willing to use and supply these services (e.g. Mitrovic & Klaas, 2012; Mitrovic et al., 2013). Hence, the Western Cape Government has strategically decided to introduce mobile technology into its service delivery processes. In other words, the WCG has decided to introduce “mobile government” or m-government as a service delivery platform. M-government, in this context, is however not a replacement for e-government but rather a complement (Kumar, 2007; Somani, 2012).

Although Munyoka et al (2014) suggest that “consumers are savvy enough to recognize mobile as a potential delivery arm for public services”, there is no evidence that the citizens of the Western Cape, notably those from previously disadvantaged areas, possess relevant ICT skills (e-skills) to effectively use ICT devices for socio-economic development - including the government services (e.g. Mitrovic et al., 2012). Furthermore, there is no clear understanding: (i) what e-skills WCG officials should have for successful delivery of

m-government services or (ii) what e-skills WC citizens should possess in order to access and utilize these services and achieve the perceived benefits.

Based on the above, the study reported in this paper sets to map the e-skills required by the citizens and government officials in the Western Cape for achieving m-government related benefits identified by Mitrovic & Klaas (2012) and other relevant authors.

APPROACH TO THIS STUDY

This study is based on an extensive literature review aimed at creating a conceptual model regarding the perceived benefits of m-government and to derive e-skills classification required for successful use of m-government. This model was subsequently tested on the purposive sample of (38) Western Cape citizens and five WCG officials involved in the development of m-government. The data is gathered in the following way:

We first gathered qualitative data using unstructured interviews that involved potential users of m-government services - these were post-graduate students of one of the Western Cape universities. Due the government officials' limited time available for the interviews, we used semi-structured interviews to capture perception of these officials regarding benefits of the intended introduction of m-government in the Province.

The unstructured qualitative data gathered from the potential users of m-government were analysed for common themes and categorised according to the identified themes. These categories were subsequently compared to the concepts found in the pertinent literature in order to establish an initial conceptual model regarding possible benefits from use of m-government. This model was subsequently tested by interviewing government officials involved in m-government development. Analysis of these interviews was used to refine the initial conceptual model and derive an m-government benefits model that can be used for further research and possible modification by the academic community and practitioners. The Klein and Myers (1999) seven principles of interpretive research were used as the interpretive guidelines for this research.

SITUATING THIS STUDY WITHIN M-GOVERNMENT FRAMEWORK

Mobile devices can simply be defined as portable technology which enables users to communicate and access information wirelessly, from any location and at any time. These devices are becoming the most rapidly adopted technology in history and the most popular

and widespread personal technology in the world (OECD/ITU 2011). In that regard, m-government forms part of a greater phenomenon of mobile-enabled development (m-development) or transformation by leveraging the current mobile initiatives to act as a catalyst and enable development. Mobile government utilises electronic services and makes them available via mobile technologies using devices such as mobile phones and other mobile devices.

On the other hand, e-Skills can be defined as the ability of people to be able to use ICT, as well as those people who need to apply these technologies and develop those (Lanvin & Kralik, 2009). These skills are needed by individuals to be able to participate in a world in which ICT is a requirement for advancement in business, government and civil society (Mitrovic et al., 2012). From the viewpoint of this study, it is apparent that there are (at least) two sets of e-skills needed for successful e-government: government related e-skills and the citizen side of e-skills (Figure 1).

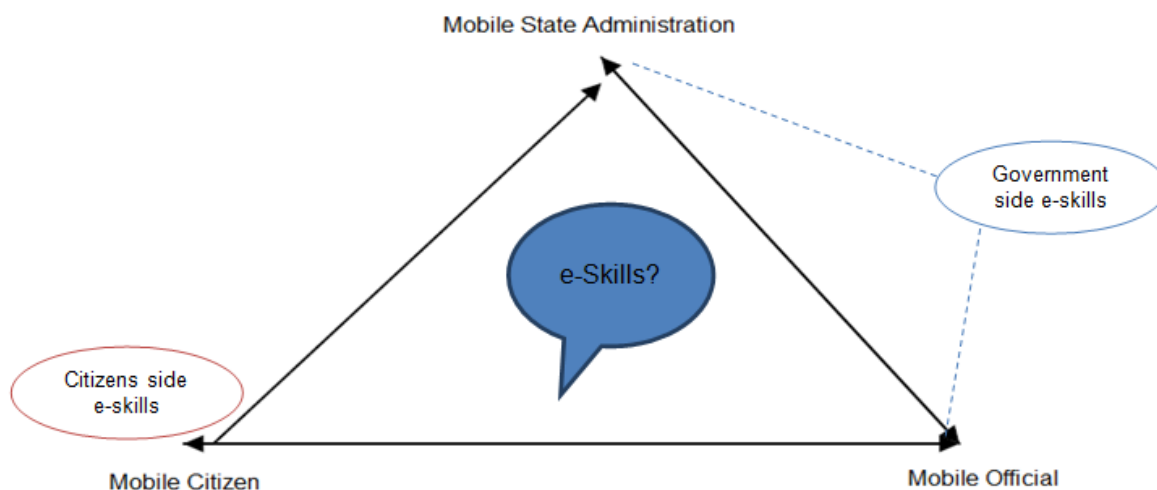


Figure 1: Positioning e-skills in m-government environment
(source: Authors, based on Snellen & Thaens, 2008)

In the mobile government delivery framework these skills can be positioned in the following quadrants: m-government skills for citizens (in mG2C) and m-government skills for employees (in m-G2E).

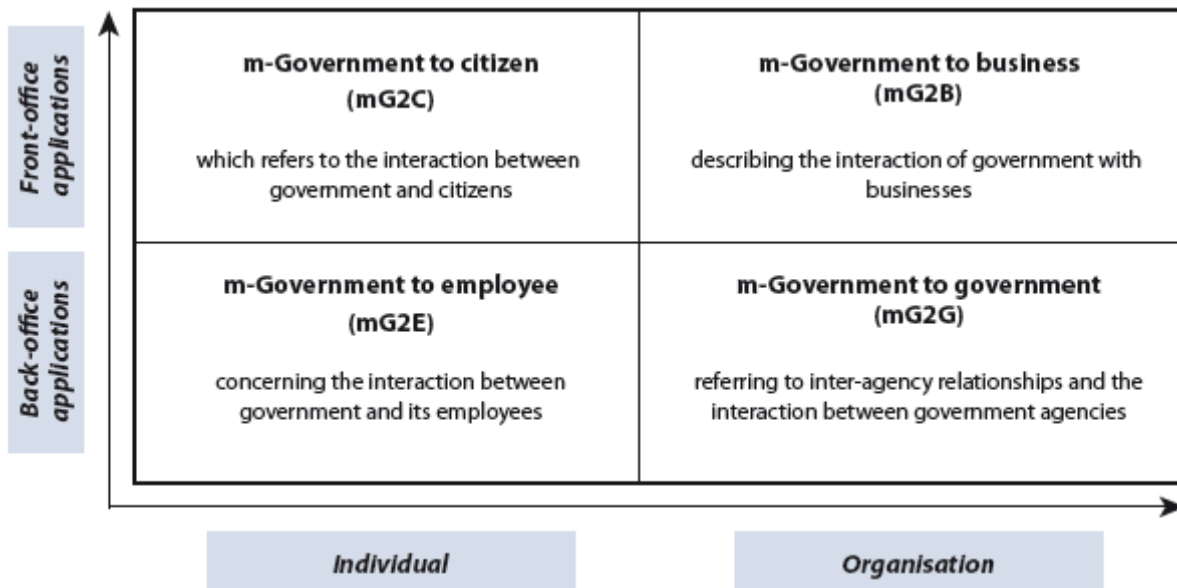


Figure 2: Primary delivery models of m-government
 (Source: Oui-Suk, 2010)

Mobile government (m-government) can be also described as a subset of e-government, which can be described as the use of ICT to improve the activities of the public sector organisations. The difference between the two is that with m-government those information and technology are limited to mobile and wireless technologies such as mobile phones, laptops and tablets, which are connected to wireless local area networks (Kumar, 2007; De Kervenoael & Kocoglu, 2012).

Having situated this study within m-government framework, the next step in our study was to establish benefits of using m-government in order to, later on, explore e-skills needed for achieving these benefits.

BENEFITS OF M-GOVERNMENT

The reviewed pertinent literature discloses a number of possible benefits that might come from using m-government, i.e. using government electronic services supplied through the notion of m-government. The reviewed literature disclosed a number of m-government benefits for citizens or government employees. As summarised in the recent study by Mitrovic & Klaas (2012), these benefits range, for example, from mobility and ubiquity of m-government to the increased service accessibility, ease of use and efficiency of these services (Table 1).

Benefit	Beneficiary	Reference
Mobility and Ubiquity	Government employees; Citizens	Goldstuck, 2003; OECD/ITU, 2011; Kushchu&Borucki, 2004; Carroll,2006; du Preez, 2009
Increased Accessibility and Wider reach	Citizens	Maranny, 2011; Ranu et al., 2010; OECD/ITU, 2011; Kushchu&Borucki 2004; ResearchICT Africa., 2013
Ease of use	Citizens	Maranny, 2011;OECD/ITU, 2011
Greater cost optimisation and increased productivity	Government employees	Kumar, 2007; Kushchu&Kuscu2003; Ranu, et al., 2010; Repacholi, 2009; OECD/ITU, 2011; Abramson, 2001; Bates, 2005; Zalesak, 2003; Carroll,2006
Improved communications and information management	Government employees; Citizens	Kushchu&Kuscu, 2003; Goldstuck, 2003; Repacholi, 2009; Ranu, et al., 2010; OECD/ITU, 2011; Sadeh, 2002; Carroll, 2006; Trusler, 2009
Expanded and improved service delivery	Citizens	Kumar, 2007; Repacholi, 2009; Ranu, et al., 2010; Maranny, 2011; OECD/ITU, 2011; Zalesak, 2003; Kushchu&Borucki, 2004; Carroll,2006; du Preez, 2009
Enhance digital inclusion (DI)	Citizens	Kumar, 2007; Bradley, 2006; Carroll,2006; Ranu, et al., 2010
Larger and wider user base (power of reach)	Government employees	Kushchu&Borucki 2004; Ranu et al., 2010
Increased democracy, participation and empowerment of citizens	Government employees; Citizens	Mirembe, 2009;Twinomurinzi, 2008; Carroll,2006; Olmstead et al., 2007
More personalization for targeting users	Government employees; Citizens	Ranu, et al., 2010; OECD/ITU, 2011; Kushchu&Borucki 2004
Sustainability benefits	Government employees; Citizens	Mirembe, 2009; OECD/ITU, 2011;Kushchu &Kushchu, 2003
Timely reacting to emergencies	Citizens Government employees	Repacholi, 2009; OECD/ITU, 2011

Table 1: Possible benefits of m-government (source: Mitrovic &Klaas, 2012)

Mobility and Ubiquity refers to the notion of accessing m-government services from everywhere at any time (24/7 availability) as people always carry their mobile phones with them.

Increased Accessibility and Wider reach is almost synonymous with the previous as it refers to provide government information and services regardless of distance, time, place, and diverse conditions.

Ease of use refers to the perception that the usage of mobile devices is easy and simple for majority of citizens.

Greater cost optimisation and increased productivity refers to the cost savings as, for example, users will use their own devices and many times do not have to travel to the internet cafes (citizens) or their offices (government employees).

Improved communications and information management refers to more effective communication and faster information management through constant, real-time update of relevant information, hence eliminating redundant information and “information overflow”.

Expanded and improved service delivery through, for example, increasing awareness of electronic government services or keeping citizens informed about the latest changes in government service delivery. It is believed by the participants in Mitrovic & Klaas (2012) that m-government, due to the very high penetration of the mobile phones, can bring vital services (e.g. information of the water supply or the transportation concerns) directly to previously disadvantaged areas.

Enhance digital inclusion refers to m-government’s potential capacity to bring much progress towards digital equality as, *socially and economically, there are divides between the rich and the poor, between those people who can access and use ICT to gain the associated benefits, and those who do not have access to technology or cannot use it for some or other reason (“digital divide”)* (Mitrovic & Klaas, 2012).

Larger and wider user base can be achieved through reaching larger number of people through mobile devices than through the stable communication lines and still low usage of PCs in the Western Cape.

Increased democracy, participation and empowerment of citizens is achieved through government accountability and transparency, and through greater citizens’ participation in the policy development processes and so called democratic decision making. This is achieved through concepts of e-democracy and e-participation.

More personalization for targeting users is based on the notion that, while computers are shared among different users, mobile devices are designed for a single user so that information can reach the preferred user at any time. This personalisation (enabled through the location services, for example) can allow for the government to be able to locate a specific individual who is in need of particular services.

Sustainability benefits are seen through the possibility that m-government can provide environmental friendliness by reducing the paper usage (as the services and information are provided electronically) and also reducing (or eliminating) the need for travel, as explained earlier. The former is more applicable to the use of the tablet computers and the latter to mobile phone usage.

Timely reacting to emergencies refers to the ubiquity of the mobile devices and networks that can help to respond to various emergencies through instant information access and release, and shared access to mapping data using mobile devices.

E-SKILLS

There are various definitions of e-skills found in the modern literature. For example, Lanvin and Kralik (2009), define e-skills as the ability of people to be able to use ICT, as well as those people who need to apply these technologies and develop them. Based on the WSIS (2003) and European e-skills Forum (EESF, 2004) documents, Ikamva National e-Skills Institute (INe-SI) defines e-skills as: "...the ability to develop and use ICTs within the context of a knowledge environment and associated competencies that enable the individual to participate in a world in which ICT is a requirement for advancement in business, government and civil society." Recognising this complexity, the INe-SI initially adopted (in 2008) a taxonomy that describes four types of e-skills (Wesso, 2008):

- *ICT practitioner skills*: the capabilities required for researching, developing, designing, managing, producing, consulting, marketing, selling, integrating, installing, administrating, maintaining, supporting and servicing ICT systems.
- *ICT user skills*: the capabilities required for the effective application of ICT systems and devices by the individual.
- *e-Business skills*: the capabilities needed to exploit opportunities provided by ICT - to explore possibilities for new ways of conducting business and organizational processes, and to establish new businesses.
- *e-Literacy*: the capabilities needed to socially appropriate ICT for local development.

This was the point of departure for an extensive discussion about the e-skills definition in the South African context and, later on, the classification of e-skills was redefined (NeSPA, 2010):

- *e-Literacy Skills*: aimed at employment readiness, particularly targeting unemployed and unskilled youth and rural society (including starting own small business);
- *e-Participation and e-Democracy Skills*: focusing on enhancing citizen interactive engagement with communities, local, provincial and national governance processes to increase participation, self reliance and equity;
- *e-Government/Governance Skills*: focusing on increasing efficiency and productivity interactive bimodal approaches to service delivery of governments and its agencies across all ICT platforms including new cell phone technology, community radio, and the like;
- *e-Business Skills*: aimed at increasing organizational efficiency and productivity;
- *e-User Skills*: focusing on enhancing the efficiency of public and private sector knowledge workers;
- *e-Practitioner Skills*: aimed at enhancing the capacity of public and private sectors to manage, support and service ICT; and
- *e-Community Skills*: aimed at increasing self-reliance, participation and community support in a socio-economic setting to build social cohesion in ways that can better build local solutions to societal matters such as crime, health, education and the like.
- *Green ICT skills*: preserving natural environment and being socially responsible.

Being more comprehensive than other e-skills taxonomies found in the pertinent literature, this study adopted this classification in order to map the benefits of m-government against the e-skills needed to potentially attain these benefits. Optimal development in e-skills will increase effective use of the Internet, wireless networks, cell phones, and other communication mediums (Rouse, 2010).

E-SKILLS FOR M-GOVERNMENT

The respondents in this study were asked to use the above e-skills taxonomy and match the skills to the perceived m-government benefits. However, we did not limit the

respondents to these e-skills, allowing them to list any other ICT skills that they deem appropriate.

e-Skills for government employees

Mobility and Ubiquity

The interviewed government officials that e-skills need by government employees in order to achieve m-government mobility and ubiquity benefits are:

e-Literacy as “the employees must be literate and know how to navigate on mobile technology” (Interviewee 1).

They also must possess *e-User skills* since “the government employees should be able to use mobile technology effectively in order to access and make use of m-government” (Interviewee 3).

The government employees also stressed importance of *e-Practitioners* skills as “somebody has to develop system and applications” (Interviewee 2).

e-Business skills, *e-Participatory* and *e-Democracy skills* are needed “to be able to understand citizens’ problems...” (Interviewee 4).

Ease of use

e-Practitioner skills as “...the government employees would need *e-Practitioner skills* because the government professionals would need to develop a system that is easy for the citizens to use..” (Interviewee 4) and “somebody must provide services that are easy to use... (Interviewee 3).

e-User skills since “... employees need to be able to also use the m-government services” (Interviewee 2).

Greater cost optimisation and increased productivity

e-Business Skills to be able “to provide a best cost effective solution for a situation” (Interviewee 3), or “...be able to develop the least expensive way of developing applications for the mobile technology and design a solution to be able to get wireless internet at the minimum expense” (Interviewee 5).

e-Government and *e-Governance skills* as a few interviewees agreed that the employees would need e-Government skills and “internet skills because the employees would need to

know how the technology systems works in order to produce an outcome effectively and efficiently” (Interviewee 3). “These skills would allow for government workers to feel inclusive of decisions and be more productive in the work which they are assigned to do” (Interviewee 2).

e-User Skills as “this will allow them not to be at physical offices to do their work but could be at any place, which will allow employees to be able to save transport and stationery stationary costs...” (Interviewee 1).

Improved communications and information management

All interviewees agree that the government employees will need *e-Government and e-Governance skills* that are aimed at improving productivity and efficiency.

e-User skills are also important for ICT professionals in order to improve communication and manage information appropriately. Having these skills is important as it helps *“in using applications and be able to navigate their way through the applications” (Interviewee 6).*

ICT Practitioner skills as the government employees must have *“...ability to manage customer information well, able to do research on citizens should they need any further information on the citizens, as well as do alterations and updates on the information” (Interviewee 3).*

E-business skills are needed to *“exploit opportunities of ICT” (Interviewee 5). “For example, government employees can make use of an ERP system to link the functions within the organisation and primarily use it for internal communication and use it to exchange information” (interviewee 1).*

Expanded and improved service delivery

e-Service skills were selected by the participants in this study as vital for the extended and improved service delivery. These skills are needed by the government employees in order *“to be able to utilize the different technologies for the different areas of expertise, and increase the productivity to offer better services” (Interviewee 6).*

Many respondents believe that *e-Practitioners skills* are needed for creating and maintaining m-government information system that will effectively deliver government services.

e-Government and e-Governance skills are also needed for an improved service delivery as, for example, these services “*can help better e-health or e-education service delivery*” (Interviewee 4).

Enhance digital inclusion (DI)

e-Business skills are indispensably need by the government officials “*because the employees would be more empowered to push the citizens to use mobile technology, and if more citizens would use mobile technology then it would be better to have e-voting and there would be less hassles when the citizens wants to vote*” (Interviewee 1).

The government employees would also need *e-Participation skills*, since these skills “*would increase the competitiveness of the employees to encourage the citizens to use mobile technology*” (Interviewee 3).

Larger and wider user base (power of reach)

e-Practitioner skills were marked as important by the participants in this study as

“*...government professionals need these skills in order for the government employees to develop programs that are easy for the citizens to use, then there would be no training costs involved*” (Interviewee 5). Also, “*ICT practitioner skills such as usability requirement skills can be useful towards developing a user-friendly website for citizens*” (Interviewee 1).

E-User skills were found also important as they are “*...required by employees to effectively use the application of ICT systems in the work place...for manage the larger user base and their information effectively*” (Interviewee 3).

E-business skills are also needed “*...to exploit opportunities required by ICT for better performance of the organisation and introducing new things, which could attract a larger user base. This skill will allow government employees to capitalise on mobile uses*” (Interviewee 5).

e-Community skills are needed by government employees “*...due to the fact the m-government brings the advantage of wider and larger user base... this means that the government will be able to communicate with the majority of the population*” (Interviewee 6).

Increased democracy, participation and empowerment of citizens

e-Participation skills were identified as “...a positive attribute because employees would be more flexible in delivering the services to the public” (Interviewee 4).

e-Democracy skills were necessary as these “...will improve relations of employees to be fair at all times with the citizen’s capabilities” (Interviewee 4).

e-Community skills were highlighted to “...enhance effective reliable service”, whilst also “enable citizens to have their voices heard” (Interviewee 2). These skills will further add to “...the development of better public services from government” (Interviewee 1)

ICT practitioner skills were important as they will enable and enhance “Government employees’ engagement with citizens through mobile applications such as, for example, for m-voting, that will provide feedback on the service provided” (Interviewee 6). A further benefit in possessing these skills were that “...it would enable employees to manage and maintain citizen information through regular updates and then be able to retrieve correct information when needed” (Interviewee 2).

ICT user skills were required “since employees needed knowledge of applications if they wanted to effectively use ICT systems in the workplace” (Interviewee 1).

e-literacy skill were marked as having the ability “...to effectively use m-government such as being able to navigate, interact and gain insights on citizens’ views and comments on social media around government information” (Interviewee 3).

e-Government and e-Governance skills were deemed as equally important in a democracy as these “...will serve to enhance collaboration and improve accountability among employees especially because of the participatory processes involved” (Interviewee 1).

More personalization for targeting users

e-Practitioner skills were needed “...so that in the event of logging information and issues raised by citizens can be done with ease as well as to facilitate a user friendly and quick response system” (Interviewee 5).

e-Community skills were raised to be needed since “...employees must be able to show the citizens that they can trust the applications made available for them to use” (Interviewee 2).

e-Business skills were regarded as important so that “...employees have knowledge about how to exploit opportunities provided by ICT such as social media and big data” (Interview 3). Also “...social media is more personalised and can be used to analyse the specific personalised data to understand one’s clients” (Interviewee 1).

ICT user skills were required otherwise employees “... would lag behind modern ways of doing and support their work in an ICT environment” (Interviewee 4).

Sustainability benefits

Environment Management & Awareness skills were becoming much needed skills since “...work spaces must be designed in being less wasteful and by making use of mobile devices employees can contribute to a greener society” (Interviewee 6).

Green ICT skills had been identified as necessary “...and if properly advocated by government will aid in preserving our natural resources and as employees we will contribute toward decreasing our carbon footprint” (Interviewee 5).

e-Business skills were raised as important especially “...in finding new effective and efficient approaches to doing business that underscore sustainability, as such we need to invest more in green computing technology” (Interviewee 2)

e-Practitioner skills were required as “...employees should constantly be able to move to newer technology, such as cloud computing, so as to achieve a more paperless environment and in becoming more green ICT savvy” (Interviewee 3).

Timely reacting to emergencies

e-User skills were needed to “...to understand ICT in a network environment and especially in knowing how to use and communicate to citizens on mobile devices in cases of an emergency” (Interviewee 6)

ICT practitioner skills were required so that employees overall “...have knowledge about network management, but also that the workplace has skilled personnel in the installing and maintenance of computer networks especially related to responding to emergencies” (Interviewee 1)

The above findings are shown in Table 2 below.

<i>Mobility and Ubiquity</i>	e-Literacy; e-User skills; e-Practitioners skills; e-Business skills; e-Participation and e-Democracy skills; e-Service skills
<i>Ease of use</i>	e-Practitioners; e-User skills;
<i>Greater cost optimisation and increased productivity</i>	e-User Skills; e-Business skills; e-Government and e-Governance skills;
<i>Improved communications and information management</i>	e-User skills; e-Government and e-Governance skills; e-Practitioners skills; e-Business skills
<i>Expanded and improved service delivery</i>	e-Service skills; e-Practitioners skills; e-Government and e-Governance skills;
<i>Enhance digital inclusion</i>	e-Business skills; e-Practitioners skills;
<i>Larger and wider user base (power of reach)</i>	e-Practitioners skills; e-User skills; e-Business skills; e-Community skills
<i>Increased democracy, participation and empowerment of citizens</i>	e-Participation skills; e-Participation and e-Democracy skills; e-Community skills; e-Practitioners skills; e-User skills; e-Literacy skill; e-Government and e-Governance skills;
<i>More personalization for targeting users</i>	e-Practitioners skills; e-Community skills; e-Business skills; e-User skills
<i>Sustainability benefits</i>	Environment Management & Awareness skills; Green ICT skills; e-Business skills; e-Practitioners skills;
<i>Timely reacting to emergencies</i>	e-User skills; e-Practitioners skills

Table 1: e-Skills needed by the government officials (source: Authors)

From the analysis of the interviews response it is apparent that vast majority of the identified e-skills needed by the government employees are represented in the NeSPA 2010 taxonomy: e-Literacy; e-User skills; e-Practitioners skills; e-Business skills; e-Participation and e-Democracy skills; e-Service skills; e-Government and e-Governance skills; e-Community skills and Green ICT skills. However, the respondents have listed another two skills: Environment Management & Awareness skills and e-Service skills. The respondents could not define these skills precisely but from their description it can be concluded that:

- Environment Management & Awareness skills refer to Green ICT skills in general and to the *Raising public awareness about condition of public goods* functionality of the Environmental Information Systems operated by public authorities (EIS) (Hilty 2008: 25).
- e-Service skills be associated with the benefits of *accessing a greater customer base and increasing services to customers* (Lu, 2001). These benefits here broadly correspond to *Larger and wider user base* and *Expanded and improved service delivery* – hence e-skills needed for achieving these benefits can be considered as adequate for an effective e-service.

e-Skills for citizens

Mobility and Ubiquity

The analysis of the interviewed citizens elicited that, in order to take advantage of the mobility and ubiquity of m-government, citizens should possess the following skills:

e-Literacy as the citizens need to “*be able to navigate and be literate so that they can successfully check what information the government is putting out there or trying to communicate*” (Interviewee 25).

e-User skills as the users of m-government services should be able to “*utilise mobile technology effectively in order to access and make use of m-government*” (Interviewee 2). Citizens need to have “*skills to use the mobile devices correctly so that the full benefit of having mobiles available 24/7 can be realised*” (Interviewee 22). Furthermore, “*citizens should have the general knowledge on how to utilize their mobile devices in order to access the services provided*” (Interviewee 34) and for that they need *Mobile e-skills* (Interviewee 15).

e-Community Skills are also perceived as necessary for citizens in order to take advantage of the mobility and ubiquity of m-government as “*citizens increase citizen participation, if government for example develops an application*” (Interviewee 7). In addition, citizens should have *Social Media skills* as “*citizens should be aware of and have the knowledge and skill on how to access and operate social media regardless of age or social status*” (Interviewee 18).

e-Literacy, *e-User skills* and *e-Community skills* are skills that figure in the NeSPA 2010 framework. However, the interviewees believe that there should be also other e-skills that should complement the NeSPA 2010 taxonomy. Such skills are *Mobile e-skills* and *Social Media skills*, which NeSPA 2010 only mentions implicitly. The importance of these skills is though stressed in the National e-Skills of Action 2013 (NeSPA 2013).

Increased Accessibility and Wider reach

The e-skills needed to take advantage of the increased accessibility and wider reach of mobile government are identified as:

e-Literacy skills as “*... they are required for things such as to search and retrieve information and to navigate and communicate on-line*” (Interviewee 23); *e-Participation*

and e-democracy skills “to be able to be more participative in using m-government applications” (Interviewee 10).

e-Community skills “...to increase participation within communities and governments...” (interviewee 13);

e-User skills as “citizens will be able to access information anywhere and anytime on their mobile devices thus they need to know how use ICT tools such as basic information mobile apps and attaining information from the net for work and personal purposes”(Interviewee 11).

“Citizens also must be astute when using m-government so they must have e-astuteness skills...like NeSPA 2013 says...e-Astuteness is the ability of citizens to be able to interact with others (social) like the government” (Interviewee 9).

Ease of use

e-User skills in order “to effectively use mobile applications to their advantage” (Interviewee 16) and are “important to know how the m-government applications work and therefore receive the benefit of ease of access” (Interviewee 10);

e-Literacy skills to be able “to experience ease of access because without it they will not be able to experience any benefit m-government has to offer” (Interviewee 10);

e-Participation Skills are important, for example, for “citizens with disabilities who need to have the skills to use the particular applications that are necessary for their full benefit” also, “...elderly people need the skills to access and use mobile devices (Interviewee 11).

Improved communications and information management

e-User skills are needed by citizens for “accessing the internet via various methods of connectivity” (interviewee 27).

E-participation skills are needed by citizens as these skills “focus on enhancing citizen interactive engagement with government at all levels... to increase self-reliance and equity” (Interviewee 22). However, it is stressed by a number of participants that these skills are built on e-Literacy and e-User skills.

e-Community skills since these skills “will increase citizen’s participation and community support to build towards better solutions for societal matters” (Interviewee 14).

Expanded and improved service delivery

Citizens should be e-literate (*E-literacy skills*) in order to “...communicate online with government agencies ...to provide feedback on service delivery” (Interviewee 31).

They must also have *e-User skills* in order to “effectively use their mobile devices to access information and keep track of latest changes made by government” (Interviewee 30).

In addition, citizens must have *e-Community skills* “to be able to use m-government services in such a way that will better the community and build social cohesion in a way that will better build local solutions” (Interviewee 20).

Enhance digital inclusion (DI)

e-Literacy skills will be needed by citizens because “citizens will not be able to use m-government applications and will not get the benefits... therefore they require it in order to increase digital inclusion and fill in the gap between technologically inclined and those that are not” (Interviewee 24).

e-User skills are also needed for digital inclusion as it will help citizens “to know how the m-government applications work” (interviewee 36).

e-Participation and e-Democracy skills are needed by citizens “in order to be more participative in using m-government applications” (Interviewee 11) and “ask government about decisions they make on behalf of citizens” (Interviewee 18).

e-Community skills can be useful “...to help those who do not have e-skills to participate within community...” (Interviewee 16).

Media skills will also be useful so that citizens can “make use of the media functionalities within mobile devices...” (Interviewee 18).

Larger and wider user base (power of reach)

e-User skills were identified as a basic requirement “...information should be provided in simple enough format, and enable citizens with basic mobile navigation skills to register and access the information without any hassle” (Interviewee 19). Also “...citizens should be attracted to use continuously use online service and to enjoy the benefits of user friendly device” (Interviewee 20)

e-Literacy were a necessary requirement so that “...services offered to citizens must be meaningful to them through ongoing literacy support and advertising campaigns to build an empowering and knowledgeable citizen” (Interviewee 17)

E-participation skills are attributed as being essential “...as contributing to being better informed about citizens needs and will influence the quality services delivered”

(Interviewee 18). Also “...this means that better relations will exist through the means of feedback between citizens and government on how services can be improved”

(Interviewee 20)

Increased democracy, participation and empowerment of citizens

e-User skills are essential because “...It enables citizens to use the appropriate applications on their mobile devices to interact about government’s service delivery performances either through, for example, their personal website or blog posts”

(Interviewee 17)

e-Participation& e-Democracy skills were viewed to be significantly relevant if “...citizens want to be interactively engaged and influence service delivery, they should increase their user base for wider impact, and in doing so can add benefit to society” (Interviewee 29)

More personalization for targeting users

e-User skills were marked to be important “...so that users can enjoy mobile device benefits 24/7 and access full range of options mobile technology has to offer” (Interviewee 30).

e-Literacy skills were a basic requirement “...without these skills citizens will be losing out on the ability to monitor the impact government has on their personal lives” (Interviewee 21). These skills will also “...allow citizens to successfully check government performance and navigate whether the right information from government reaches the relevant constituents” (Interviewee 25)

Media Skills are viewed as important “...as citizens become empowered to share pictures, videos, etc., of their experiences with others on their mobile devices” (Interviewee 16).

Sustainability benefits

ICT green skills were identified as important “... citizens’ awareness about their own role they can play in protecting and sustaining our living environment” (Interviewee 12).

e-Community skills were viewed as essential “... as citizens we learn from each other and in this respect such skills will enhance our social responsibility as well as contribute to sustainable development” (Interview 18)

Timely reacting to emergencies

e-User skills were needed “...so citizens will have the capability to react to emergencies and have access to information from others on what action to take in instances of emergency” (Interviewee 15)

e-Literacy skills were important “...if there is one person that is not e-literate it will be one too many, because in an emergency that person remains at a disadvantage on what to do in crisis times because of lack to mobile technology” (Interviewee 19)

e-Community skills were deemed to be vital for life of community “...it is through being connected through various mobile devices and applications that we sustain communities and help them to meet all forms of community needs” (Interviewee 23)

The above skills are cumulatively shown in Table 2 below.

m-Government Benefit	Needed e-Skills by Citizens
<i>Mobility and Ubiquity</i>	e-Literacy; e-User skills; e-Community skills; Mobile e-skills
<i>Increased Accessibility and Wider reach</i>	e-Literacy; e-Community skills; e-User skills; e-Astuteness
<i>Ease of use</i>	e-Literacy; e-User skills; e-Participation and e-Democracy skills;
<i>Improved communications and information management</i>	e-User skills; e-Participation and e-Democracy skills; e-Community skills
<i>Expanded and improved service delivery</i>	e-Literacy; e-User skills; e-Community skills
<i>Enhance digital inclusion</i>	e-Literacy; e-User skills; e-Participation and e-Democracy skills; e-Community skills; Media skills
<i>Larger and wider user base (power of reach)</i>	e-Literacy; e-User skills; e-Participation and e-Democracy skills;
<i>Increased democracy, participation and empowerment of citizens</i>	e-User skills; e-Participation and e-Democracy skills;
<i>More personalization for targeting users</i>	e-Literacy; e-User skills; Media skills
<i>Sustainability benefits</i>	Green ICT skills; e-Community skills;
<i>Timely reacting to emergencies</i>	e-Literacy; e-User skills; e-Community skills;

Table 2: e-Skills needed by citizens (source: Authors)

From the analysis of the interviewees’ response it is apparent that there are fewer e-skills needed by citizens in order to realize perceived m-government benefits – compared to e-

skills required by the government employees. These skills are e-Literacy, e-User skills, e-Community skills, e-Participation and e-Democracy skills, and Green ICT skills – all of them represented in the NeSPA 2010 taxonomy.

However, the respondents have listed another three skills: Media skills, Mobile e-skills and e-Astuteness. Media skills are explained by Romani (2009) and are described as an understanding of how traditional and digital media are merging and taking new format. Here, it refers to use mobile devices for primarily accessing traditional and digital media. Mobile skills are, on the other hand, classified as the part of e-Literacy (NCCFCG, 2013).

E-Astuteness skills that were mentioned by some of the respondents are defined in the NeSPA 2103 as “*capacity to continuously appropriate the technology into personal work, education, business, social and family contexts for both personal and collective benefit*”. These skills, explained in more detail in Mitrovic et al. (2013), are equally applicable for mobile and non-mobile computing devices.

The next figure (Figure 3) gives a diagrammatical view of the results of this study:

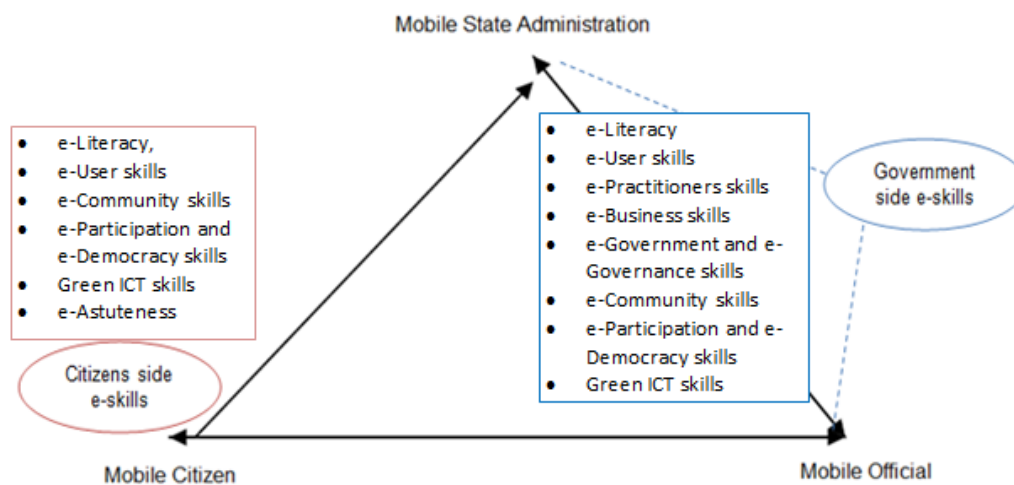


Figure 3: e-Skills for citizens and government employees for effective m-government (source: Authors)

CONCLUSION

The results of this study show that government officials and citizens in the Western Cape should possess certain ICT skills, also known as e-skills, if the perceived benefits of m-government, listed by Mitrovic & Klaas (2012), are to be achieved. It is indicative that government officials must have a larger number of e-skills and also be better equipped with e-skills than citizens. For example, they must have e-Business or e-Practitioners skills

in order to make m-government systems easy accessible and useable for citizens. On the other hand, citizens cannot solely rely on “simple phoning” skills if they are to reap possible benefits from m-government services. They, for example, must be appropriately e-literate and possess e-users skills in order to effectively use m-government services or e-Participation and e-Democracy skills and e-Community skills if they wish to participate in the social and political processes.

This study is now left to the academic community and m-government practitioners to use, critique and hopefully advance our work. In that regard, we acknowledge some limitations of this study of which one was a limited sample of government employees. The sample of the interviewed citizens was adequate in number but was limited by the social group of participants: university students. We, however, believe that this sample had certain advantages as these respondents are likely to be “early adopters” of m-government services and are also having above-average knowledge of e-skills and m-government.

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READINESS ASSESSMENT OF CLOUD-COMPUTING ADOPTION WITHIN A PROVINCIAL GOVERNMENT OF SOUTH AFRICA

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ABSTRACT

Cloud computing, as a shifting paradigm, is expanding its “bandwagon effect” across industries worldwide. This is due to the several advantages of cloud computing that have been revealed by the public sectors (empirical setting of this study), including improved levels of flexibility and mobility, lower total cost of ownership, reduced energy savings and carbon missions. Most importantly, cloud computing can free government from building, maintaining and upgrading its infrastructures and technologies, and focus more on serving the citizens with optimised resources. Hence, this paper focuses on the readiness assessment of cloud-computing adoption within the Provincial Government of the Western Cape (WCG), South Africa, which is in its cloud-computing embryonic phase. An extensive study of the literature on cloud-computing concepts, its characteristics, the possible non-technological readiness indicators for cloud-computing adoption, was conducted. This led to the identification of three main groups of readiness indicators: (i) Infrastructural indicators; (ii) organisational indicators; and (iii) environmental indicators. A conceptual model was then developed, according to these three main groups, with twelve sub-indicators. This model was subsequently tested in the empirical setting of WCG by using the qualitative approach through the case-study methodology. The intended audience for this study are both academic and practitioners as it brings a conceptual model and the guidelines for assessing the government’s readiness for the adoption of these cloud-computing technologies and services.

Keywords: *Cloud-computing adoption, government, readiness indicators, developing economies, Africa, South Africa*

INTRODUCTION

Cloud computing is an abstract term, which encompasses several services that are remotely controlled by a server, managed by a third party, and accessed via the Internet. The unique technological and business advantages of this paradigm are becoming increasingly evident; and it is expected that, in the coming years, the cloud computing

adoption will radically increase, to see the majority of IT services being delivered via public or private clouds (Anjomshoaa & Tjoa, 2011).

The advent of cloud computing has rapidly triggered interests in many industries, especially in the developing countries. Theoretically, cloud computing reduces infrastructure costs, and leverages the service demand and resource supply. However, issues, such as broadband connectivity (e.g. Wyld, 2010), security (e.g. Dhiman, 2010), contract issues (e.g. Federal Financial Institution Examination Council Agencies, 2012) and regulatory environment (e.g. ITU, 2012) hinder this adoption in both the private and the public sectors. Moreover, in order to efficiently and effectively initiate a successful deployment of cloud computing, a comprehensive examination of the current state of readiness is vital, especially when taking into consideration the unique opportunities and challenges of a country or region.

Adopting cloud computing would add value and benefit to government. First of all, cloud services could improve the level of service delivery, while lowering the overall costs (e.g. Lam, 2011). Secondly, optimised utilisation of onsite resources could be achieved by leveraging the purchasing power amongst different departments – through the use of cloud-computing technologies (e.g. Creeger, 2009). Lastly, the adoption of cloud computing could enrich government's ability to develop innovative ways to interact with the citizens in a broader realm (e.g. Wyld, 2009 & 2010). Hence, many public organisations believe that in the current circumstances of the global, prolonged economic downturn, cloud computing technology affords a viable strategy for government to be effective and efficient in the service delivery outcomes. Hence, this study recommends a conceptual testing model for cloud computing readiness of the public organisation. In that regard, the research problem of this study focuses on identifying and testing the readiness indicators of cloud computing adoption, and applying them to the cloud computing (CC) initiative of the WCG. Here, it should be emphasised that this study explores the *non-technological* readiness factors, i.e. it concentrates on the managerial (i.e. organisational or environmental) factors, rather than on the “core” technological factors, such as hardware, software or the networking equipment.

APPROACH TO THIS STUDY

The primary purpose of this study was to identify and test the readiness indicators of the cloud computing adoption in the studied Provincial Government in South Africa (i.e. WCG). In order to answer the research questions, and to meet the research objectives, this study

was primarily qualitative in nature. This study selected a single division in a relevant department of the studied Provincial Government that is directly involved with the delivery of IT services. This study, therefore, adopted the single case study methodology since, according to Yin (1994; 2003), this methodology is designed for examining in-depth meanings of studied phenomena (i.e. the readiness for adopting CC technology) in a real-life environment (a studied Provincial Government).

This study focused on investigating the participants' perceptions and experiences associated with their knowledge of cloud computing and the adoption issues. We believe that the case study methodology was best suited for this study in regard to understanding the research question ("What are the readiness factors that influence a successful the cloud computing adoption and what is the actual readiness of WCG for this adoption?) *via* the meanings that participants assign to them (Klein & Myers, 1999).

Multiple data evidences were collected from both non-empirical and empirical sources, namely: literature reviews, focus-group interaction and semi-structured interviews. The purposive sampling approach was adopted by applying the following selection criteria: (i) working in the relevant department in charge of CC adoption; (ii) holding relevant IT positions at a division of the department in charge of CC adoption; (iii) having at least one year's experience in the current position. It was presumed that the people who had qualified for these three criteria would be able to provide a meaningful input. The participants in this study included the focus group of 38 contributors and seven government officials who participated in in-depth interviews.

The information that emerged from focus group discussions and the interview answers were analysed using the content analysis technique, which helped to identify themes, build categories, and highlight emerging patterns. These emerging patterns were then compared with the findings of the literature review in order to draw the final conclusions.

CLOUD COMPUTING IN THE GOVERNMENT ENVIRONMENT: THE STATUS QUO

The idea of "cloud" existed long before Google's CEO Eric Schmidt used the word to describe the business model of providing services across the Internet in 2006 (Zhang, Cheng & Boutaba, 2010). In 1997, Professor Ramnath Chellapa foresaw that the term "cloud computing" was going to be "*a new computing paradigm, where the boundaries of computing would be determined by economic rationale, rather than by technical limits alone.*" (Shoshatari, 2013; Hsu, Wang & Shieh, 2010). However, due to the fact that the

term has been utilised mainly as a marketing term, a lack of any standard definition for cloud computing has led to the market hype: *“Cloud computing was simply a trap aimed at forcing more people to buy into locked, proprietary systems that would cost them more and more over time.....It’s a marketing hype campaign”*, said Richard Stallman, the founder of the Free Software Foundation and creator of the computer operating system GNU (Johnson, 2008).

There are numerous definitions of cloud computing (e.g. Gartner, 2010; Martens et al., 2011; Shoshatari, 2013) but there is still no widely accepted uniform definition of this term. For the purpose of this study, we have adopted a definition of cloud computing as *“a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort, or service-provider interaction”* (NIST as found in Mell & Grance, 2011).

The cloud-computing is perceived by the public sectors as a concept that brings economic value; hence it is taking place around the world for improving government performance through electronic government (e-government) and mobile government (m-government). With data applications stored on the cloud, it enables multiple users to collaborate on the same project regardless of their locations. Other advantages achieved by moving e-government or m-government services onto the cloud platform include increases flexibility, improves levels of automation and employees mobility (Wyld, 2009).

The United Kingdom, for example, utilises the “G-Cloud” Programme (UK_G-Cloud, n.d.), which is described as a strategic priority (Wyld, 2010) aimed at utilising the new technologies to deliver more efficient public services at a lower cost. The Japanese government uses the “Kasumigaseki Cloud” as a major cloud-based government initiative while in China, the cloud-computing based government developments remain at the regional level. In 2012, New Zealand’s “cloud-first” government approach towards cloud computing was introduced to undertake a cloud-computing programme in an “all-of-government direction” (DIA, 2012).

In South Africa the use of cloud computing in the government context is still in its embryonic phase (Mitrovic & Klaas, 2013). Hence, the contribution of this study was to produce a list of factors that can gauge the readiness of one South African Provinces (Western Cape) to introduce cloud computing services

CLOUD COMPUTING READINESS INDICATORS

New forms of technological solutions bring multiple changes to businesses and society. Sometimes such changes challenge the routine capabilities for staff and the organisational environment: both technically and socially. Cloud computing definitely has the ability to affect the way we operate things now to a whole new level we could never have previously imagined.

The reviewed literature suggests that there are technical and socio-technical challenges that need to be addressed before adoption (Niazi & Mahmood, 2011). These challenges can be translated into three groups of factors that can influence the adoption of cloud computing:

- Infrastructural
- Organisational, and
- Environmental.

These factors can be also translated into high level of the cloud computing readiness indicators.

Infrastructural indicators include:

- *Electricity availability and reliability*, as the electricity supply availability plays a vital role in serving the first step of the CC adoption (e.g. Maurice et al., 2012), which remains one of the primary challenges in some parts of the studied Province.
- *Broadband connectivity* is the vital prerequisite in enabling the ultimate cloud services. Poor quality and speed of Internet service is often blamed for insufficient investment in the telecommunication networks (e.g. ITU, 2012).

Organisational indicators encompass the following:

Strategic business considerations include (i) *Strategy* as “the first step in the process of migrating towards cloud technologies, both within the public and [the] private sector” (Kundra, 2011); (ii) *Top management support* as highly skilled top-management, a positive climate and effective communications must be in place to support capable personnel, utilising adequate resources, to ensure successful system transformation and integration (e.g. Low et al., 2011; Swink 2000); (iii) *Human resource strategy* since for adopting cutting-edge cloud-computing services, it is critical to have skills as part of the core

competencies in the organisation to achieve maximum expected improvements (Lam, 2011); and (iv) *Vendor management/Service level of agreement* as organisations need to acquire a comprehensive examination of the service provider, in terms of its areas of specialties, capability, pricing, and most importantly, the Service Level of Agreements (SLAs)(Bollineni& Kumar, 2011).

Operational business considerations consist of: (i) *Security issues* includes Data security (e.g. Dhiman, 2010) and Data-Access Management (Petkov, 2008); (ii) *Trust* as the fear of losing control of one's own data would lead to the critical trust issue, when adopting cloud services (e.g. Pearson, 2012). The perceived lack of reliability is determined by the availability and reachability of cloud service (e.g. Habib et al., 2010); (iii) *Compatibility* (the degree to which cloud computing services fit into the business or organisation's operational needs) and *interoperability* (different service providers may run on different infrastructural service providers' platforms) are essential factor for new technology adoption (Low et al., 2011); and (iv) *Cost performance* since in an economic context, both private and public sectors are constantly looking for solutions to minimise their operating expenditures, while making the most out of their investments (ITU, 2012). The cloud computing "pay as you go" model allows users to only pay for what they need, according to the requested time and volume of their own usage and consumption patterns, which frees organisations and businesses from investing heavily in internal resources.

Environmental indicators include: (i) *Regulation environment* as with the datacentres located everywhere around the world, issues around security and privacy of data and the location of data become the most paramount concern, when it comes to cloud-computing adoption. Therefore, this is a challenge in the context of regulation formulation since a lack of universally accepted standards also creates a barrier for cloud computing to flourish in the present era (e.g. ITU, 2012); and (ii) *Sustainability* here chiefly refers to the energy consumption and the "carbon footprint" of large data centres used for cloud computing. Garg, Yeo and Buyya (2011) give an example: if cheap energy is used to generate cloud datacentres, such as coal, the release of CO₂ emissions would only increase under such circumstances. Therefore, as a whole, it is not environmentally sustainable.

The above portrayed indicators are cumulatively given in the following table (Table 1).

Context	Factors	Sub-factors	References

<i>Infrastructural indicators</i>	Operational infrastructure	Electricity availability and reliability	Biles, 2008; Greenpeace, 2011; Kim. Lee. & Lee 2009; Maurice et al., 2012; Smith, 2012
		Broadband connectivity	Wyld, 2010; ITU, 2012; Kuda et al., 2012; Federal Financial Institution Examination Council Agencies, 2012
<i>Organisational indicators</i>	Strategic business considerations	Strategy	Kundra, 2011; DFD, 2011
		Top management support	Lam, 2011; Furrier, 2009; Ragu-Nathan et al., 2004; Low et al., 2011; Swink, 2000; Dhiman, 2010
		Human resource strategy	Lam, 2011; ITU, 2012
		Vendor management/Service level of agreement	Bollineni & Kumar, 2011; Federal Financial Institution Examination Council Agencies, 2012; Ernst & Young, 2011; Habib et al., 2010.
	Operational business considerations	Security issues	Dhiman, 2010; Federal Financial Institution Examination Council Agencies, 2012; Kim et al., 2009; Pearson, 2012; Schreiber, 2011; Petkov, 2008; ITU, 2012
		Trust	Habib et al., 2010; Bollineni & Kumar, 2010; Pearson, 2012; IDC, 2009; Furrier, 2009; Li & Ping, 2009; ITU, 2012; Cloud Forum IP Ltd., 2011
		Compatibility and interoperability	Low et al., 2011; Ernst & Young, 2011; ITU, 2012; Pearson, 2012; Wang et al., 2012; Parameswaran & Chaddha, 2009;
		Cost performance	Dhiman, 2010; ITU, 2012; Lam, 2011; Low et al., 2011; Kim et al., 2009
	Regulation environment		ITU, 2012; Kuada et al., 2012
	Sustainability	Energy and carbon efficiency	Paper & Continuity, n.d; Hamilton, 2009; Gartner, 2007; Brill, 2007; Garg et al., 2011; Eskom, n.d.; Berl et al., 2010

Table 1: Indicators for the cloud computing readiness in the government context (source: Authors)

The above indicators were tested by conducting a focus group with 38 participants, followed by face-to-face interviews with seven government officials. All the interviewees currently hold positions in the WCG division responsible for introducing the modern technologies into government operations.

TESTING THE WCG READINESS FOR THE ADOPTION OF CLOUD COMPUTING

Infrastructural readiness

Electricity availability and reliability

The responses gathered from the participants on the state of current electricity supply indicated that there is a mismatch between the supply and the demand, due to years of underinvested energy infrastructures and distribution. This is illustrated by a member of the focus group: *“...the electricity situation in South Africa with Eskom is unstable, meaning that we have power outages”* - this was confirmed by all the participants. Some of participants even suggested that it would be advisable to rely on the local data centres and cloud services: *“...the reason for not relying on a local cloud base is because of the electricity supply (situation in South Africa)”* (Interviewee G).

Broadband connectivity

The empirical investigation on the current broadband status in the Western Cape elected: (i) Poor coverage; (ii) slow connection (; (iii) expensive to some lower-end markets; and (iv) availability. For example, the Interviewee D remarked that *“...connectivity is the biggest constraint...”* and *“being a developing country, South Africa is still behind [the] first-world countries”*, further explained by the Interviewee E that *“...being a developing country, South Africa is still behind [the] first-world countries.”* However, the situation will be soon changed to better as *“the [current WCG] broadband initiative will open up the way so that we can make use of cloud computing”* (a member of the focus group).

Organisational readiness

Strategic business considerations

The empirical investigation has revealed that there is still not clear strategy regarding the introduction of cloud computing: *“I am not aware of that. At this point, we don’t have any solid plans towards that”*... *“...we haven’t yet determined that we are going to adopt a*

private cloud, and whether, or not, we are going to build our own infrastructures". (Interviewee A). The other respondents could not also give more details on the strategy, hence the conclusion that there is not clear strategy or the employees are not aware of the existence of that strategy.

Top management support is also seen as important by the respondents and the general perception is that the Provincial leadership supports this initiative. However, there are still some managers that does not grasp value of technological advancements such as cloud computing: *"...people still come from the old age where they still want to own things, so it's a culture thing that needs to change; and it all takes time..."* (Interviewee E). In addition, some of respondents believe that there is also political influence that might impact on the introduction of new technological initiative. For example, Interviewee G explains that *"...we are not able to introduce cloud computing without involving SITA (State IT Agency), which is controlled by the National government...it might impact on technical delivery as this Province is ruled by another political party..."* (Interviewee G)

Skill shortage is another concern by the respondents as *"...from the technical resource angle, I don't think we have much skill in that area"* (Interviewee B). Also, *"...we don't have those engineers to run those private cloud infrastructures...and then when it comes to our sourcing as well, we are not very experienced with outsourcing"* (Interviewee A) .

The Vendor management, including the Service-level agreement is also deemed important by the respondents but they have expressed some concerns regarding the readiness in this regard: *"I think a lot of work needs to be done on the certification of cloud providers and contracts for clouds"* (Interviewee E). There are many component of vendor management that are still do be understood, for example *"...as you move from one service provider to another one, you need to make sure you are getting all your information out of that cloud"* (Interviewee D).

Operational business readiness

In regard with the Operational business readiness, it is revealed that the security of data is the highest priority, which includes both technological and human factors: *"Security issues are everywhere; you cannot even ensure your information is completely safe at any given time or condition, people are the ones behind technology"* (Interviewee G). The respondents stated that there is security-related work still to be done regarding the cloud computing security.

The trust in service providers is also deemed as important but that trust is yet to be developed as *"...it's not that I don't trust cloud computing in general, the bandwidth issue and electricity supply we've discussed earlier worries me, because I don't know how it's going to work in South Africa, if we still have those unsolved issues"*. (Interviewee K). This readiness indicator, however, cannot be gauged at this moment as there is not yet experience with the service providers. The Interoperability and compatibility of the cloud computing providers is seen by the respondents as very important as, for example, *"...we should be able to have that data out and transfer to another platform, if we need to"* (Interviewee A). However, there is still work to be done on exploring compatibility and interoperability of potential providers of cloud computing services. The cost performance is seen by the respondents as one of the most important factors when considering introduction of cloud computing. However, they expressed concern that the cost implications of introducing certain types of cloud computing are not yet understood sufficiently: *"...there are certain models of cloud computing that are cost-efficient; however, particularly when implementing a private cloud, it requires quite a heavy investment upfront"* (Interviewee A).

Environmental readiness

When the question regarding regulations in the field of cloud computing was asked, the interviewees and also the members of the focus group mainly linked this topic to the State IT Agency (SITA) as technological implementation agency of cloud computing in all spheres of South African government. It was stated by the respondents that this agency will be responsible for complying with national and international regulations. However, the respondents expressed concern regarding SITA support since *"...they [SITA] also want to provide cloud services to government, but for some reason it takes a long time to make this happen"*(Interviewee G).

A few of respondents did mention certain concerns regarding international regulations that might impact on the readiness for cloud computing in the Western Cape: *"...unfortunately, laws apply to certain countries; and I think there should be international laws that all the countries should be having the same conversation about cloud. So, the standard should be the same; and the laws that apply to clouds and service providers should be the same across the board"* (Interviewee E).

As the *sustainability issues* are generally linked to the concept of "green computing", the interviewees and the focus group agree that these issues are equally important to the

cloud computing users and service providers. However, the respondents largely limited their discussions to how cloud computing enables energy-efficiency. For example, Interviewee A stated, *"...when consolidating a lot of different applications onto a single-cloud platform, a reduction of services is likely, and the power consumption of it"* while a member of the focus group cautioned *"...I think we have an energy-scarce country; it (is) quite important to look where we can spare energy"*. From the supply angle, one participant (Interviewee D) pointed out, that *"...if you need to think greener, definitely use manufacturers who have a green policy, and who will buy back their service and refurbish it, or re-use the components in the technology"*.

Emerging readiness indicators: Attitudes towards cloud computing

Attitude generally refers to a mind-set or tendency to act in a particular way, which is usually caused by an individual's experience or temperament or both (e.g. Pickens, 1998). As a consequence, it reflects the state of readiness for action of individuals, which is based on their experiences and other influences. This explains that participants with different positions, work experiences, and personalities hold different views on cloud computing readiness in this particular provincial government in South Africa.

Overall, the participants in both senior and middle-level management positions showed a positive attitude towards cloud-computing adoption in government services: *"There is definitely a desire to begin to adopt cloud, because the benefits that cloud computing brings"*. Another participant (Interviewee B) added *"...the fact that we can introduce new features quickly, and we can be more agile"*. However, there are some different opinions amongst employees towards cloud computing adoption. Their perceptions of cloud computing services were expressed as *"not very trustworthy"* (Interviewee G), especially when considering the issues, such as security and legislation. They feel that *"it is not secure to put your emails and information with somebody else"* (Interviewee D) and *"...it needs a cautious approach that people have to do research on... so that is the approach at the present time"* (Interviewee C). This suggest that the cloud computing concept still remains a peripheral possibility to organisations and even some IT professionals (Lin & Chen, 2013). As, *"...people are just not sure about how to handle it"* (Interviewee E), it is important for the public organisations to attain the employees buy-in by spreading awareness on benefits and possible treats of introducing cloud computing.

Suitability of the cloud computing deployment models

The analysis of the interviews also showed that the respondents were concerned about possible CC deployment models. As already cited earlier, the security concerns prompted the respondents to favour the private CC option. However, evident shortage of skills among the government employees makes this option difficult to implement. In addition, the served population (e.g. citizens, businesses or education) will have limited access to government's private cloud. Hence, the findings suggest that the combination of the public and private clouds (hybrid cloud) will better serve the purpose of the service delivery.

While the private cloud model ensures security of sensitive data and high quality of service, the negative side of this deployment model requires high IT infrastructure investment as well as high cost of managing and maintaining that infrastructure. On the other hand, the public cloud model minimises the resource's wastage and the IT infrastructure cost but also has inferior protection of sensitive data and offers lower quality of service. The hybrid cloud deployment model offers better data protection than the public cloud but is less cost efficient than public cloud (e.g. Shoshatari, 2013). The community cloud computing model was deemed by the interviewees as less suitable for government-based service delivery.

CONCLUSION

This study found that the respondents identified as relevant all cloud computer readiness indicators elicited by the literature relevant but they also highlighted some other factors such as political influence or the employees' attitudes towards adoption of new technology, linked to the organisational culture. Although the attitude towards adoption of cloud computing was positive, it seems that the organisational culture can cause some worries.

Regarding the infrastructure readiness, there are some concerns regarding electricity supply in the province but, more so, worries regarding the current broadband connections. However, the current WCG broadband initiative has potential to significantly improve the broadband connectivity, thus in that sense, make the Province ready for the cloud computing introduction.

Organisational readiness of WCG for the introduction of cloud computing at the strategic level is characterised by absence of clear strategy or that strategy is not clearly communicated to the employees. It is also revealed that there is the highest leadership support but some levels of management do still not sufficiently understand the advantages

of new technology. The skills shortage is a rather worrying factor as well as current insufficient understanding regarding management of possible vendors and signing the service level agreements with them.

In regard to Operational business readiness, it is revealed that the security of data is of the highest priority. The trust in service providers is also deemed as important but that trust is yet to be developed during interaction with future service providers. Although deemed very important, there is still work to be done on exploring compatibility and interoperability of potential providers of cloud computing services. The cost performance is seen by the respondents as one of the most important factors when considering introduction of cloud computing but there is still insufficient understanding about capital and operational expenditures regarding different types of cloud computing.

Environmental readiness of the WCG for introducing cloud computing is characterised by the belief that the cloud computing regulations belong to the national domain, through the State IT Agency. The respondents were not aware of their responsibilities in that regard. Environmental sustainability also was deemed by the respondents as important issue but the focus was mainly on the energy-efficiency and, to some extent, to the supply of “green” technology. Other components of “green computing”, such as disposition of the used equipment or printing were not mentioned.

In conclusion, it can be stated that the Western Cape government is not yet entirely ready for the introduction of cloud computing based government services but there are indications in preparation of readiness requirements such as currently being addressed in the Province-wide broadband initiative.

We believe that this study can help the practitioners within the Western Cape Government to better understand what is required for non-technological readiness for introduction of cloud computing (this study excludes discussion regarding core hardware and software or platforms). We also hope that this paper can be a basis for further academic advancement of the topic.

A limitation of this study that needs to be borne in mind was the research sample. Although we believe that the sample mix is adequate, we believe that sampling from only one, but highly relevant, department may impacts on the generalizability of this study. Hence, we suggest replicating this research in other WCG departments in order to gain

more general picture on the readiness for cloud computing within this Provincial government in South Africa.

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IS UCD APPROACH APPLIED BY INDUSTRY IN BOTSWANA? CASE STUDIES ON THE APPLICATION OF PARTICIPATORY APPROACH TO NPD.

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ABSTRACT

These case studies follow up the semi-structured interviews conducted previously in this on-going study; with an aim of understanding how the user was involved in the product development process (PDP) of a selection of recently completed design projects. The assumption was the more the user was involved the better the resulting product was for the user. The case studies involved an observational study and the follow up semi-structured interviews that were run parallel to each other. These case studies were carried out on two companies from the Graphic and Advertising (GA) design industry that participated in the previous interview study. The questionnaire was derived from ISO 13407 (Human-centred design for interactive systems) and consists of 29 questions spread across five categories. The majority of the user-centred design (UCD) practices were carried out at the start of the PDP; moreover the majority of these activities were not documented. The majority of the documentation was found at "Specification of context of use" and "Evaluation of designs against user requirements: User testing" categories. Results suggest that successful use of a UCD strategy depends on an established PDP and the ability to review previous projects to identify opportunities. User involvement in a PDP has to be well organised to reap the full benefits.

Keywords: *User-centred design (UCD), Product development process (PDP), ISO 13407, Botswana, Client, Graphic, Advertising.*

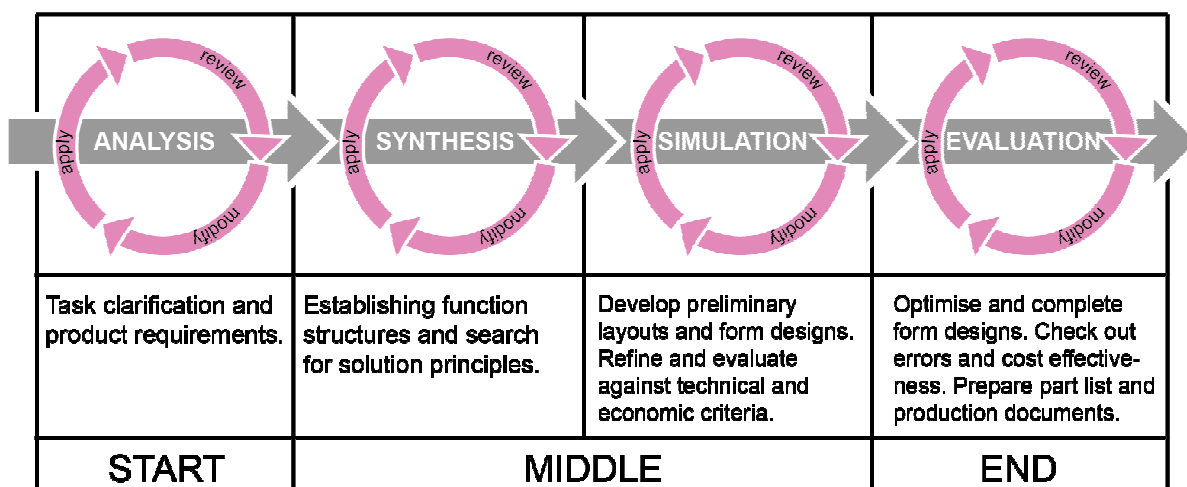
INTRODUCTION

Any project that utilises the user in the product development process (PDP) aims to make an appropriate product, reduce development time and that there is market potential for the product. User-Centred Design (UCD) offers "sensitivity to aspects underlying customer / user reactions to products can have a significant impact on both the direction that the product development takes, as well as the eventual success of the final product" (Veryzer

and Borja de Mozota, 2005:132). Having a lot of contact with the consumer also means a better collaboration and the creation of new products that can truly satisfy the user requirements (Sandmeier, et al., 2010:93; Tu, et al., 2011:5). However, Redstrom (2005) argues that the movement towards the user as being problematic since it leaves no room for improvisation (non-intended use). The ability to improvise sheds light on other possibilities and can play a crucial role in new product development (NPD) and innovation.

The aim of this study was to find out to what extent companies are adopting UCD approaches on a recently completed project. Two companies from the Graphic Advertising (GA) design industry participated in this study. The authors intend to inform readers on the application of a participatory approach to data collection and the PDP. Since, a UCD strategy is always built on top of a sound PDP, this investigation also looked at the effectiveness of the PDP within the participating companies. An adaptation of the basic design model by Roozenburg (2008) is used in this study as a PDP to provide a simple and common model for all participating companies, see Figure 75. Roozenburg (2008) points out that “someone who claims to have solved a design problem must have gone through the design cycle at least once.” For this study, participants were already familiar with the PDP from previous studies; therefore in a better position to focus on the UCD activities executed. However, the use of the phrase “user” was still alien to the participants despite participating in the past two studies (survey and semi-structured interviews) where the phrase was used extensively.

Figure 75: Product development process, derived from the basic design cycle.



This study follows a grounded theory approach, as the nature of the data being sought was heavily dependent on the findings from the previous studies (survey and the semi-

structured interviews). At the same time, the study also followed a deductive research approach where the researcher sought to find the meaning from the data collected. It was anticipated that data from this study would verify some of the data collected from previous studies and enable an investigation of what is actually done by the companies during a project.

Data from the survey carried out previously on 48 companies show a slight majority (56%) of the participants reporting going beyond the purchaser (client / customer) to get in touch with the end-user. Reasons given for getting in touch with the end user were to obtain user-needs and educating the end-user. However, participants that did not go looking for the end-user pointed to the customer being the same person as the user, while others thought the customer / client and the industry standards provided sufficient information for NPD. Thus, in these cases the client / customer was used as proxy to the user. The client or customer can be considered the person purchasing a product while the user is the person that uses the product; moreover the client / customer and the user can be the same person.

METHODS

Procedure

The case studies involved an observational study (project documentation inspection) and follow-up semi-structured interview for the undocumented UCD practices. Observational study was performed on the documentation of the PDP and the application of UCD practices from a recently completed project. The objective of the follow-up semi-structured interview was to find answers to UCD practices that were not documented or performed at all. Furthermore, case studies attempted to link the UCD activities to different stages of the PDP and the level of PDP documentation.

Moultrie et al (2006:187) refers to observations as “process audits” used to gather the evidence of the existence and the robustness of a PDP in the participating companies. During an observational study Murphy (2001) describes activities of the researcher as “watches, listens and records what happens in everyday interactions, involving themselves to a greater context of on-going activities.” However, the researcher has to make sure data is collected in a similar manner across participating companies for the study to be valid. Moultrie et al (2006) further explains that, semi-structured interviews were used to inform

the content and the structure of the audit; including errors of omission, commission and organisation of the information.

The PDP and the order, in which UCD activities were done during this particular project, were expected to show where the design team spent most of its efforts on the project. The researchers tried to standardise the manner in which data was collected for the observational and semi-structured interviews to allow comparison between responses from both methods. The failure by participants to prepare for the observational study part of the case study; prompted the researchers to conduct both observational and semi-structured interview studies at the same time.

Observational Study

The observational study was also conducted to make a connection between what participants had mentioned in prior studies (during the survey and semi-structured interviews) and what is actually being practised in the participating companies. The documentation review was expected to present unbiased information and reveal a realistic picture of how the project was conducted. Since previous studies had shown little to no documentation of the PDP; therefore, investigating the most recent project made it easier for the participant to remember how UCD practices were applied to the PDP.

Time and resource constraints did not allow the researcher to observe a live application of UCD practices in a PDP as initially planned. This would have revealed much more reliable data and rendered the follow-up semi-structured interviews unnecessary.

Semi-structured Interview

Semi-structured interviews targeted the remaining unanswered questions from the observational study. The researchers interviewed a member of the NPD team involved in the projects being investigated, preferably the project leader. Participants were asked whether they performed UCD practices missing from the observational study. Previous studies have shown lack of process documentation, thus the researcher anticipated the lack of documentation of the PDP and would be missing or not documented.

Participant selection

This study has been carried out on two selected companies that had previously contributed to this research, in earlier studies. The intent was to select a Graphic Design inclined company (PV) and an Advertising Design inclined company (AD), from the sample

of companies already identified in the Graphic Advertising (GA) design industry. Therefore, the criteria used to select two participating companies from each industry were;

- The level of sophistication of PDP organisation.
- Presence of UCD activities and/or making custom products.
- Employment of designers or a potential need for designers.
- More than two products being developed at the same time.
- Interest in the study.

Furthermore, the companies selected had to be a reasonable (average) representative of the majority of the companies within each industry. Since these are case studies, the sample is not expected to represent the whole industry, but rather the specific projects under investigation. Data collected can only provide a window onto how participating companies apply UCD practices to PDP.

Questionnaire

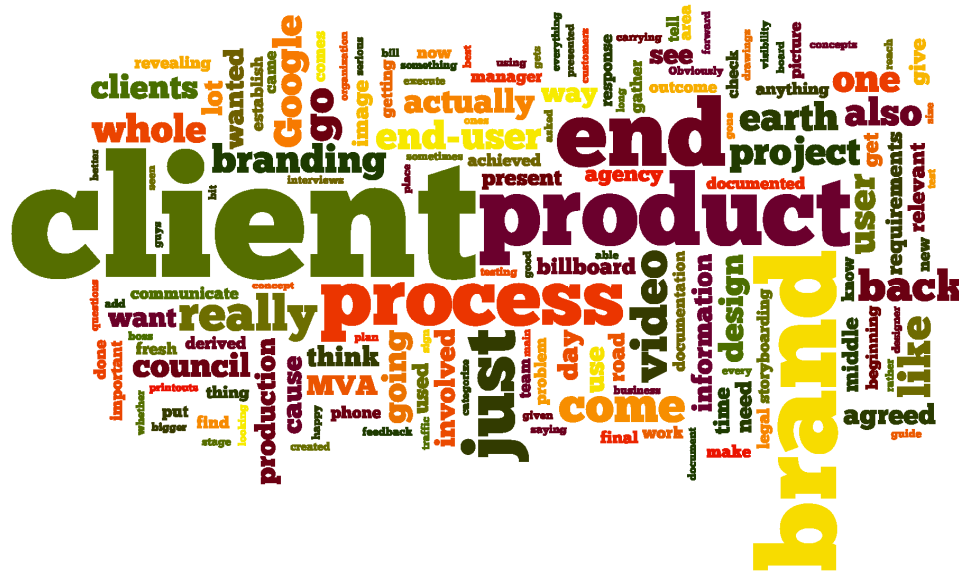
The same questionnaire was used for both the observational study and the semi-structured interview to allow data from both companies and different data collection methods to be compared. The modified basic design model was included in the questionnaire to enable the researcher to find out at which stage of the PDP each of the UCD activities was done. The participants were already familiar with the basic design model from previous studies; therefore they may have been in a better position to focus on the UCD practices executed during the PDP.

The questionnaire was primarily derived from ISO 13407 (human-centred design for interactive systems). The use of ISO standards provided a tried and tested international benchmark to investigate UCD activities in the targeted companies. ISO13407, (1999:8), states that "Evaluation is an essential step in human-centred design and should take place at all stages in the system lifecycle." UCD activities provided by the ISO standard were converted into 29 questions. Additionally, the questionnaire sought to reveal the PDP stages where UCD activities were carried-out and whether they were documented.

ANALYSIS

Data analysis began with transcription of the interviews; Figure 76, is a word map showing a snapshot of the transcripts from the case studies. These are words that were mentioned the most in both case studies (AD and VP).

Figure 76: GA case study word map.



For these case studies the word map shows, 'client', 'brand', 'product', 'process', can be considered the most frequently mentioned words. Since data collection involved two companies it made sense to transcribe all interviews verbatim, except repeated statements, examples, icebreakers etc. The transcribed data was then uploaded into ©Nvivo (qualitative research software) for analysis.

Post processing

Questions were interpreted as nodes in ©Nvivo and then grouped into categories already established in the questionnaire. The intent was to analyse responses to the nodes within each of the five categories and then collate observations that were representative of each. Thus the categories;

- i. Planning the human-centred process: six questions.
- j. Specification of the context of use: five questions.
- k. Specification of the use and organizational requirements: seven questions.
- l. Evaluation of designs against user requirements: four questions.
- m. Evaluation of designs against user requirements: user testing: seven questions.

RESULTS

Study Categories

At first glance, the comparison between AD and VP show more differences than similarities in how these companies applied UCD activities to the PDP. This is clearly visible across all categories. Part of the difference between the two case studies can be attributed to differences in the nature of projects under investigation.

Planning the human-centred process

The two case studies from the GA industry had different influences on the planning of UCD activities. The VP project (Roadside billboard) was mainly influenced by the context (use of Google Earth), industry and municipal regulations; while the AD project (Brand revealing video) was primarily influenced by the brand manager for the company.

Both companies failed to plan the UCD practices at the beginning of the PDP. AD failed to document activities under this category, while VP documented over half of the activities. However, AD was able to apply most of the user-centred activities across the PDP (start, middle and end) compared to VP that only managed to apply one user-centred activity across the PDP. AD met with a lot of stakeholders and this included periodically obtaining user-feedback and an agency that created the logo being revealed. VP mainly involved the client at the beginning and at the end of the project.

Specification of the context of use

Both companies carried out the majority of UCD activities in all stages of the PDP. Moreover, information necessary to understand the context of use was obtained from the client, but the procedure was not documented.

Again AD failed to document all UCD activities within this category, while VP documented more than half of the activities. In addition to involving the client, VP followed the legal requirements and contextual data (Google Earth). However, AD used more stakeholders to better understand the context of use.

Specification of the use and organizational requirements

AD failed to produce the specification of use and organisational requirements and VP only managed to gather the contextual specifications from the client at the beginning of the project. AD was fully guided by the client and the user; while VP guided and educated the user on the possibilities, and then allowed them to make decisions.

In both companies, clients / users helped make 'go or no-go' decisions at critical stages of the project. VP did most of the UCD practices mentioned in this category, while AD failed to do the majority of them. Moreover, VP documented the majority of the UCD practices, but AD failed to document the few activities completed.

Evaluation of designs against user requirements

AD only performed half of the UCD activities in this category, while VP carried-out all activities under this category. However, for AD, UCD activities that were carried-out throughout the PDP; while for VP, UCD practices were only performed on a single stage of the PDP.

NPD teams from both companies evaluated the product prior to involving users in the evaluation process. Moreover, the user was used by both companies to evaluate the final product. User and organisational requirements were not documented in both case studies and that left the client and / or user as the only means to product evaluation.

Evaluation of designs against user requirements: User Testing

The VP case study points to minimal user testing, while AD heavily involved client and user testing throughout the PDP. Almost all activities done by VP were documented, but the design team only managed to apply one activity throughout the three stages of the PDP.

The final evaluation for VP's ultimate product was much more organised by confirming adherence to regulations, compared to AD's final product where it was more like an up or down decision without using any benchmark for judging. Both companies believed the final product was a success, since it was what the client wanted.

Number of coding references: Top ten UCD activities in GA industry.

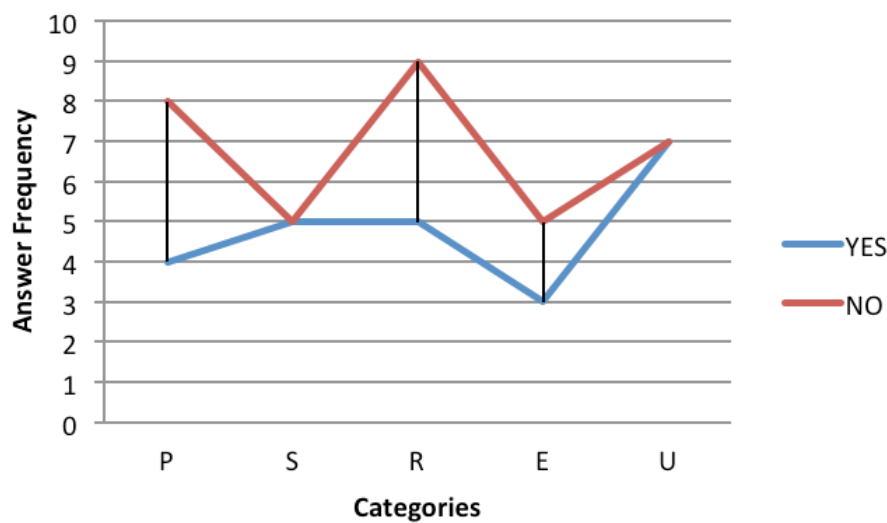
The top 10 UCD activities were generated through ©Nvivo for both AD and VP. Table 16, shows categories 'E' and 'U' as the least important to the GA industry; the comparison between the two shows no common top 10 UCD practices in these categories. Clearly, the table further shows that the most common UCD practices were in 'Planning the human-centred process' category; thus making this category the most important.

Table 16: Top ten common activities in the GA industry, and the relevant categories.

Category		Activities
Planning the human-centered process	P	The individuals and organization(s) responsible for UCD activities and the range of skills and viewpoints they provide.
		List human-centred activities carried out during the study.
		What are the procedures followed for integrating human-centered activities with other development activities.
		Are there procedures for establishing feedback and communication on UCD practices as they affect other design activities and methods for recording these activities?
Specification of the context of use (ISO 9241-11)	S	How do you gather specifications on the range of intended users, tasks, equipment and environment?
		What are the sources from which the context of use is derived?
Specification of the use and organizational requirements	R	What were the CRITERIA against which the design can be tested?
		What is the range and relevance of users and other personnel in the design?
Evaluation of designs against user requirements	E	
Evaluation of designs against user requirements: User testing	U	

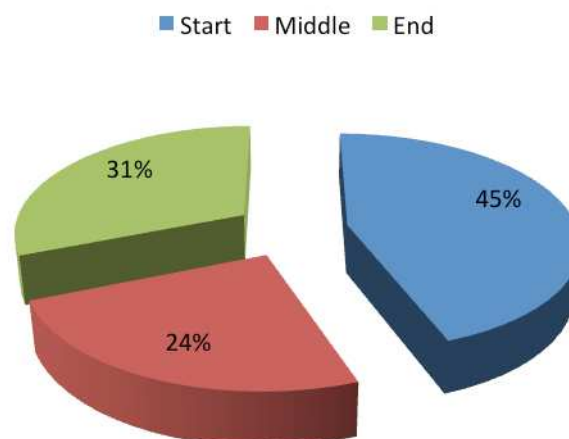
Documentation

The documentation data of the GA industry reveal the majority (59%) of the UCD practices in this project were not documented. The documentation by the two participating companies (AD and VP) had an inverse relationship with VP doing the majority of documenting. Figure 77, shows the extent to which each category is documented in the GA industry. The most documentation was done in the categories 'Specification of the context of use' (S) and 'Evaluation of designs against user requirements: user testing' (U), where the YES-documentation and NO-documentation are at par.

Figure 77: GA Documentation per category.

UCD activities and PDP stages

Figure 78, shows the three stages of the PDP (Start, Middle and End) and the relative amount of UCD practices applied at each of the stages. Results show that the majority of UCD practices in the GA industry were performed at the 'Start' stage of the PDP; followed by the 'End' stage and lastly the 'Middle' stage.

Figure 78: PDP stages and associated UCD activities.

DISCUSSION AND CONCLUSION

The satisfying nature of the PDP makes it harder to effectively plan the UCD process, NPD team learn more about the problem from the process of solving it. User involvement

observed in these case studies can best be described as occurring naturally, random and less organised. Furthermore, UCD practices were not applied on top of a well-structured PDP. Both case studies show the most effort at the 'Start', followed 'End' and lastly 'Middle' stage. The middle stage will have to have more UCD practices than the end stage in order to avoid costly mistakes at the end stage.

There has to be a balance on the involvement of the user in the PDP; documentation provides a point of reference to user wants / needs and prevents unnecessary user involvement. Documentation further helps the client better appreciate the design profession and an effort put into a project by the NPD team. In this study, the majority of the UCD practices were not documented, thus the majority of data came from the follow-up interviews. Making a written agreement with the user helps guide the design team and ensures the user is consulted only when it is absolutely necessary. Furthermore, the failure to document user expectations might have left the design teams too reliant on client feedback without their own independent evaluation mechanism. This is reflected in Table 1, where the top ten common UCD practices from both companies did not come from "evaluating against the user requirements" and "user testing" categories. UCD practices are not about unlimited user involvement in the PDP, but rather efficiency and professionalism in gathering relevant information.

It would have been ideal to capture the data in real time as it would have reduced the need to discuss what and how UCD practices were implemented. Also the data collected would have been more reliable as the researcher would have observed the PDP. However, this approach would have brought a lot of variables into the study; when will a project start? How long will the project last? How researcher's presence will interfere with a project?

Despite not being aware of the term UCD, it seemed like common sense to involve the client in the PDP. Participants failed to refer to the user as a "user" instead they preferred to use "customer or client"; this is despite having participated in the previous studies (survey and semi-structured interviews) where the phrase "user" was used extensively. Thus, in this instance UCD can be referred to as customer / client centred design (CCD). Customer and client seem to have been used to represent the user; however, this had no negative effect on this study as the objective was to investigate how UCD practises were applied to the projects under investigation.

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A SYMBIOTIC RELATIONSHIP BETWEEN FORM AND FUNCTION (USER VALUE)

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ABSTRACT

Design is an important medium of communication that expresses values of systems within which it functions. The designers' creations incarnate the human spirit and also demarcate physical environments and lifestyles of people and the carrier of the culture (Ning & Liang, 2006). This highlights a fact that design affects people's livelihoods and promotes social connectivity. Though many design interventions have been made, their impact on society have arguably been minimal. Additionally, most of designers base their assumptions on the notion that design empowers. Through a qualitative case study approach the paper focused on Bulinde village found in Luweero district. The essence of this paper is to discuss and contribute to the issue of design to empower, to which should be a symbiotic relationship between form and function (user value). This paper is twofold purpose; firstly to discuss user values, design and culture, and design and context as a useful point of departure for understanding their importance in design outputs intended to empower users; and secondly, to analyse how design solutions are embraced in a community, act as an inspirational springboard for the designer to develop design solutions. Uganda is the context of study for this paper where in a number of solutions that have been proffered to engender some of these products with the potential to transform and emancipate collaborating communities.

Keywords: *design and context, design and culture, social transformation, symbiotic relationships, user values*

INTRODUCTION

Design is a powerful tool, its impact and fundamental role in social transformation is potentially unlimited -it brings fresh perspectives into people's livelihoods and promotes of social connectivity. Design as a tool for empowerment cannot be properly understood without contextualizing the import of user values, for they form the core of acceptability and usability of a designed solution. Firstly, one needs to understand who the intended user is, and what the users' aspirations are so as to design a product that is in a harmonious relationship of form and function with users, as consequence of embracing the social transformative design solution .The big key challenge is one of embedding user

values into the designed solutions to effect desired change in the users' lifestyle there by enabling products to trickle down in to various social strata of the community.

Additionally, a critical factor to appreciate is that design is primarily concerned with assigning user value to products and services (Boztepe, 2002). Subsequently, design has to ensure that the objects' functions serve as extensions of human body and mind, and that they fulfil actual needs (Norman, 1988). The notion of value as meaning and meaningful difference calls for considerations not only of the physical contexts of products usage but also of how they make sense of (Csikszentmihalyi & Halton, 1981). The importance of user values in design solutions necessitates adequate interrogation of these issues.

USER VALUES

User values sometimes known as appearance attributes provide the user with an overall impression of the product (Blijlevens et al., 2009). Value as creator of meaning in user values on product is core in design process under where the notion of value as meaning and meaningful difference calls for considerations not only of the physical contexts of products usage but also of how they make sense of (Csikszentmihalyi & Halton, 1981). Values are represented by codes within a cultural set up with the ability to add new shades of connotation to every aspect of life. Codes also provide the framework of meaning that creates possibilities to interpret and understand signs (anonymous, 2012). Further, supported by Boztepe (2002) that values are socially and culturally defined, and justified standards that determine actions, preferences and attitudes including the ones towards objects.

The value of a product reflects the owner(s)' and/or buyer(s)' desire to retain or obtain a particular product. An individual's level of desire to retain or obtain a product depends on how much the product details and/or its performance agree with the value system of the specific individual (Celik & Shevket, 1999). As such, design has to make sure that the objects function as extensions of the human body and mind, and that they fulfil actual needs, whether these needs be explicit or not (Norman, 1988).

Much as value is a creator of meaning in user values, value does not reside in tangible product properties alone, or in social systems only, but in the interaction between the two (Holbrook, 1999; Graeber, 2001). Consequently value creation results from harmonious combinations between product properties and what the users and their local context bring

to such interactions (Boztepe, 2002). This can be attributed to the fact that user experiences have shifted from physical and cognitive human factors to emotional, social and cultural contexts in which products and communication takes place (Jewitt & Oyama, 2001; Heskett, 2002; Harrison, 2003).

User values (sometimes known as product appearance) constitute *functional* and *symbolic values* that are intended for causative effect on the design output. It is *functional* and *symbolic values* that are intended to reflect express and reconstruct a system of social relationships and their perceived place with the users.

Functional values of a product are defined as values that distinctly communicate attributes of the product that are utilitarian (such as those that explain its practicality or usefulness). These values should result in personality perceptions associated with product type. According to Park et al. (1986), functional design outputs are described as those that satisfy immediate and practical needs. Whereas *symbolic value* in this sense refer to perceived abstract of product properties like aesthetic qualities (Leder, Belke, Oeberst & Augustin, 2004; Hekkert, 2006). *Symbolic values* relate to the personality, social identity and the self-expression possibilities the product expresses to the users (Creusen & Schoormans, 2005). Additionally, Ravasi and Rindova (2004) argue that symbolic values of a product as the social cultural meanings associated with the product that enable users to express individual and social identity through the product's purchase and use.

Functional and *symbolic values* form the roots of any product, the meaning and interpretation given to each value varies according to user's preferences. In order to break down function and symbolic values further, Boztepe (2002) identifies four major categories of functional and symbolic value that is utility values, social significance values, emotional values and spiritual values which are critical to the appreciation of context-specific aspects of user value.

Utility value refers to the utilitarian consequences of a product; it encompasses values of convenience, and quality among others. *Social significance value* refers to the socially oriented benefits attained through ownership of and experience with the product, which include attainment of social prestige and construction and maintenance of one's identity. *Emotional value* refers to the affective benefits of a product for people who interact with it, benefits such as pleasure or fun. Desmet and Hekkert (2007) acknowledge that, for affective benefit to occur it is on three levels; the aesthetic, meaning and emotion levels - Norman (2004) ascribes emotional value primarily to psychological phenomenon. *Spiritual*

value on the other hand refers to spiritual benefits such as good luck and sacredness as enabled by a product.

Therefore, functional and symbolic values are the reasons why the product exists, they are crucial in design output towards user empowerment because they provide a platform on which a product communicates its perceived benefits or qualities to the users.

CULTURE AND DESIGN

Design is about developing meaningful products (artifact)-better for people in terms of function, performance or aesthetics. The meanings of an artifact manifest themselves through a set of contexts into which a community of its stakeholders place them deliberately (Krippendorff & Butter, 2007). Design outputs are designed to incorporate social interactions with communities to constitute cultural values and characteristics of a traditional society to create harmonious association with that social setting. As such social activities inherently embodies in a cultural context (Huang & Deng, 2008).

To further understanding of culture and design, Yang, Ho and Hui (2011) suppose that culture is a foundation on which designers unleash their creativity and design that lacks culture is just like a tree without roots. Culture is an important ingredient to design process where the symbolic and functional values operate. Further, from a design perspective culture is seen as an environment where design brings out inherent social activities embodied in a cultural context communicating particular values to the users.

Culture generates diversity that is naturally revealed in all human action such as products, people and design. Subsequently, products are seen as one of the mediums through which culture manifests an embodied dependence on the user's cultural background (Brett, Tinsley, Janssens, Barsness & Lytle, 1997; Press & Cooper, 2003). According to Diehl and Christiaans (2007), users focus on aspects concerned with effectiveness, efficiency or satisfaction when using such products.

In this manner, cultural beliefs and social practices create and reinforce frames of meaning that determine ways of relating to a product in a context that those local communities would better understand their meaning. Culture is a set of codes shared by people to guide individuals' behaviours or to achieve group acceptance (Schadewitz, 2009; Yang et al., 2011). Fiske (1982) views codes as compositions of signs and common practice. Additionally, Eco (1976) suggests that communication functions as the transmission of

messages on the basis of codes or system of signification. Yet Schmidt (cited in Burdek, 2005), suppose communication as a construction but not transmitted (as in telecommunications). Burdek believes that in every situation, socio-cultural and personal factors have a potent influence and should be taken into account during the construction process. Design therefore, is an important medium of communication that expresses values of systems within which it functions. The designers' creations incarnate human spirit and also mark out physical environment of people and lifestyle of people is the carrier of the culture (Ning & Liang, 2006).

DESIGN AND CONTEXT

Design is a social undertaking, studying social life of groups of people as part of the design endeavours. The sustainability of design depends upon its mediation and qualification by the users as a design solution to the community's needs or wants. Harmonising design concepts with users requires contextualised thinking processes to tailor the creative blueprint within the targeted audience.

To have a profound understanding of design and context there is a need to comprehend on "context" as a construct. Though context is a multifaceted construct (Edmonds, 1983; Sonnenwald, 1999; Räsänen & Nyce, 2008; Wan, 2009), it provides source of meaning for human information behaviour (Dervin, 1997). Clark and Carlson (1981) view context as that information available to a particular person on a particular occasion, for use in the meaning-ascription process. Further, Holy (1999) associates the notion of context as a combination of a phenomenon and an environment within which it is embedded.

Räsänen and Nyce (2008), argue that context should be used as a frame, an environment, a background, a perspective or a stage that surrounds a phenomenon or an event that provides resources for its appropriate and meaningful interpretation. Consequently, the point of view on context advanced by Räsänen and Nyce (ibid) generate two key issues that inform design – the one being the structure; and the other being interpretation.

In this regard, structure is reviewed as the manner in which various parts of something connect – the way they are arranged or organised. The arrangement implies organising something into a system or pattern; or the relationship or organization of the component parts of a work of art. Subsequently, structure lays the foundation required in the creation of synergy between form and function during the design process.

On the other hand, interpretation is a particular way of explaining or understanding something; it provides an explanation of the meaning of something. Aligned to this explanation of interpretation above, shows how shared relationship of interpretation and meaning emerges. Further, it is through interpretation that we come to know the meanings (Kernan & Kleine, 1991; Stall, 2003). In a design process a significant degree of interpretation of various elements is required by designers to evolve user values that are in synch with desired design outputs expected by the users.

As a result, understanding structure and interpretation as ingredients of context is imperative to enable the choice of entities, the choice of properties, and the notion used for binding the more crucial for systems development (Wan, 2009). Systems development in this discussion is a set of activities that designers carry out to develop and implement an information system of a designed output. The designed output bridges the communication gap between the designers and users and bringing them closer to each other.

During the design process, the user's way of life informs the weaving and threading of user values. In so doing, the constructed 'context' corresponds to what Clarkson and Carlson (1981) call "common ground". To this end, the notion of common ground is technically the mutual knowledge, beliefs, and assumptions shared by the speaker and the addressees—these are the most favourable principle on which design relies (Clark & Carlson, 1981; Clark & Marshall, 1981). To further this notion, context in the design process is seen to be the common ground that holds between the product (speaker) and the user (addressee). And more specifically, those aspects of common ground such as user values are the pertinent ones that the user needs to appreciate in order to understand what and how the product communicates.

DISCUSSION

Design thinking that is intended to better humanity looks for answers in the environment in which communities live. To this end, designers focus their attention on visualizing user-centred outputs that are in harmonious relationship with the users. Underpinning this process, user values play a crucial role where in new paces are initiated for questioning of the status quo with an appreciation of the great potential for change. In this regards, the environment can be viewed as a dynamic one in which designs are created in various contexts and scrutinized by users to inspire further exploration of product values. Through use of a qualitative methodology the study engaged a community in Bulinde -Luweero

district in Uganda to gain insights into how design outputs have transformed society. Using a case study approach, selected a hoe (*enkuumbi*) and paraffin lamp (*tadooba*) to analyse and discuss the symbiotic relationship between the design output (hoe & Paraffin lamp) and how their user values have impacted the community.

In Uganda the majority of design outputs, are proffered in the name of social transformation, yet their impact on the targeted communities have been minimal. Notwithstanding, there are those design output which have inspired tremendous social change in various communities across the country. An exemplar of a successful design output is the hoe known as *enkuumbi* (see Figure 1).



Figure 1: hoe (*Enkuumbi*)

A hoe might look like a simple implement but this humble design output has empowered countless local people for many years, embraced and incorporated into people's livelihood through agriculture. Deeply embedded in Ganda culture (one of several ethnic groups in Uganda), a hoe has been deeply assimilated in their way of life to the extent of the emergence of sayings and proverbs about this design artifact. Sayings such as "*omukazi agumira ku nkuumbi*" meaning a woman stands by the hoe, shows the context in which this design output is deeply engrained in the socio-cultural fabric of the Baganda. In Bulinde many farmers appreciated how this hoe, the design output has transformed their livelihood. 'Enkuumbi terimba' meaning that the hoe doesn't lie, this saying from the respondents indicated that hoes have managed to improve their wellbeing and it is vividly seen through having a well balanced diet, earning from their sales, to be able to cater for their families.

What we learn from this case study is that the functional and symbolic values of the hoe are highly contextualized in the design process, with the concomitant evolution of well-

calibrated user values to suit the socio-cultural milieu of the Ganda community whose economy is agro-based. Understanding of the user's social and cultural environment enables the designed output to settle in well with users. Another good example of affordable design solution that enables the user to live in harmony and aligns with their lifestyles is the paraffin lamp such as that shown in Figure 2 below.



Figure 2: Paraffin lamp (*tadooba*)

Many respondents from Bulinde indicated that the paraffin lamp have managed to enable them live a normal life. It has enabled them to reduce on eating supper at 6:00 pm before the sun sets. These lamps have managed to extend the night hours to be able do things that were not possible before the introduction of this design output. To the community the paraffin lamp is an affordable product that any member of the community can afford it.

Bulinde might be a case under study but these life improving design outputs are deeply engrained in so many communities that they are part of socio-cultural fibre of the community. The above mentioned design solutions and many more are good examples to shows how they have created a design conversation. This creative conversation process is affected by highly contextualised socio-cultural knowledge that designers should research on to come up with a user- centred design output. A process that provides information that is relevant to the task at hand and tuned to the background knowledge of the user (Fischer, 2001).

Through a process of 'dialogue' between production and consumption, mediated by other institutional forces attains meaning construction (Ravasi & Rindova, 2004; Burdek, 2005). This highlights the importance of meaning creation. Meaning creation is pertinent to user

values generation that they provide the platform on which designs spring from to infuse values in a design output. Meaning creation is an inevitable consequence of human interaction with nature and culture (Hein,1998) in that meaning making help people understand and define their life through empowering people to make sense of where they are today, and where they were yesterday (Gould, 2012). Meaning can only be achieved through understanding of signs and symbols and how they relate to the users. To effectively design outputs that empower people, there is a need to comprehend how meaning is infused in the design process such that the design output is synchronized with the users' aspirations and expectations.

In conclusion, Bulinde used as a case study used to understand how the hoe and paraffin lamp have transformed the people's livelihoods. The two design outputs indicate that design empowers, they provide a representative sample of many design outputs that continue to transform lives of many communities. As we move further into the Information Age, knowledge is critical in the design process towards development of design outputs that are able to empower communities. It is therefore crucial to design common knowledge configurations to be able to trace the right knowledge and make it available for making better decisions (Ouertani, Baïna, Gzara and Morel, 2011). This process should be based on the peculiar socio-cultural dynamics familiar to a community; the context in which they are thought out should be grounded in local knowledge. This leads to an interpretation of meaning that is about perception or interpretation of objects, and that effortlessly arises from interaction of individual, object and context (Kernan & Kleine, 1991). Design is an important medium that significantly impacts upon people's livelihoods - it is thus of the utmost importance that designers take cognizance of how to calibrate user values to be in a symbiotic relationship between form and function in the design outputs so as to contribute towards social emancipation.

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IMPROVING THE UTILISATION OF SMART TECHNOLOGY IN SOUTH AFRICAN HOMES

L.Cilliers and S. Gaba

ABSTRACT

Smart homes make use of technology to automate many of the tasks that are usually performed manually by the inhabitant. These smart technologies collect and analyse data in order to make inferences about the habits and preferences of the inhabitant. This information is then used in one of three areas within the house: security, energy consumption and management and lifestyle support. The aim of the article is to investigate the barriers for the utilisation of smart technologies in South African homes. A thorough literature review was performed of peer reviewed articles in order to identify possible barriers for the utilisation of smart homes around the world. Furthermore, the Technology Organization Environmental framework was used in order to group the barriers according to the various factors, and from this process critical success factors were formulated for consideration. There are five critical success factors that were identified in order to increase the utilization of smart technologies in South African homes. These include the provision of legislation to standardise smart home infrastructure in the country and regulate privacy concerns; involving the end-user in the designing of smart homes; increase the availability of smart technologies in South Africa, and decrease the costs associated with smart homes.

Keywords: *smart home, smart technology, Internet of Things, utilisation, critical success factors*

INTRODUCTION

Humans interact with the environment around them and can act, react or adjust accordingly. If the environment was able to reciprocate this behavior and respond in turn, various tasks that humans now perform manually, could be automated (De Silva, Morikawa, & Petra, 2012:1313). The inclusion of Information and Communication Technologies (ICT) in the home environment has enabled the emergence of 'smart homes' (Noury & Hadidi, 2012: 1216). Balta-Ozkan, Davidson, Bicket, and Whitmarsh (2013a: 364) found that the use of smart technologies is gradually infiltrating the urban home. A smart home is characterized by a homelike environment that possesses ambient intelligence and automatic control that allows it to respond to the behavior of the residents and improve their quality of life (De Silva, Morikawa, & Petra, 2012: 1313).

DiCarlo and Cove (2010) states that smart home technology in a house consists of monitoring systems and special wiring to allow the inhabitants to program, control and operate a variety of appliances and other household features. Thus the smart home has been computerized with a variety of sensors that can gather different types of data about the residents or utility consumption of the home. The collected data is analyzed and the technology responds by controlling the mechanisms built into the home (De Silva, Morikawa, & Petra, 2012: 1314). Examples of such behavior range from simple actions such as switching on the lights when someone enters the room, to more complex situations where the fall of an elderly person is detected and reported to emergency personnel (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013a: 363).

Despite the technology being available to make homes smarter, the utilization of smart homes has not increased (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013b: 365). There are many examples of smart home projects around the world, but these have been mostly prototypes. In addition, projects focus on a top down approach where citizen input is minimal (Washburn & Sindhu, 2010: 15). Frequently there is a lack of interest from the public, especially in developed countries, to make use of smart technology, as they do not see the advantage of appliances communicating with each other. Furthermore, residents become frustrated if the house has to be rebooted in case of system failure (Schaffers, 2010: 438). According to the industry stakeholders, this lack of interest from the general public is because they are uneducated and unaware of the benefits that smart houses can provide the resident with. The solution has been to install the smart technology in pilot projects regardless of whether end-users want it or not. The assumption on the part of the industry is that the end-users will 'grow into' the technology (Lindsay, 2010).

The aim of this article is to investigate how the utilization of smart technologies in South African homes can be increased. In order to accomplish this goal, a thorough literature search was conducted in the most popular academic databases: Pubmed, EBSCO, ProQuest and JSTOR. The purpose of the search was to identify relevant studies of high quality that documented the barriers to the implementation of smart homes in developed and developing countries. The different types of smart technology, benefits of smart technologies in homes, and examples of existing smart home projects are also discussed.

The rest of the article is structured as follows: The next section provides an overview of smart homes, including the different types of smart homes and services that are offered in a smart home. This is followed by the barriers that have been reported for the utilization of

smart technologies in homes in developed and developing countries, while the following section will provide examples of various types of smart home projects around the world. The barriers identified are integrated with the Technology Organization Environmental (TOE) framework before the last section will identify and discuss the critical success factors (CSF) that must be considered if the utilization of smart homes in South Africa is to increase.

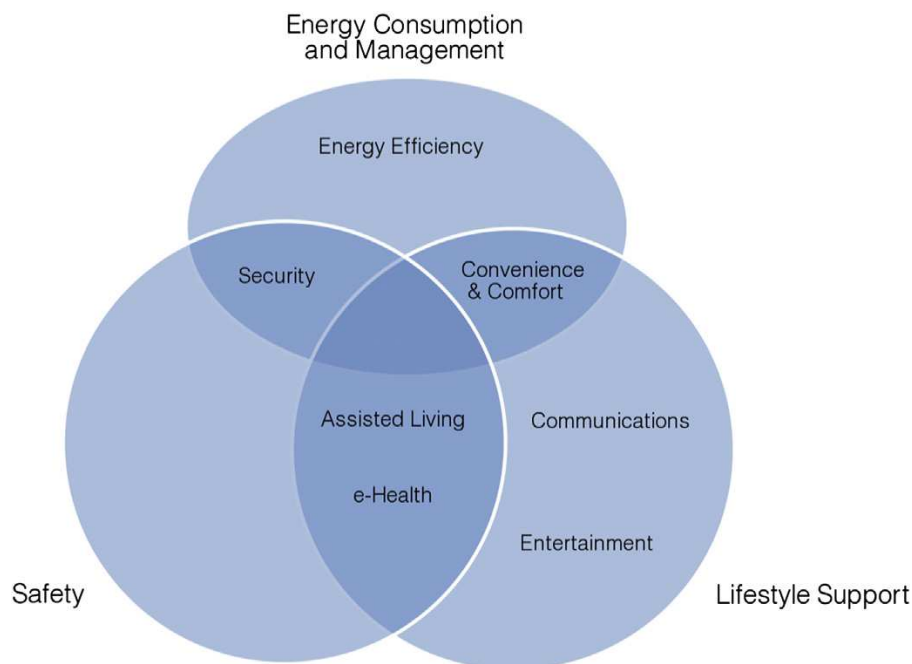
APPLICATIONS OF SMART HOMES

Jiang, Yang and Liu (2004: 1) define a smart home as follow:

“A dwelling incorporating a communication communications network that connects the key electrical appliances and services and allows them to be remotely controlled, monitored or accessed”. According to Balta-Ozkan, Davisdon, Bicket, and Whitmarsh (2013b:361), there are four key aspects that characterize a smart home. These include a communication network that enables different devise to communicate with each other; intelligent controls to manage the system, and sensors to collect information and smart features which respond to information from the sensors, user instruction or system provider (Scott, 2007: 15).

At present, there are three types of application categories that can be found in a smart home (see Figure 1). These include the security of the home, lifestyle support and energy consumption and management (Balta-Ozkan, Davisdon, Bicket, & Whitmarsh, 2013b: 362).

Figure 1: Three types of application categories in a smart home (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013b: 362)



Security in the smart home entails obtaining and analyzing data from the environment which can be used to protect the home and the residents from inside threats, e.g. fires or outside security threats such as burglaries (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013a: 364; De Silva, Morikawa, & Petra, 2012: 1319). This means that smart technology can be used to increase security inside and outside the home. Examples of smart technologies used to increase security services in the home include monitoring movement around the house, alerting residents of open doors and windows, and programming random room lighting patterns to deter thieves from a temporarily unoccupied property (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013a: 366).

Lifestyle support consists of data collection about the wellbeing of the residents of the home (Chan, Esteve, Escriba, & Campo, 2008: 56). As people become older, they are unable to perform certain tasks for themselves and need constant monitoring. Smart technology can help the elderly to stay at home for as long as possible by increasing their safety and independence (De Silva, Morikawa, & Petra, 2012: 1314). Lifestyle support can be further divided according to the purpose of the technology: improving comfort, dealing with medical rehabilitation, monitoring mobility and physiological parameters, and delivering therapy through wearable biomedical sensor (Chan, Esteve, Escriba, & Campo, 2008: 57). Technologies such as bed sensors, motion sensors, kitchen safety sensors and falls and detection sensors are used to monitor the residents in their homes and relay

the information to health practitioners. Bed sensors are placed under the mattress to detect heart rate and respiration. Motion sensors are used to detect motion within the home, e.g. a motion sensor in the bathroom will detect how many times a patient visits the bathroom. Finally, the falls detection sensor is used to alert the care givers of any falls that happen in the home environment (Courtney, Demiris, Rantz, & Skubic, 2008: 197). Chan, Esteve, Escriba, and Campo (2008: 64) stated that miniature transmitters can be worn around the neck or wrist or carried in a pocket, allowing an individual to signal danger or request help by pressing a button. Smart technologies further assist the elderly to manage medication information, adherence, supply, and tracking (Armas, Berger, & Broderick, 2009: 10).

The third category, energy consumption and management, assists the home owner to conserve energy. Smart homes incorporate devices that are able to quantify and distribute energy consumption in the home contributing to the energy management systems of the house (Karnouskos, 2010: 2). This can be done either directly through automated energy saving devices, such as reducing the heat on a warm day, or indirectly by providing the home owner with centralized access to data about their real-time energy usage (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013a: 364). Many systems in the house, such as heating, air conditioning and lighting, will be automated and controlled via remote control, while electrical appliances, such as washing machines or refrigerators, can be programmed to complete tasks autonomously. In addition, remote management of energy, water and telecommunications data readings is controlled by the utility company, eliminating the process of manual readings (Chan, Esteve, Escriba, & Campo, 2008: 64). The next section will discuss the technology that makes a smart home possible.

SMART TECHNOLOGY

Smart homes rely on technology to collect, store and analyse data in order to take appropriate action. Therefore, smart technology can be defined as IT systems which are capable of informed decision making (Thomas, 2012: 1; De Silva, Morikawa, & Petra, 2012: 1313). Recent advances in technology have made this possible and will be discussed in this section.

The virtual environment consists of physical devices, called sensors, which translate what they are observing in the virtual environment. Without sensors, the virtual environment will be detached from the actual world (Ndlovu & Smith, 2011: 6). Wireless sensor networks are used as communication technology in a variety of areas and are beneficial for remote

system monitoring and equipment fault diagnostics (Gungor, Lu, & Hancke, 2010: 3559). The Internet of Things (IoT) makes it possible to connect any object in the physical and virtual environments (Dimitriou, 2012: 3). With the introduction of the IoT, objects of daily life are now able to connect to a data network (Atzori, Iera, & Morabit, 2010). Interconnectivity is achieved through the placement of a large amount of sensors in everyday objects (McConnachie, 2012). The electronic devices, which can range from radio-frequency detection to nanotechnology, collect a large amount of data that can be analysed and mined in order to provide solutions to the home owner wanting to make use of smart technology (Dimitriou, 2012: 10). It is estimated that the number of devices that will be connected to and by the Internet will be 50 billion in 2020 (Komninos, Pallot, & Schaffer, 2012: 1).

Near Field Communication (NFC) allows users to share or transfer small amounts of data using Radio Frequency Identification (RFID) transponders between different types of devices (Du, 2013: 352). According to Thangaraju (2013), NFC is a wireless communication standard that allows two devices, which are in short range of each other, to establish communication for a short period using radio frequency waves in the 13.56 MHz frequency range. Examples of NFC in the smart home include the resident making use of their smart phone to secure the home or to gain access to the house or activating the air-conditioning by simply swiping the NFC enabled phone over the unit (Du, 2013: 353).

Another technology that is enabling smart technology is cloud computing. This technology provides new ways of delivering computing resources which makes use of recent advances in ICT such as high-speed networks, virtualisation, and standardisation of platforms and applications (Komninos, Pallot, & Schaffer, 2012: 2). Advantages of cloud computing include flexibility of the system and the ability to maintain operations in times of austerity as a reduction in the fixed cost of Information Technology (IT) is achieved (Gimenez et al., 2013). Cloud computing may be used in instances of notifications or to monitor home appliances via the World Wide Web (Garcia, Chan, Commedador, Cornell, Celestial, & Marcolesia, 2013: 45).

Bluetooth provides wireless connectivity which is easy to utilise as it does not require line of sight to work correctly. Portable electronic devices are able to connect and communicate wirelessly making use of ad hoc networks, while the devices do not consume a lot of power and are inexpensive to operate (Haartsen, 1998: 45). Bluetooth

can be used, for example, to control the lighting in a home making use of a smart phone (Du, 2013: 353).

However, these technology are not without challenges. Technical, legal, ethical and social challenges must be addressed in the future for these technologies to reach their full potential. Technical challenges include the interaction between the technology and environment. While the technology must be flexible enough to adapt to the environment, the user does not want to be aware of or be inconvenienced by the technology. The technology and environment must interact seamlessly and in a meaningful way (Dimitriou, 2012: 16). As large amounts of data is collected, the privacy of the user must also be protected (Santucci, 2009). Users should have the power to control the data that is collected about them, but governance in this area is still lacking. Models and frameworks guiding the legal and ethical aspects of privacy in this field are vital to guarantee proper trust, identity and liability management. The next section will elaborate on the barriers that were found in literature that limit the utilisation of smart technology in homes in developing and developed countries.

BARRIERS TO UTILISATION OF SMART HOMES

With any new technology there are potential barriers that can be expected. According to Low, Chen, and Wu (2011: 1006), a barrier is defined as a substance or obstacle which prevents a human being from attaining a particular goal. The development of smart homes is subject to governance issues such as policy and regulation of the industry, technology and commercial frameworks and investment conditions (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013b: 367). These barriers will be discussed in more detail below.

Technology

Smart technologies have become cheaper and more energy efficient due to recent advances in electronics and computing (De Silva, Morikawa, & Petra, 2012: 1317). The interoperability of the various networks, sensors and other devices are still a problem (Vermesan & Friess, 2013: 25). The smart home must be able to easily assimilate new devices to the network, and the devices need to be able to communicate with one another. At present, the different networks in a smart home will depend on their own industrial and communication protocols which do not subscribe to a common standard (Chan, Esteve, Escriba, & Campo, 2008: 71; Balta-Ozkan, Davisdon, Bicket, & Whitmarsh, 2013b: 363). The high cost of Internet services and limited data transfer rates will also deter the use of

smart homes in South Africa. Internet penetration in Africa is the lowest of all the developing world regions with only 0.3% fixed broadband penetration on the continent and Internet penetration at 16.3% (Mars, 2013: 330). Telecommunication costs are considered to be very high with 14 of the 20 most expensive countries located in Africa (International Telecommunications Union, 2012). Additionally, providing the ambient intelligence that is required to make decisions for smart behaviour is still a challenging task. Advance pattern recognition is necessary to detect the behaviour of multiple residents (De Silva, Morikawa, & Petra, 2012: 1314).

There are several challenges concerning the sensors that collect information. Self-sustaining sensors will need to be developed for the IoT to reach its full potential. Self-sustaining sensors can generate their own electricity from the immediate environment making use of vibrations, light and air flow (Le Roux & Evans, 2011: 110). Sensors are also prone to radio frequency interferences, such as dust, dirt, vibrations and other conditions preventing the sensor to collect information and a portion of the sensor network to fail (Gungor, Lu, & Hancke, 2010: 3558). Sensors that collect data in smart homes will require unique Internet Protocol (IP) addresses in order to interface with the Internet. Without the deployment of IPv6, the progress of the IoT will be impeded as the auto configuration, security and management of networks will not be possible (Le Roux & Evans, 2011: 112).

The reliability of technology in smart homes is one of the major difficulties that are preventing the utilisation of smart homes to increase. In homes where the elderly are monitored or where smart technology is used for security reasons, the technology must be able to detect and signal dangerous situations (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013a: 364). Therefore, the accuracy of input data as well as the method used to decide if an alarm should be triggered must be reliable. These methods can include neural networks, predictive algorithms, decision trees and statistical or probabilistic models. The ability of smart homes to predict human behaviour correctly is limited at present, e.g. the detection of the health of the inhabitant can only be determined if they live alone (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013a: 366; Chan, Esteve, Escriba, & Campo, 2008: 71). The technology must be robust and dependable enough to be able to monitor vital signs and evaluate the inhabitant's lifestyle in a reliable manner, trigger an alarm in case of danger, and organise emergency response rapidly and effectively in case of need (Chan, Esteve, Escriba, & Campo, 2008: 72). The next section will introduce the barriers to smart home utilisation in the organisational context of the TOE.

Organisation

User satisfaction and acceptance have become an important topic in the smart home environment. The end-user, or home owner, must be included in the building, dissemination and maintenance of smart home products. If their needs in a smart home environment are not determined during the design phase of the project, user-friendly technology systems cannot be achieved. (Chan, Esteve, Escriba, & Campo, 2008: 69).

The fit between the inhabitant and smart home includes the integration and potential of the technology to evolve and remain useful. The smart home's technology and services should be well integrated into the design and lifestyle of the inhabitant (De Silva, Morikawa, & Petra, 2012: 1314). The system must also be simple enough to be managed by the inhabitant who will be interacting with it.

Poorly integrated smart home technology will add to the hassle and complexity of daily life rather than helping to reduce it. The user requires a minimum level of expertise in how to manage and troubleshoot the smart home's systems and technology (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013a: 366). Without these qualities, the lasting usefulness of the smart home for the inhabitant is undermined, and the smart home and its services risk becoming redundant or in the worst case, not being adopted at all (Balta-Ozkan, Davisdon, Bicket, & Whitmarsh, 2013a: 370).

The home owner expects a return on investment when they invest in smart technologies. However, the traditional method of proving return on investment fails to take into account the full intricacy of a smart home (Thomas, 2012). Costs that the home owner is likely to incur include the transaction costs to seek out price and consumer information about smart homes, as well as the installation cost of the technology and the high repair and maintenance costs (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013b: 369). King (2003) propagates three methods that can be used to make a home smarter: retrofitting existing homes; converting other properties tailored to buyers' requirements, and purpose-built homes. According to Balta-Ozkan, Davisdon, Bicket, and Whitmarsh (2013b: 362), the latter two are used most often as the home owner can control cost, but the high installation costs of smart homes in general does mean that only luxury domestic buildings can make use of the technology. Unfortunately, this also means that new buildings are constructed without the ability to accommodate smart technologies in future (Balta-Ozkan, Davisdon, Bicket, & Whitmarsh, 2013b: 365).

There are only a few institutions around the world that have incorporated smart technologies to monitor and assist the elderly to live more independent lives. Remote surveillance systems, however, are more often used and tested in the context of research and not practical application. In Japan, users can buy remote monitoring systems, but with the current price range set between US\$ 2000 – 3000, these systems are beyond the reach of most consumers (Chan, Esteve, Escriba, & Campo, 2008: 74). This points to the immaturity of the field, even in developed countries.

Environment

Governance can be defined as “rule of laws, administrative rules, judicial rulings and practice that constrain, prescribe and enable government activity, where such activity is broadly defined as the production and delivery of publicly supported goods and services” (Chourabi et al., 2012: 2292). Standards involving the security, privacy, architecture and communication networks of smart homes must be developed (Le Roux & Evans, 2011: 115). When a user interacts with a smart system they expect it to be secure as the barrier that separates the home from the public domain disappears (Correia & Wunstel, 2011). Large amounts of data are collected by sensors and stored in the cloud to be used in a smart home (Vermesan & Friess, 2013: 2). The collection of information from individuals does raise privacy concerns for the inhabitants, while utilising the cloud to store personal information will produce security issues due to the lack of transparency in the cloud. Unfortunately, these concerns have not been addressed by policy makers as the concept of smart homes are still relatively new (De Silva, Morikawa, & Petra, 2012: 1314).

In order to eliminate the barriers around smart technology, implementation policies need to be set in place. Removing legal and regulatory barriers will smooth the introduction of smart city initiative (Chourabi et al., 2012: 2292). Nikayin and De Reuver (2012) have put forward the following services platforms that need to be governed in order to improve the utilisation of smart cities:

- Home automation service platforms: These are the platforms that are used to offer generic home entertainment service such as lighting, ventilation, energy and security;
- Energy service platform: This platform is used to raise awareness of electric consumption by consumers and encourage energy saving actions;

- Health care service platform: This platform is responsible for exchanging data between service providers and the household to monitor the health status of the home owner;
- Security service platforms: These platforms are designed to protect the home owner and are designed to offer adaptive services such as audio/video control of the residence by using the internet and mobile devices, and
- Entertainment platform: Internet and broadband connections are used to provide online content on-demand which means that devices must become smarter.

All these platforms need communication infrastructures in order to transfer and communicate data between the service provider and the household. Sensors and controlling devices also need to be interconnected. The government needs to put in place laws and regulations to ensure a vision of common services platforms for smart living services (Nikayin & De Reuver, 2012).

Continued progress and cost reduction in electronics and IT have made smart home projects feasible and cost-effective. However, as discussed in the previous section, many of the projects around the world are still at a prototype stage. This shows that smart homes are still in a vendor-pushed, rather than consumer-pulled phase (Chan, Esteve, Escriba, & Campo, 2008: 69).

Market penetration of smart homes can be grouped into two categories which are closely related to each other (Nikayin & De Reuver, 2012). These two categories include technology and economy concerns. Technology concerns include the development of integrated hardware, software and networks that can offer IT systems with real-time awareness of the world from which analytical predictions can be made. Economic concerns focus on the state of the industry where a limited number of suppliers are competing to supply specialised services (Nikayin & De Reuver, 2012).

Table 1: Overview of barriers that prevent the utilisation of smart homes

Dimensions	Challenges

	Policy + Protocol	Privacy + Security	Interconnectivity	Cost	Availability of technology	Reliability	Efficiency	End user participation
Governance								
Technology								
User need								
Investment								
Commercial penetration								

The next section will provide an overview of some of the smart home projects that have been undertaken across the world. The projects will focus on all three of the application categories found in smart homes: security, lifestyle support and energy consumption and management.

EXAMPLES OF SMART HOMES

Smart homes can provide many different advantages to the home owner. This section provides an overview of a variety of smart home projects and examples, both in developed and developing countries, which illustrate the usefulness of the technology.

- Smart homes provide convenience to the home owner by automating many of the tasks that had to be performed manually before. Examples include a washing machine that determines the washing program required by examining the amount of dirt on the garments. Vacuum robots can navigate their way around the house while avoiding small objects, and smart refrigerators displays information about the contents and order finished items from the store (Sandri, 2011: 23).
- The ACHE project makes use of neural networks to economize energy resources while respecting the lifestyle and needs of the inhabitants. The system controls the temperature, heating and lighting by continuously monitoring the environment and collecting data about the actions of the residents. From this data the system infers

patterns in the home and uses reinforcement learning to predict future behaviour (Mozer, 1996).

- The MavHome project was started by the University of Texas. The MavHome makes use of databases, multimedia computing, artificial intelligence, mobile computing and robotics to maximise the comfort of the inhabitants while minimizing operations costs. The LeZi method is used to create a probabilistic model that predicts the occupants' mobility habits and their use of electrical appliances. Specifically, the LeZi algorithm calculates the probability of every possible action occurring in the observed sequence, and predicts the inhabitants' actions with the highest probability (Das, Cook, Bhattacharya, Lin, & Heierman, 2002: 78).
- The GatorTech Smart House in Florida is designed to optimize the comfort and safety of elderly inhabitants. Objects in the house such as the mailbox, entrance door, bed, bath and floor is fitted with sensors that tracks and locate the occupants, evaluate their mobility and help them to better control their environment (Helal, Mann, El-Zabadani, King, Kaddoura, & Jansen, 2005: 51).
- The University of Massachusetts has developed a simulated intelligent home environment consisting of four rooms. The goal is to improve the efficiency and quality of services by automating some of the tasks humans performed. Various intelligent agents (WaterHeater, CoffeeMaker, AirConditioner, DishWasher, VacuumCleaner, etc.) control the home environment. There is even a robot that can be used to move goods from one location to another (Chan, Esteve, Escriba, & Campo, 2008: 69).
- Elite CARE (creating autonomy-risk equilibrium) is an assisted living facility for retirees in Portland, Oregon using smart home technologies. Many of the inhabitants suffer from dementia or Alzheimer's disease. Smart technologies help the staff to identify health problems and prolong the independence of the inhabitant for as long as possible. The system detects behavioural cues of the inhabitant that can indicate change in an individual's physical or cognitive condition, enhances social networks via electronic mail, and regulates ambient conditions (Adami, Hayes, & Pavel, 2003: 1362)
- Japan is also making use of smart houses to improve the quality of life of elderly citizens. The bathrooms in the smart houses are equipped with automated medical

devices that collect data on inhabitants' health and physiological signs. Physical activity is monitored by equipping the rooms with infrared (IR) sensors and the doors with magnetic switches (Chan, Esteve, Escriba, & Campo, 2008: 61).

- Security can be upgraded in an existing home in order to become smarter. In France, independent systems are offered by contractors which can be integrated into the existing home infrastructure. These systems typically include panic buttons that are connected to a remote assistance center, infrared (IR) motion sensors and substance detection devices to detect smoke or gas (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013a: 369). The next section will discuss the TOE framework as it relates to smart home utilisation in South Africa.

CRITICAL SUCCESS FACTORS

The TOE framework has been chosen for this research study because it will be useful to analytical framework that can be used for studying the adoption and assimilation of different types of IT innovation. The framework was developed from a theoretical basis and is supported by consistent empirical evidence (Oliveira and Martins, 2011: 114). The TOE framework makes use of the technology, environmental and organizational context to increase the utilisation of smart homes in South Africa. The barriers that have been identified in the previous section are now considered, making use of the three different contexts of the TOE framework in order to formulate the CSFs that will influence the utilisation of smart homes in South Africa.

CSFs are defined as the critical areas in which an organization or the individual must accomplish in order to achieve its mission. CSFs also involve examining and categorizing the impact of those critical areas. The following five CSFs are used to address the critical areas that will allow the utilisation of smart homes in South Africa.

CSF 1 – Provide legislation to standardise smart home infrastructure

Balta-Ozkan, Davidson, Bicket, and Whitmarsh (2013b: 363) identify two methods to obtain consistency and coherence in smart home systems. The first is to adhere to universal standards for communication protocols for smart home devices, and the second is the development of a gateway that can act as an interpreter between the different smart home devices. However, if smart home infrastructure is not regulated by the South African Government, it is unlikely that businesses will adhere to these standards on their own.

CSF 2 – Regulate privacy concerns

Smart homes are still a relatively new concept and therefore it is not reflected in the legislature of the country. Legislation to control the personal information of individuals are regulated making use of the Protection of Personal Information (POPI) bill, but it is unclear how it will be applied in the smart home environment. More research is needed in this area.

Furthermore, the use of smart technologies to provide health care services in the home must also be considered. Health care data is exchanged between the service provider and smart home in order to monitor the health status of the home owner. It is important to verify that the lines of communication are safe and secure, that they ensure confidentiality, and that it is impossible for a third party to intercept the data. Also, the transmitted data must be uncorrupted and of high quality to ensure its correct interpretation (Cellar, Lovell, & Chan, 1999: 518). The government needs to put laws and regulations in place to ensure the confidentiality and privacy issues of the patient (Nikayin & De Reuver, 2012).

CSF 3 – Involve the end-user

Smart home technology should 'fit in' physically in terms of being suitably installed and integrated into the house so as not to complicate, but rather contribute to the quality of life of the inhabitant (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013a: 372). The smart home system should be outwardly intuitive and easy to use which can only be achieved if the inhabitant is involved during the design of the smart home. In addition, both the technology and services the smart home provides should fit the lifestyle of the inhabitant and integrate seamlessly with the home environment. This will increase the user satisfaction and acceptance of the technology (Chan, Esteve, Escriba, & Campo, 2008: 79).

CSF 4 – Address availability of technology

As discussed, most of the smart homes around the world are still in the research phase, and only a limited application has been found in industry. However, as the cost of smart technology decreases and more companies enter the smart home market, this is set to change. As sensors are developed that can collect data with increased integrity, the power of analytical processes are improved and Internet protocols are developed to enable smart technologies to communicate with each other, the reliability and efficiency of the smart home will increase.

CSF 5 – Decrease the cost of utilising smart home

The cost of making use of smart homes includes transaction, implementation and maintenance costs. Transaction costs include the cost of finding information about smart homes and comparing the different products from suppliers. Education of home owners and improved availability of smart technology in South Africa will decrease transaction costs, while the implementation cost of smart technologies will become more competitive as more companies enter the smart home arena. Recent technological advances have also made the storage of large amounts of data possible in the cloud which decreases the cost of the technology (De Silva, Morikawa, & Petra, 2012: 1313). One of the main inhibitors of the utilisation of smart homes in South Africa is the high telecommunication costs and bandwidth limitations. These concerns must be addressed before the technology will become commonplace in the country.

CONCLUSION

This paper provided CSFs that must be considered to increase the utilisation of smart technology in South African homes. The benefits of smart homes have been documented in literature, but despite this, many of the smart home projects around the world are built only for research purposes. In order to address some of the barriers that have been cited in literature, five CSFs were introduced as possible solutions to increase the utilisation of smart homes. Future research should focus on how each of these CSFs influence the utilisation of smart homes in more detail. In addition, there is currently no effective measure to determine the cost of investment of smart technology for the home owner as it is very difficult to measure the impact of the technology on the home environment.

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PERSONAL HEALTH RECORDS: DESIGN CONSIDERATIONS FOR THE SOUTH AFRICAN CONTEXT

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ABSTRACT:

A Personal Health Record (PHR) is a set of internet-based tools that allow individuals to create, store and coordinate their lifelong health information in one place making it available to relevant parties. It typically contains the individual's demographic information, medical care providers' details, health summary, family history, list of past and current illnesses, symptoms, allergies, medication and so forth. A PHR introduces many advantages as far as improving the health status of people. These include better doctor-patient relationships, improved health knowledge, better monitoring of chronic illnesses and many others. The South African health system is in need of a more preventative approach to healthcare as opposed to its current system that is considered as a highly curative. South Africa's planned National Health Insurance (NHI) aims at achieving this. The South African Department of Health also aims at improving access to quality health care, increasing patients' participation and the dignity afforded to them, reducing underlying causes of illnesses, injury, and disability, to mention a few. A PHR can prove useful to achieve these health goals and more in South Africa.

There is, however, no PHR that is specifically aimed at the South African population and thus adoption rates in South Africa are typically low. There is also a lack of design guidelines for PHRs that are suitable for the needs of South African consumers. This paper will highlight design guidelines and other factors that should be considered when developing a PHR for use in the South African context.

Keywords: *Personal Health Record, South Africa, Design guidelines*

INTRODUCTION

South Africa as a developing country is faced with many challenges, quality healthcare provision being one of them. The country is faced with a burden of disease which deteriorates the quality of healthcare. A Lancet report terms this as the quadruple burden of disease which consists of (Department of Health, 2011:6):

- HIV/AIDS and TB;
- Maternal, infant and child mortality;
- Non-communicable diseases; and
- Injury and violence.

These demand a preventative approach to healthcare provision rather than the current health system of South Africa which is considered highly curative (Department of Health, 2011:6). According to the National Health Act (2004:22), the people of South Africa using health services have the right to participate in decisions that affect their personal health and treatment. It is recommended that the National Department of Health's e-Health infrastructure should focus on person-centric healthcare (Department of Health & CSIR, 2014:17). There is a National e-Health strategy (2012:9) that, amongst other principles, focuses on patient-centeredness. This means providing care that focuses on respecting and being responsive to individual patient needs and values and also making sure that these guide all clinical decisions regarding the patient's health. This necessitates a solution that promotes the health goals of South Africa and a Personal Health Record (PHR) may be suitable for this.

A PHR gives individuals direct access to the health information as it allows them to create, manage and share their health information in one central place (The Markle Foundation, 2003:13). They decide which parts to make available for other parties to see and this feature becomes useful when a doctor is involved in the monitoring of one's health status. Family members can also participate in the health management of an individual that owns a PHR and this increases the involvement and promotes better care (Archer et al., 2011:515). PHRs introduce many benefits and these include but are not limited to the following (Kim & Johnson, 2002; Tang et al., 2006:123-124; The Markle Foundation, 2004:15):

- Improved patient and doctor communication: PHRs allow doctors and patients to communicate beyond the usual face-to-face encounters. This fosters a better relationship and better understanding between the two parties.
- Better health information knowledge: There are PHRs that provide individuals with health information to educate them about what is currently happening in the world of medicine.

- Improved quality of care: Individuals who use PHRs can take to their doctors a comprehensive health summary which contains past procedures that had already been conducted on the patient. This avoids duplication and speeds up the diagnosis process.
- Increased patient safety: Some PHRs provide individuals with information about possible drug interactions, side effects, allergic reactions and so forth.
- Better family support: There are PHRs that allow for family members to be involved in taking care of an individual's health granting them access to the PHR.

Despite these benefits of PHRs, adoption rates in South Africa are significantly low. A survey conducted in the Nelson Mandela Bay area of South Africa in 2012 indicated that 84% of participants were not aware of the existence of PHRs (Pottas & Mostert-Phipps, 2012:501). It is vital to understand the types of individuals and consumers of PHRs and the functions they mostly use in order to create PHRs that will actually benefit them (Tang et al., 2006:125). There is no PHR system that has been developed specifically for the South African population.

This paper will highlight design considerations and other factors that should be considered when developing a PHR that will benefit South Africans. A literature review focusing on content relevant to the South African context was employed to gather data related to factors that should be considered when developing a PHR for the South African market.

DESIGN CONSIDERATIONS FOR A SOUTH AFRICAN PHR

This section will highlight some design considerations that should be considered when developing a PHR for the South African market. A PHR is a lifelong health record that has been gathered from different sources at different time intervals. It is crucial that the information contained in such a record has some qualities that will ensure its usefulness in decision-making for a patient's health. There are four core characteristics of lifelong health records as identified by Van der Westhuizen and Pottas (2010:63) that should be considered when designing a PHR. These are interoperability, comprehensiveness, legal value and availability. The subsections below elaborate on these characteristics and design associations related to them.

Interoperability

Interoperability refers to the ability of information and communication technology (ICT) systems as well as the business processes they support, to communicate through the sharing and exchange of information and knowledge (IDABC, 2004:5). This allows for a greater two-way communication of the patient's health data. PHRs are managed and owned by the patient. He can decide if he wants to share the content of his PHR with his healthcare provider or not and that also depends if that particular PHR has that feature. This, however, limits the chances of better coordination and continuity of care as the data stored in the PHR may only be recorded by the patient. There are other health systems in place that contain patient health information but are not owned by the patient.

An Electronic Medical Record (EMR) contains medical information and treatment history of a patient gathered in one practice while an Electronic Health Record (EHR) contains data collected from more than one practice (Garrett & Seidman, 2011). An EHR is a patient's medical record collected from various health organizations. It may include data such as patient demographics, test results, images, symptoms and so forth. This data may be gathered from various stakeholders such as the patient's primary healthcare provider, specialist, pharmacists, nurses etc. (Ludwick & Doucette, 2009:24). Everyone involved in the patient care can have access to the EHR, including the patient (Caligtan & Dykes, 2011:220). A patient can upload information from their PHR to the EHR and vice versa (Mostert-Phipps, 2012). This improves the quality of data in that the patient's health record is more comprehensive, containing all relevant information from the various sources which aids in better decision-making (Caligtan & Dykes, 2011:226; Hargreaves, 2010:174).

Interoperability between health systems such as EMRs, EHRs and PHRs is critical in a national healthcare system (Department of Health & CSIR, 2014:22). South Africa, according to the eHealth Strategy South Africa (2012:21), is planning on implementing a National Health Insurance (NHI) and this is dependent on an effective national electronic, patient-based information system. South African health information systems have, however, been faced with some challenges namely: fragmentation and lack of coordination, too many manual systems and where automation existed, a lack of interoperability was a problem (NDoH, 2012:5).

The question always rises with regards to how PHR applications can interact with EHRs (Kharrazi et al., 2012:591). The lack of interoperability between various systems is a major obstacle to realizing the potential benefits of eHealth (Department of Health & CSIR,

2014:22). Amongst others, the eHealth strategy of South Africa (2012:8) has principles that address this problem.

One of the principles is to enable integration between systems wherever appropriate. One of the ways they aim to achieve this is through the establishment of common data standards and terminology across information systems. The document has objectives for the e-Health interventions that are required and these include eHealth standards. Establishing a national standards authority, facilitating training in eHealth standards and finally localizing eHealth interoperability standards and mandating their use all form part of the objectives. The eHealth strategy has priorities and strategic priority three is standards and interoperability, this highlights the importance of interoperability between the country's health systems.

This need for interoperability has led to the development of a National Health Normative Standards Framework for eHealth in South Africa (HNSF). Its primary objective is to set the foundational basis for interoperability (Department of Health & CSIR, 2014:17).

Using standards to govern the development of IT systems yields great advantages such as alignment, integration, flexibility, reusability, portability and reduced time to market (Department of Health & CSIR, 2014:19). The implementation of proper standards is critical to the successful integration of PHRs with systems such as EHRs and EMRs. This can be achieved through the use of standardized messaging structures, medical vocabularies, comparable information, comparable terminology and agreed-upon means of communication, amongst others (Kharrazi et al., 2012:591; van Heerden, Tomlinson & Swartz, 2012:393).

Comprehensiveness

For a health record to be useful, it should be comprehensive. This means the data entered in it must come from trusted parties, it must be up-to-date, correspond to real world objects, and it must be complete i.e. contain the entire health history (Van der Westhuizen & Pottas, 2010:64). There are standards that should be followed in order to ensure that the information contained in a PHR is comprehensive. The ISO multi-part standard on health informatics for the patient healthcard data includes the following standards that can be used to ensure comprehensiveness of a PHR (Department of Health & CSIR, 2014:108-109; International Organization for Standardization, 2004):

- **ISO 21549-1:2004(General Structure):** This standard defines the general structure of data that is contained in a PHR.
- **ISO 21549-2:2004(Common Objects):** It specifies a common framework for the content and basic structure of common objects used to construct PHR data. It does not define the specific data-sets for storage on devices.
- **ISO 21549-3:2004(Limited Clinical Data):** This provides the basic structure of data contained within the limited clinical data object. It does not specify the particular data sets for storage on devices.
- **ISO 21549-4:2004(Extended Clinical Data):** Specifies the basic structure of the data contained in the extended clinical data object. It is only applicable to situations where such data are recorded on, or transported by patient healthcare data cards
- **ISO 21549-5:2004(Identification Data):** Provides a common framework for the content and the structure of identification data held on healthcare data cards. It gives the specification for the basic structure of the data, without specifying the particular data-sets for storage on devices.
- **ISO 21549-6:2004(Administrative Data):** Specification of the basic structure of the data held within the administrative data object, without specifying the particular data-sets for storage on devices.
- **ISO 21549-7:2004(Medication Data):** Specification of the basic structure of the data held within the medication data object, without specifying the particular data-sets for storage on devices.
- **ISO 21549-8:2004(Links):** It defines a way to facilitate access to distributed patient records and/or administrative information using the PHR through references to individual patients' records and their subcomponents. The standard does not cover services relating to access control mechanisms, data protection mechanisms, access methods and other security services.

Legal Value

This characteristic speaks to the fact that the patient should have a way to grant/revoke access to his PHR. Only authorized parties should have access and be able to make changes to the PHR and there should be audit logs to monitor who had access to the PHR (Van der Westhuizen & Pottas, 2010:63). The most commonly recognized PHR adoption barriers are privacy and confidentiality concerns (Wynia & Dunn, 2010:69). A study conducted in the Nelson Mandela Bay in South Africa by Jojo and Mostert-Phipps

(2013:28) however, reveals that 70% of the participants are willing to share their PHR information with their primary care doctors, 52% with family members or friends and 48% with other healthcare providers. Participants were less inclined to share their health data with their employer (3%) and government officials (2%). This suggests that they are willing to have some parties access their PHRs but there is the concern of unauthorized parties gaining access too. A similar study was conducted in the Nelson Mandela Bay municipal area to gain insight on the attitudes of the citizens towards PHRs (Pottas & Mostert-Phipps, 2012:501). It was found that 58% of the participants were concerned about their privacy when using a PHR.

In order to protect the PHR, some safeguards need to be implemented and these can be categorized as administrative, technical and physical safeguards (Maglogiannis, 2011).

- **Administrative safeguards:** These address the security management process, assigned security responsibility, security aware and training and contingency planning.
- **Technical safeguards:** Access controls, audit controls, integrity and person or entity authentication and transmission security.
- **Physical safeguards:** These include facility access control, secure installation environment protection of devices and media controls.

Since the PHR is in full control of the individual, they play a huge role in ensuring their privacy. PHR users should therefore choose wisely when deciding on a PHR provider. They can also apply encryption methods to protect their data before handing it over to the provider which will be responsible for storing it (Li et al., 2013:131). According to Tang and Lansky (2005:1294), a strong national leadership also plays a huge role in ensuring that the legislative and regulatory policies to protect the PHRs privacy and confidentiality are in place.

Availability

It is important that a PHR is available when a healthcare provider needs it. Failure of the PHR is not acceptable because once that happens, lives are put at risk. A health record should be continuously available for it to be deemed lifelong (Van der Westhuizen & Pottas, 2010:63). A PHR, therefore, should be made available at all times and should be easily accessible. This subsection will introduce some options that can make this possible.

South Africans that have access to the Internet at home are only 10% according to Statistics South Africa's General Household Survey (2013:51). 9.6 % of the population accesses the Internet at Internet cafes or at educational facilities while 16.1 % access the Internet at work (Statistics South Africa, 2013:52). This shows that South Africans have little access to the Internet. Looking at households that only use cellphones for their telecommunications, Statistics South Africa's General Household Survey (2013:13), shows that they cover 81.9 %. This accounts for the high Internet access via mobile phones which is 30.8% (Statistics South Africa, 2013:52).

Patients are increasingly searching for means to access their health records that are more accessible and portable (Archer et al., 2011:515; Maloney & Wright, 2010:98). This creates the opportunity to utilize mobile PHRs (mPHRs) in order to better manage the health of the South African population. MPHRs are mobile applications that enable an individual to record, manage and store their health data (Dohan, Abouzahra & Tan, 2014:2576). One can record symptoms, allergies, medications, access emergency information and so forth depending on the features offered by the mPHR they are using (Dohan, Abouzahra & Tan, 2014:2576). They can also decide if they want to share this with others e.g. doctors or family members. The use of mPHRs in a diabetes case study has proven them to be successful as the participants could better manage their health (Preuveneers & Berbers, 2008:186). People already access sensitive information via their cellphones such as cellphone banking, shopping, and maintaining their financial data. It is therefore highly likely that they will be comfortable with using mPHRs (Kharrazi et al., 2012:590).

Cellphones offer a sense of mobility as well as instant accessibility. This means a person will have access to his medical data anywhere and anytime he needs it. According to Kharrazi et al (2012:590), having instant access to one's PHR can significantly decrease errors and time needed to repeat health history, the need to recall past immunizations and medication history. Cellphones also come with features such as a camera, Global Positioning Systems (GPS), and touch-screen. These can prove to be useful to an mPHR because the camera can be used to scan and import documents, take pictures to describe symptoms, take video notes, or scan medication barcodes. The GPS may be used to locate healthcare providers nearby. Touch-screen interfaces can provide better data entry and navigation mechanisms hence improving usability (Kharrazi et al., 2012:591). The advancement in technology allows for the creation of new applications that can be applied to healthcare. South Africa is said to have the most advanced mobile phone and Internet

industries in Africa therefore, mPHRs can prove useful in the eradication of poor health management in the country.

Using the mobile phone to access health applications demands infrastructure such as storage, processing power and bandwidth and this creates the need to make use of Cloud Computing (CC) capabilities (Dinh et al., 2013:1587; Dohan & Tan, 2014:411). CC can be defined as “a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction” (Mell & Grance, 2011:2). NIST describes the following major characteristics of CC (Mell & Grance, 2011:2):

- **Ubiquitous network access:** resources are made available over the network through standard mechanisms that can be accessed over different platforms (e.g. smartphones).
- **On-demand self-service:** a user can have access to computing capabilities as needed without interacting with the service provider.
- **Resource pooling:** computing resources are pooled to help multiple users through a multi-tenant environment. The users share physical and virtual resources dynamically and these are assigned and reassigned as the users demand them.
- **Rapid elasticity:** this is the ability to dynamically scale the resources according to the user' demand.
- **Measured service:** a pay-per-use method is used to automatically control and optimize resource usage. This allows for resource usage to be monitored, controlled and reported, which promotes transparency between the service provider and user.

Using CC to access mPHRs means mobile devices will not require a powerful configuration such as CPU speed and memory because all the computing modules have been transferred to the Cloud (Dinh et al., 2013:1589). Some of the advantages of using CC with the mobile phone also include extended battery life, and improved reliability. MPHRS used in conjunction with CC will provide pervasive access to Cloud-based health services thus promoting self and domestic care. This in turn will blur the boundaries that currently exist between the physical and digital worlds, allowing personalized and universal healthcare services (Sultan, 2014:179).

Apart from interoperability standards, CC is another important cornerstone needed to streamline healthcare for maintaining health records, monitoring patients, managing diseases and care more efficiently and effectively (Zhang & Liu, 2010:268). Healthcare providers are looking for more innovative and cost-effective means to address many of the problems facing healthcare (Sultan, 2014:183). Cloud Computing has the potential to address some of these problems.

It can reduce healthcare integration costs, optimize resources and introduce a new era of innovations (Ahuja, Mani & Zambrano, 2012:12). There is a great potential in CC for managing EHR/PHR systems in the US (Alagoz et al., 2010). CC can play a vital role in ensuring interoperability between disparate systems such as EMRs, EHRs and mPHRs. The fact that CC services can be accessed on any device ensures that these systems can communicate together. This feature is something healthcare IT is desperately in need of (Ahuja, Mani & Zambrano, 2012:13). Data stored on a Cloud-based system would eliminate the need for an EHR to communicate with a PHR if a Cloud service can act as a storage mechanism and intermediary for data transfer between these health systems. This may also eliminate the problem with platform-specific software as well as incompatibilities between different operating systems used by different manufacturers (Kharrazi et al., 2012:591). CC is offered in three service models (Mell & Grance, 2011:2-3; Gong et al., 2010:275):

- **Software as a Service (SaaS):** The software or applications that users use are provided to them via the Internet on a pay-per-use basis instead of them incurring costs of downloading and maintaining software on the computers.
- **Platform as a Service:** The user has the ability to deploy applications they have acquired or created using a programming language that is supported by their vendor.
- **Infrastructure as a Service:** Infrastructure providers are able to deliver huge computing resources such as storage, network and processing power.

The ability for accessing a PHR on different platforms such as a mobile phone is supported by the SaaS model. This type of service would also be marketed to small practices that are looking to adopt EMR usage (Schweitzer 2014). The ability for patients to provide access to their health history and other information from their PHR stored in the cloud to hospitals is also made possible through the use of SaaS (Bahga & Madiseti 2013). EMRs built with the PaaS model could be offered to practices large enough to have

their own IT support and are interested in rapidly customizing their EMR (Moore 2009). PaaS systems could also supply the software developers with the tools needed to add on the basic functionality that comes with an EMR. This would address the clinicians' concerns about EMR applications' agility and adaptability to local business workflow (Schweitzer, 2014:162).

In terms of mPHR integration with EMRs, IaaS can be used in order to transfer the resources needed to support these healthcare systems. The costs of building and maintaining infrastructure will decrease while allowing better access to health information (Dohan, Abouzahra & Tan, 2014:2580).

Cloud services are deployed according to different deployment models (Kuo, 2011:3; Mell & Grance, 2011:3; Zhang & Liu, 2010:269-270):

- **Public cloud:** Cloud Computing resources are made available to the general public on a pay-per-use basis via the Internet. This Cloud is owned by the Cloud provider.
- **Private cloud:** This is operated exclusively for a particular organization e.g. healthcare facility. It is managed by that organization or by a third party.
- **Community cloud:** Cloud services are shared by a community of organizations that share a common goal e.g. healthcare facilities that want to share their EMRs. This is managed by the organizations or outsourced.
- **Hybrid cloud:** This is a combination of two or more cloud models (public, private or community). An organization may decide to manage some resources internally while outsourcing others.

Depending on the deployment model that an organization chooses, there are security issues that they should consider. Healthcare facilities, for instance, should decide whether they want to use private or public clouds. They should look at regulations that govern access to healthcare systems and how they can ensure the privacy and security of patient data (Dohan & Tan, 2014:409). An in-depth understanding of the healthcare security and privacy concerns could be the first step towards the adoption of CC for healthcare systems (Zhang & Liu, 2010:268). Once the challenges of CC have all been addressed, it seems that Cloud-based systems will likely become the norm in healthcare (Ahuja, Mani & Zambrano, 2012).

DISCUSSION

Health plays an important role in a country's well-being and should be treated as such. There are Health Information Technologies available that can play a supporting role in improving healthcare services such as EMRs, EHRs and PHRs. The challenge with these systems is that they operate in isolation and so do not fully benefit a country's health status. This paper highlighted that South Africa is currently in need of a patient-centric health system that will promote preventative care and aid in improving the quality of care. The use of a mobile PHR was suggested because of the fact that South Africans have high access to the Internet via their mobile phones. Achieving this, however, will require a lot of collaboration from all parties involved in the care of an individual.

Healthcare systems exist but for as long as they work in isolation they will not yield the results that the South African health system is currently in need of. Interoperability between these systems would play an important role in ensuring that they communicate together in order to provide a better health system. Universal standards need to be adopted by the different organizations that participate in providing healthcare systems so as to reach the goal of integration and interoperability. This in turn will offer a faster and more efficient method of improving the patient care process. CC has proven to be another vehicle that can drive better collaboration between systems. Healthcare stands to benefit from this technology not only through better communication between health systems but it can also cut operational costs.

CONCLUSION

The lack of design guidelines for a PHR system aimed at the South African context has led to the problem of not having a PHR specifically designed for the country. This plays a role in the poor adoption rates of PHRs in South Africa. Implementing the suggested design considerations in this paper has the potential of improving the current state of health for South Africa. Better decision-making, better diagnosis and treatment which will yield better results, are some of the benefits. The high usage of mobile phones by South Africans to access the Internet and the great need for a highly curative approach expressed by the National Department of South Africa advocates for the need of a mobile PHR in South Africa. The use of CC and the implementation of eHealth standards provide means to make this system both interoperable and affordable.

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DESIGN LED PSS ADOPTION AS A COMPETITIVE APPROACH IN NON-DESIGN LED SMES IN BOTSWANA

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ABSTRACT

This paper focuses on addressing the gap in supporting manufacturing SMEs towards Product Service Systems adoption. There is growing attention in developing Product Service Systems in manufacturing companies. There is almost no research that can help manufacturing SMEs in Botswana towards this service oriented business strategy. Competitiveness concerns of SMEs in Botswana can be addressed by following emerging trends in entrepreneurship development, which encourage resource efficiency at the same time. Low levels of design awareness in these companies can be a good opportunity to use new design capabilities to drive new directions for entrepreneurship development. Through a design capabilities approach, sustainable product service systems can be a competitive business strategy for SMEs where a clear supporting process has been defined as a guide. This paper discusses a case study research approach conducted with manufacturing micro SMEs in the leather sector in Botswana. The aim of the research was to identify effective and contextually appropriate means through which manufacturing SMEs in Botswana can address their competitiveness needs through design and sustainable Product Service Systems. The paper concludes by discussing a framework which has demonstrated one way of using design capabilities to demonstrate PSS benefits to micro SMEs in the leather sector with no prior design knowledge. The framework supports a conscious way of using design to support a shift towards PSS in SMEs.

Keywords: *Design capabilities, sustainable product service systems, SMEs, competitiveness, entrepreneurship development*

INTRODUCTION

Little has been done in terms of defining design capabilities that can support a designerly approach for supporting manufacturing SMEs towards sustainable Product Service Systems (PSS). However De Lille et al (2012) argue a set of design skills that make a

designerly approach suitable for supporting organisational change towards PSS. Even though a process of change is suggested by the authorities, it is still limited as it is only representative of opinions of design consultants. Using design in this endeavour, also referred to as a strategic design approach (Manzini and Vezzoli, 2003) require that capabilities be defined and developed in SMEs to support new design activities. In PSS value is defined as a combination of both tangibles and intangibles (Morelli, 2003). This is a new dimension in traditionally product oriented manufacturing companies who define value in tangible terms only (Tan et al, 2006). It is argued that developing and deploying capabilities in a product oriented approach differs in a service oriented approach in the same manufacturing company. There is no solid theoretical framework that provides the link between design capabilities and competitiveness in a PSS value creation setting.

An appreciable variety of tools and methods have been developed to support manufacturing companies in the transition towards PSS. These vary from defining product development models in a PSS context (Tan et al, 2006) to developing methodologies for changing design activities (Morelli, 2003), PSS tools for the Maritime industry (Finkel et al, 2014) and tools for design and ICT integration for PSS in SMEs (Hernandez-Pardo, 2012). It is important to go beyond developing tools and address capabilities that SMEs can develop in order to develop capacity to handle complexities involved in the shift towards service oriented competition through PSS. This increases the challenge to comprehend the not insoluble but complex PSS dilemma as a competitive strategy especially for SMEs in a developing context of Botswana. The challenge for design here is to offer a leadership position beyond traditional design tasks (Perks et al, 2005). Appreciable arguments of design leadership at corporate level have been presented by Turner (2000) and Javnaker, (2000) but do not link actions involved to developing a service oriented strategy in manufacturing companies. Further, there is no link between these leadership actions and developing competitiveness opportunities. Although collaborations between SMEs and designers in projects could promote design as a partner in innovation and management, this reduces the potential design has to creativity only visible through products and services (Mozota, 2006). The paper demonstrates the use of design at an organisational change level where SME owners/managers can develop specific design capabilities to support service oriented competitiveness through a shift to PSS.

THEORETICAL FRAMEWORK

Sustainable product service systems

Product Service Systems come out as a business strategy that is based on continuous life cycle improvement taking into account the product and service life cycles (Tan and McAloone, 2006). In this way, the concept is representative of a holistic approach to sustainability innovation. A view of the whole landscape of the problem, the environment in which the problem is being investigated, relationships between factors causing the problem and possible factors that might lead to a solution is necessary in this holistic view of especially if looked at from the design perspective. A whole system design approach is necessary to aid such decisions (Fiksel, 2006) and move design away from its traditional focus on material products (Morelli, 2003).

Product service systems target addressing customer needs through focusing on functions that can lead to customer satisfaction with less or no environmental and social impacts (Clark et al, 2009). The function focus removes the need for production of a physical product to be owned by the user. Different authorities have defined product service systems (Clark et al, 2009; Tan and McAloone, 2009; Fiksel, 2006; Morelli, 2003; Morelli, 2006; UNEP, 2002; Kang and Wimmer, 2009; Ness, 2011) based on their focus on satisfying customer needs through the utility they provide. PSS has also been called servitization (Baines et al, 2007; Martinez et al, 2009). Value is provided through a mix of products and services. This utility focus enables the providers to meet values (knowledge, information, time saving, convenience, comfort, information) to which the market has attached great importance over ownership of physical product (Kang and Wimmer, 2009). PSS thus attract customers through their individualised offerings representing their socio-cultural and emotional values.

Organisational development view of competitiveness

It is generally acknowledged that efforts for organisational development should be targeted at developing dynamic capabilities for the organisation to be responsive and adaptable to change (Dawson, 2000; Eisenhardt and martin, 2000; Lawson and Samson, 2001). Each organisation differs with these capabilities and how they deploy them. These differences constitute what Hoopes and Madsen (2008) refer to as competitive heterogeneity. Differences in company characteristics need constant innovation for the company to sustain its advantage over competitors. One of the contributing aspects towards this

sustained advantage is developing dynamic capabilities. In strategy research, this approach is discussed under the resource-based view (Barney, 2001; Hoopes and Madsen, 2003; Eisenhardt, 2000), where an understanding of how competitive advantage can be achieved and sustained.

The idea behind the resource-based view is to implement strategies for creating value that cannot be easy to duplicate by competitors. For example, Barney (2001) draws a distinction between the neo-classical microeconomics view and the resource-based view. The former assumes that resources and capabilities can be bought and sold depending on demand and availability. While this is true in terms of recruiting experienced human resources, it does not guarantee the development of internal resources and capabilities that need time. While the latter recognises this supply and demand point of view, it also urges that development of resources and capabilities occur over time making the supply and demand issue not readily suitable for all resources and capabilities. This is the case for traditionally product oriented manufacturing companies shifting to PSS. PSS's service orientation requires that SMEs develop this capacity, especially working with stakeholders (Gabauer, 2011) and defining new activities where the shift is to be facilitated by design (Manzini and Vezzoli, 2003). For SMEs in Botswana who operate under both operational and strategic shortcomings (see Figure 1), a capabilities approach assumes the dimension of capability upgrade. In capability upgrade, especially in new organisations, learning new knowledge is more by actions than planning. The goal is "filling major gaps in the firm's existing capability portfolio to explore opportunities for organic growth (Zahra et al, 2006).

EXTERNAL	External operational problems are external to the firm and affect operational efficiency	External strategic problems are external to the firm and affect long- term competitiveness
	E.g., death of owner/manager; important employees leaving the firm; unreliable suppliers; high liability; lack of training facilities; extraordinary event like fire or earthquake; forced to leave business premises; local competition; lack of barriers to new entrants; firm product harming someone.	E.g., lack of integrated business development policy; unavailability of skilled labor; changing socio-economic trends; globalization of competition; lack of credit facilities; rapid technological changes; high bank collateral for loan/credit; stringent loan repayment terms; high interest rates on loans.
INTERNAL	Internal operational problems are internal to the firm and affect operational efficiency	Internal strategic problems are internal to the firm and affect long- term competitiveness
	E.g., lack of functional planning and budget; ineffective recruitment practices and dependency on family labor; lack of delegation; lack of quality control; lack of financial record-keeping; poor working capital management; lack of effective product/service marketing; lack of information on markets/customers;	E.g., lack of strategic business planning; ineffective human resources policy and procedures; poor financial planning and control; misperception of marketing as advertising; organizational misalignment; lack of participative management; lack of standardization of products
	OPERATIONAL	STRATEGIC

Figure 79: Problems of SMEs in Botswana (Temtime, 2008)

A designerly approach

Design leadership can support identification and filling of gaps in SMEs' capability portfolios to cope with PSS value creation. A leadership position for design in new product development as argued by Perks, Cooper and Jones (2005) expands beyond traditional design tasks to include direct interface with customers. This role addresses the gap often found between design teams and the marketing departments (Von Stamm, 2004). Relating with external partners and a life cycle approach necessary for successful sustainable PSS value creation can benefit from design capabilities like interpreting, coordinating and facilitating (Turner, 2000). In SMEs cultivating design capabilities can create competitive advantage given a superior role of coordination between functions in the value chain (Mozota, 2002). Identification of opportunities and interpreting them in a service context rather than in a product context will be a new capability required for product oriented SMEs. This shift in perspective can be facilitated by such design capabilities as the human centeredness of design, empathic design and a futuristic mindset of designers among others (De Lille, 2012).

Lack of design literacy highly prevalent in most SMEs often lead to failure of design led interventions (Ravasi, Marcotti and Stiliani, 2008). This lack of design literacy in SMEs often combined with lack of strategy and flexible management styles make interactions

between design and management difficult. In light of PSS in traditionally product oriented SMEs with no design literacy, these interactions will especially require enabling capabilities to be defined and cultivated. According to Kowalkowski, Witell and Gustafsson (2013) infusing the service component in SMEs require developing operational, innovation, relational and networking capabilities.

Knowledge creation in the innovation process

“Knowledge and knowledge co creation are the key to sustainable competitive advantage in this global network economy” (Kohlbacher, 2008). Knowledge for SMEs should be co-produced with them in recognition that they are the ones in full appreciation of the problems at hand (Manzini, 2006; Kohlbacher, 2008). The natured ability of stakeholders to collaborate through sharing ideas, co designing and shared production enhances their ability to learn current market competition trends and absorb them into their organisations and enhances their versatility to adapt to these changes (Lusch et al, 2007; Blincoe et al, 2008; Spangenberg et al, 2010). Through collaborations stakeholders can discover their hidden needs through sharing of experiences during a relating process of knowledge co creation (Roux et al, 2006; Lusch et al, 2007). Through collaborations SMEs can be assisted to leapfrog to innovative practices like PSS (McAloone and Andreason, 2004). An exploration of effectively forging collaborations between SMEs and designers in Botswana is necessary to support their shift into PSS providers. This contextualised approach to knowledge creation will ensure successful transition for SMEs since PSS is socio-technical in nature. It is a social construction based on goals, results and problem solving criteria which stimulate stakeholder participation (Morelli, 2006).

Most PSS research conducted is on large companies (Kang and Wimmer, 2009; Finkel, 2014) and mostly in a European context. As an academic research concept, the transfer of the concept to industry has also been looked at in a European context, for example by Cook et al (2006). Manzini and Vezzoli (2002) mention the potential benefits of PSS in a developing context as enabling them to bypass a stage of development characterised by product ownership. The manufacturing industry in a developing country like Botswana can therefore be developed in line with servitization. This can encourage both resource decoupling and impact decoupling (Evans et al, 2007). That is, SMEs can be competitive and gain financially using less resources and causing less negative environmental impacts. Appreciably, transferable interventions can be adapted to the context of Botswana. However, a vibrant SME business community will need to be created through

active engagement of indigenous knowledge and understanding of social and local business practices.

METHODS

The purpose of this research: exploration of how the micro SMEs can improve their competitiveness through developing design and sustainable Product Service Systems capabilities, and the chosen context (Botswana) provide sufficient grounds for this research to be conceptualised as a case study. Further boundaries defining the case are manufacturing typical micro SMEs in the Leather industry. The case was looked at in an iterative way involving different data collection approaches at different stages of the research to gain understanding of its multifaceted perspectives.

Phase one: Identification of factors relevant for SMEs to embrace PSS as a competitive strategy

The fundamental changes required in order for the benefits of design and PSS to be realised needed examination of contextual priorities that can enable SMEs to be PSS providers. Establishing contextual priorities will enable identifying suitability of and strategies through which companies can be able to adopt PSS. The potential to innovate and ultimately gain competitive edge through strategies like PSS needed to be investigated in the same context in which beneficiary SMEs operate. The socio-technical nature of PSS (Tan et al, 2006) required that contextually relevant conditions be established. Being socio-technical means that PSS deploys resources both human, equipment and other capabilities from a subsystem within the organisation (e.g., measuring and marking out line in a shoe manufacturing SME) to the entire organisation and environment as well as systems in communities, industrial sectors and institutions operating in the society (e.g., government support in SMEs) (Trist, 1981). With limited scholarly publications about manufacturing SMEs in Botswana and the need to understand contextual dynamics the Delphi technique was used. The Delphi technique involves building a consensus from expert opinions in an iterative process usually involving three rounds (Loo, 2002). Consensus between a homogeneous sample of 9 experts resulted in seven prioritised goals (Figure 2) and twelve prioritised strategies (Figure 3).

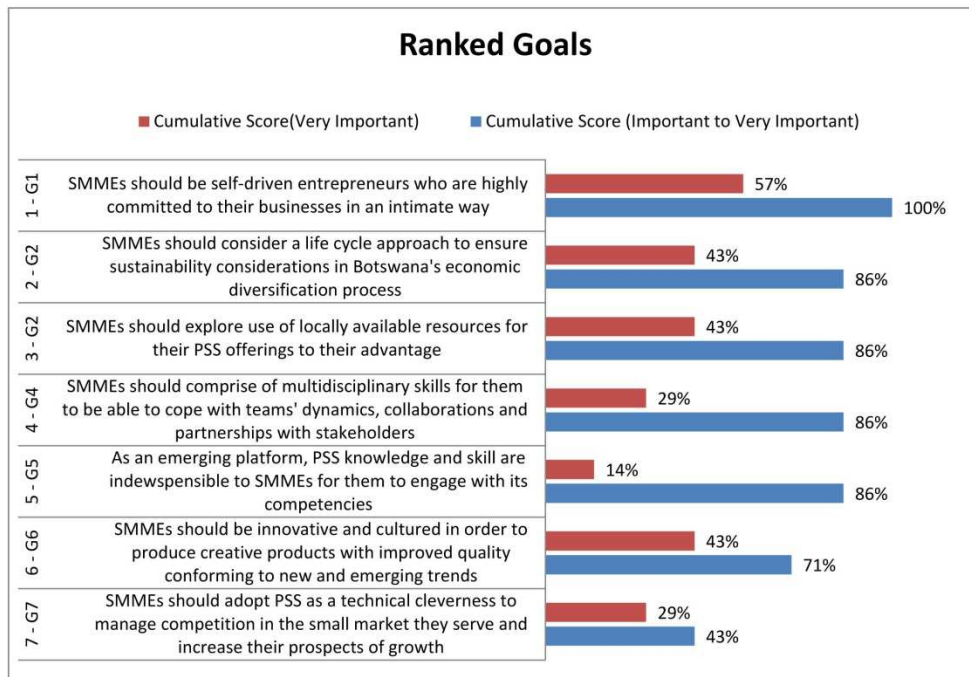


Figure 80: Prioritised goals

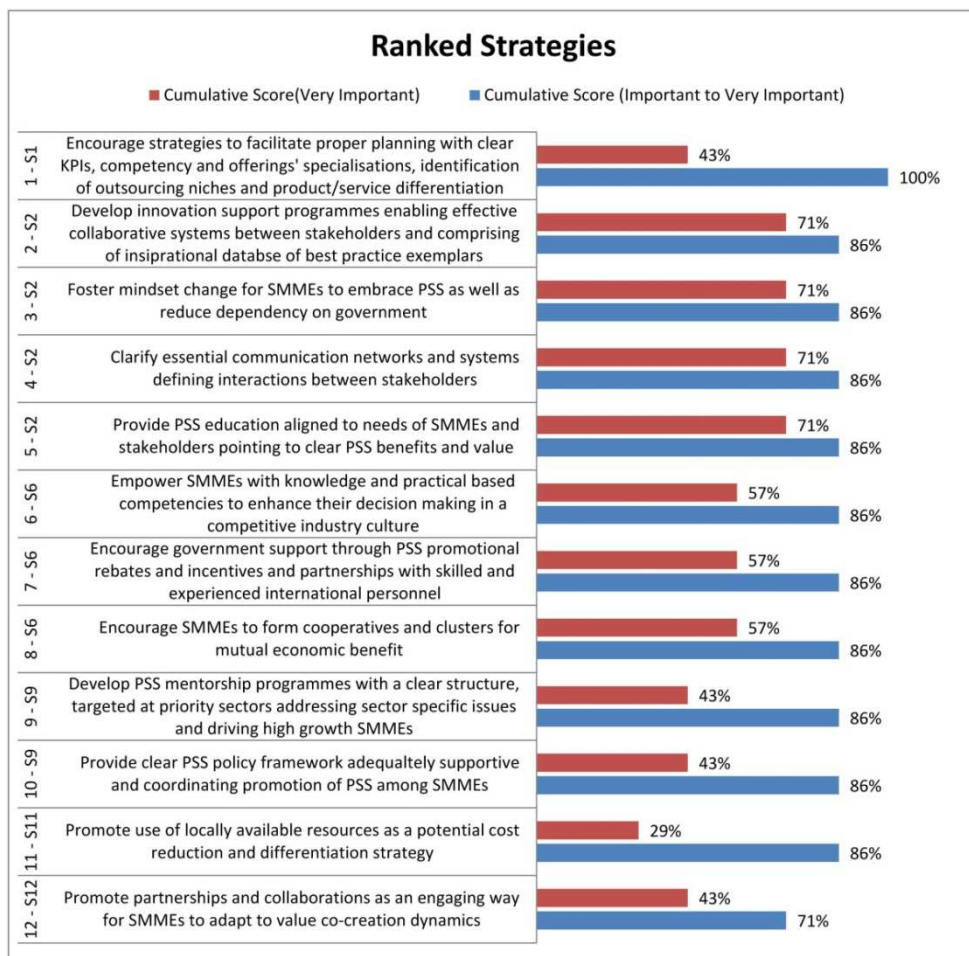


Figure 81: Prioritised strategies

The existing relationships between goals and strategies were further explored through a thematic approach following Braun and Clarke (2006) to capture the main thematic areas representative of the priorities (Figure 4). These themes were then used to inform phase two stage 1.

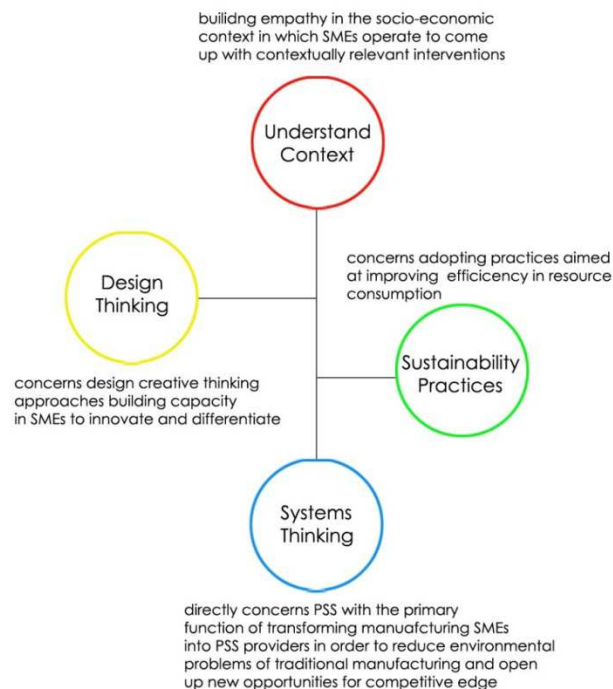


Figure 82: thematic representation of themes

Phase two stage 1: Exploration of factors contributing to the performance of leather manufacturing SMEs' products in the market and their perceptions of sustainability and product service systems

A specific SME sector was selected to investigate priorities from the Delphi study further. The context in which the investigation was done is the leather industry in Botswana. This followed a single case with embedded multiple units of analysis. The case was factors contributing to the performance of leather SMEs' products on the market from the perspective of their value creation experiences and their perceptions about sustainability and product service system. The units of analysis were 16 typical leather manufacturing SMEs in Botswana. All companies employed 1-6 people including the owner/manager. In this type of design Yin (2003) and Creswell (2013) warn that researchers should pay attention not to shift focus from studying the case to studying units of analysis.

Data was collected through document review, field notes from observations and interviews. The bulk of the data was gathered through semi structured interviews. All data collected was documented and organised into a database and analysed following a six

staged process of thematic analysis by Braun and Clarke (2006). Six themes were identified during the analysis and were interpreted into a reference framework called systems success framework (Figure 5) following categories of guarding against failure by O’Rafferty et al (2009).

Category	Systems success factors					
	Competitiveness	Design	Sustainability	Relationships	Business environment	PSS
Infrastructure	Reduce complacency Increase innovative responses to threats Promote brand equity	Create awareness of emerging design for sustainability Create awareness of design innovation	Promote resource efficiency to combat material cost issues	Create support for design to promote design innovation and sustainability	Develop strategies to cushion material cost Explore use of locally available material	Invest in strategy creation
Institutions		Promote designers involvement in delivering support to SMEs	Develop policy framework to drive sustainability initiatives	Develop structured and coordinated partnerships to engage designers	Support design innovation as a means of dealing with material cost issues	Develop policy framework to promote PSS
Interactions and networks		Promote user involvement in value creation	Engagement of SMEs with external support to develop initiatives	Promote links between business networks and designers		Involve designers to demonstrate design of services in manufacturers
SME capacity	Need for use of technology	Develop design capabilities to empower SMEs stop copying	Promote life cycle thinking		Develop a clear business intent	Exposure to design tools and methods to aid PSS design
Culture	Owner/manager's open mind and commitment	Reduce the risk of market failure by engaging SMEs with design	Expand benefits of sustainability beyond economic benefits		Cap ad-hoc approaches through development of owner/manager skills and knowledge	Encourage long-standing links to develop trust

Figure 83: Systems success framework

Phase 2 stage two: exploration of how SMEs recognise and apply design capabilities to distinguish themselves by creating sustainable PSS offerings through interactions with industrial designers

At this stage of the research the focus was to develop an innovative design driven capabilities based approach to supporting entrepreneurship development with respect to sustainable PSS adoption. An interaction between SMEs and designers was therefore deemed necessary to allow designers as carriers of capabilities transfer them to case SMEs as receptors in a knowledge co-creation setting. Exploring SME-Designer(s) relationship mainly involved interactions between SMEs and designers in workshops. Three separate workshops were conducted with SMEs in the furniture, shoe and leather industries in Gaborone, Botswana. These companies participated in the phase two stage 1.

These workshops were half day design experiments conducted to get first hand results from SMEs. Activities aimed at addressing the main issue discussed as the purpose of this paper were developed (see Figure 6 for the programme). These activities evolved as designs engaged from the design consultancy point of view with SMEs from their business

perspective. The experiments were guided by the research purpose and provision of supporting tools and other resources. Figure 7 shows one of these workshops in session. The workshops resulted in tangible outcomes upon which design influenced decisions were made. Figure 8 shows one of the outcomes from activity 3, when participants were exploring their users in order to design suitable and pleasant experiences for their PSS ideas.

Time	Activities
08:00 - 08:10	arrival, introductions and housekeeping
08:10 - 08:15	quick introduction of the workshop and its purpose
08:15 - 08:30	Activity 1: Lost on a Desert Island
08:30 - 09:00	Presentation
09:00 - 09:10	Brain dump
09:10 - 09:40	Activity 2: Linking company goals
09:40 - 10:00	Activity 3: building customer experiences
10:00 - 10:20	
coffee break	
10:20 - 11:20	
Activity 3 continues	
11:20 - 12:15	Activity 4: plotting a sustainable PSS blueprint
12:15 - 12:35	activity 5: business pitch
12:35 - 12:45	winding up and closure
Food time!	

Figure 84: Programme of activities for explorative workshops with SMEs in Gaborone



Figure 85: Workshop session with bag manufacturer

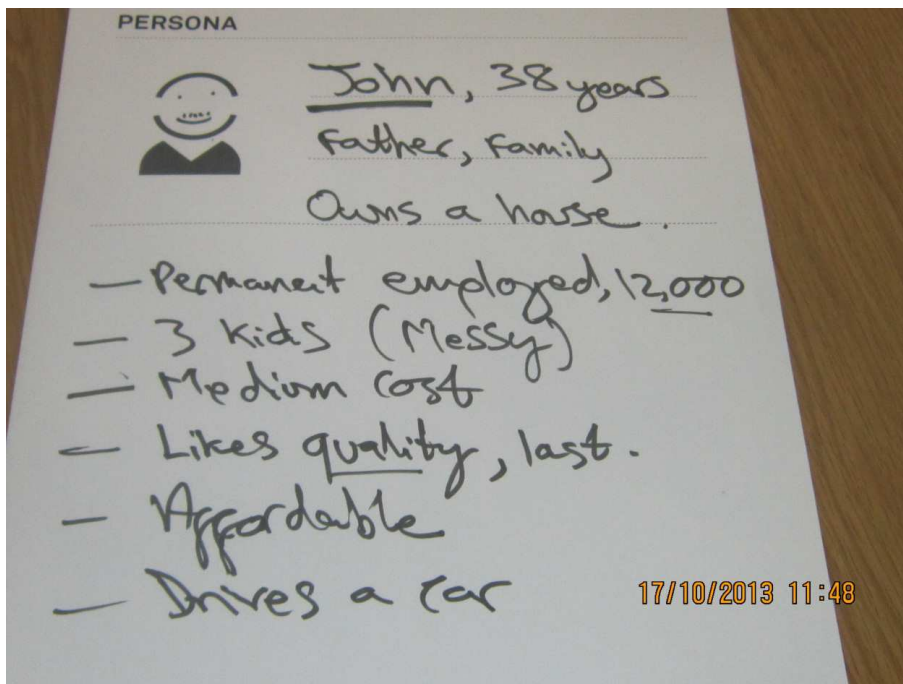


Figure 86: One of the personas developed with the furniture manufacturer

During this phase a solution seeking approach to problems identified in stage 1 was adopted. Findings gained in this study also provide insights into usability of the systems success framework developed in stage 1. Following on the need to explore the missing relationship of SMEs-Designer(s), a process based approach was identified. In this approach a shift process is identified based on relationship between themes together with their impact on SMEs' orientation towards sustainable PSS (Figure 9). The process is based on prompts such as market issues, building SME understanding through codesign, exposing SMEs to examples they are familiar with, introducing use of design tools and methods to empower SMEs, addressing the impact of the shift on company resources and differentiation avenues in a service context.

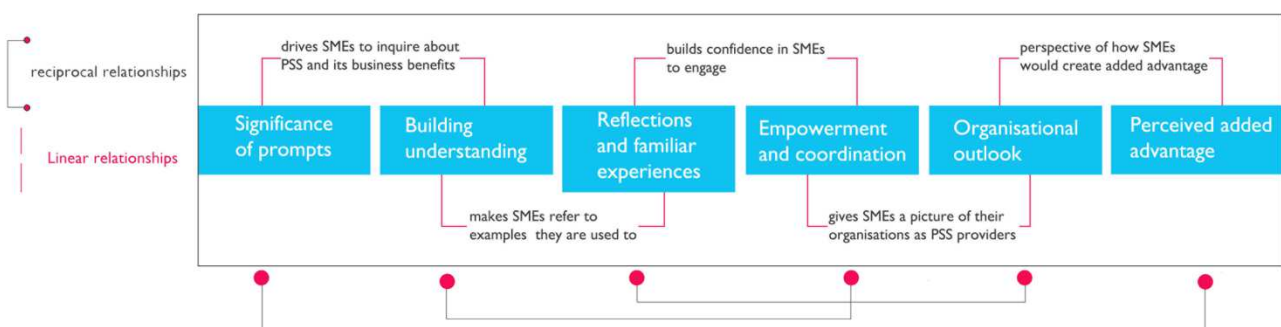


Figure 9: The shift process

Data analysis

Semantic (Palmquist et al, 1997) or relational analysis was adopted to identify relationships between categories of the systems failure framework by O'Rafferty et al (2009) and themes identified from data sources and sets in phase two: stage one. This interpretation of meaning through looking for relationships among concepts inherent in themes and categories by O'Rafferty et al (2009) led to the systems success framework. Interpretation of participants' perspectives in the context of whole system design (Charnley et al, 2011) offered alternatives of how SMEs can be supported in a shift towards sustainable PSS. The same approach was adopted in phase two: stage two where a design capabilities approach towards sustainable PSS was interpreted in the context of the systems success framework developed in phase two: stage one.

FINDINGS

Relational analysis led to the framework defining a shift process with collaborative activities by designers and SMEs within a whole systems design context (Figure 10). The shift process was developed to show elementary and readiness issues to be supported through developing design capabilities. The relationship between design capabilities across stages of the process and categories from the systems success framework show the progression of a supportive environment for PSS adoption by SMEs in the leather sector in Botswana.

Design capabilities in the framework overlap across three categories: Infrastructural (Design exposes SMEs and initiates engagement of SMEs with sustainable PSS); Infrastructural/Institutional (Design as an engaging activity); and Institutional (Design defines strategy and builds possibilities of win-win scenarios to stakeholders).

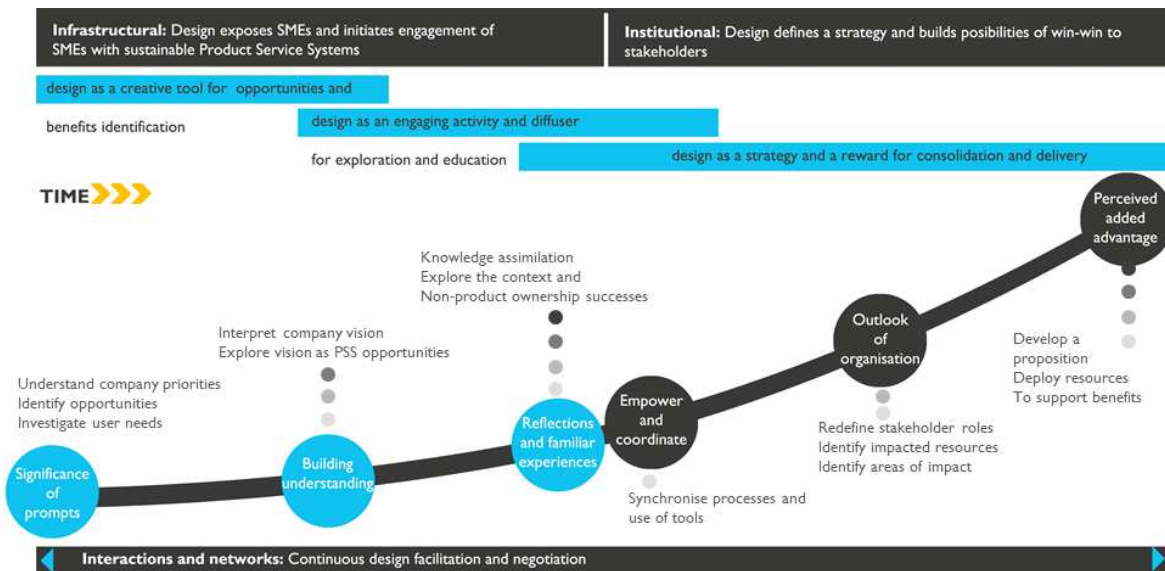


Figure 10: SME-PSS adoption framework

Infrastructural (Design exposes SMEs and initiates engagement of SMEs with sustainable PSS)

The two stages (significance of prompts and building understanding) are crucial in setting the right pace. These stages provide appreciation of factors that motivated SMEs to embrace design and PSS as means of seeking added advantage. These factors drive SMEs to inquire about PSS and its business benefits. A description of how SMEs develop an understanding of how design and PSS fit into their businesses leading SMEs towards referring to examples they are used to, is also provided. Design activities at these stages are focused on understanding company competitiveness priorities and looking for opportunities in line with those priorities. User centred design as a capability should be developed at these stages to ensure priorities and opportunities are what people really need. The companies' ability to interpret its vision in a PSS context requires redefining how user needs are met. The focus is on using codesign activities to engage SMEs in exploring alternatives of their vision as PSS providers. Insights from user centred design approaches put company priorities in context of what people may derive satisfaction from as an offering from the company. Use of user centred research tools like personas can be used to understand users where funds may not permit contacting real users. SMEs should also be exposed situational analysis tools like SWOT and PESTLE to get an overall perspective of areas they need improvement on and opportunities they can take advantage of. However, more PSS specific situational analysis tools like the situation characterization sheet (Hernandez-Pardo, 2012) can be adopted for a holistic view. An

emphatic design approach should be initiated as early as these stages to understand issues from SMEs' point of view.

Infrastructural/Institutional (Design as an engaging activity)

Here the focus is on clarification of SMEs' decision making and how they connect potential benefits of design and PSS to their projects and activities to build confidence in SMEs to engage with design and PSS. These also provide an explanation of how SMEs can be supported to develop PSS concepts and the effect of the process on their mind set towards design and PSS. This engagement gives SMEs a picture of their organisations as PSS providers. Supporting SMEs' buy-in should be supported through assimilation of experiences. Design exploration should focus on developing examples of existing PSS offerings in the context from either the service industry or the product manufacturing industry, including cases where the provider may not necessarily be the manufacturer. Visualisation approaches like using sticky notes and quick sketches can bring these examples closer and SMEs can map what is achievable. Design activity increases at this stage through refining project goals and translating them into briefs and offering process to support developing ideas and producing tangible concepts. Interactions between SMEs and designers through sketches, systematic idea exploration, and quick low fidelity prototypes will build confidence in SMEs. This will also demonstrate viability of concepts. The interplay between infrastructural and institutional considerations stems from design iterative approach of going back and forth between the brief and concepts as more understanding is gained through PSS examples in familiar and similar situations. Capabilities to be developed here include prototyping using tools like the customer journey maps and building scenarios of use cases (Morelli, 2003). Since these ideas are likely to involve people from outside the company, stakeholder maps should also be introduced to show stages where they will be brought in and their likely benefits.

Institutional (Design defines strategy and builds possibilities of win-win scenarios to stakeholders)

These stages focus on capturing emerging strategic issues as SMEs gain understanding and see PSS potential in their organisations. This emerging position of SMEs as a result of interactions with designers shows strategic issues pointing to requirements at organisational level needed for SMEs to create added advantage. At this stage it is possible to define a PSS strategy for the company. Priorities will have been set, with a defined PSS vision. Codesign activities in previous stages will have begun building

capacity in SMEs in terms of differentiation through services supported by their products. Stakeholders need to be identified and presented with business propositions of their roles and benefits. Resources will need to be assigned to facilitate changes that need to be done in the short term and long term. Other impacted strategic issues include company image in the market. Developing a strategy will be possible for SMEs at this stage since early experimental prototypes will show their impact on resources not directly related to products and services. Building brand equity is one important area to be developed since confidence will need to be built in customers and other stakeholders about the companies' offerings. Other resources needing mobilisation will need to be identified and support sought from relevant stakeholders with clear demonstration of benefits.

Various rewards that SMEs were looking to achieve should be mapped out and demonstrated in terms of viable propositions following design development activities. These should be directly related to factors that prompted them to inquire and engage with design and PSS to measure the impact of the benefits in the business when compared to their traditional product oriented approaches. Since these SMEs are generally low technology companies, PSS should be strongly developed to exploit offerings inclined to user experiences (Tan et al, 2009), leveraging on user centred design approaches.

DISCUSSION

PSS research has highly focused on developing tools and methods to support manufacturers offer service oriented solutions, big companies and in developed contexts. It is worth noting however, that a designerly approach has been advocated for in similar studies leading to a PSS blueprint (Morelli, 2003), system resource optimisation (Manzini and Vezzoli, 2003), an organisational change process (De Lille et al, 2012) and Design and ICT integration (Hernandez-Pardo, 2012). There is little research focusing on developing design capabilities in a way that supports a shift towards PSS in non-design SMEs. This study has focused on this subject and has raised its complexities using SMEs in the leather industry in Botswana. Several issues have been raised through this study especially the absence of design in the leather industry. A missing relationship with designers could be developed through the framework in figure 7, to support developing these activities into capabilities over time (Barney, 2011).

The social construction nature of PSS mentioned by Tan et al (2009) has shown in this study that observing examples in the context improves buy-in of SMEs into the concept.

The framework resulting from this study shows a shift process with key design capabilities to support SMEs towards addressing their competitiveness concerns through PSS. The underlying importance of a relationship with designers in this framework is to sue designers as capabilities carriers and dissipate them into SMEs over time. Collaborations of this nature support the argument that knowledge co-creation under such settings will expose companies to learn current market competition trends and enhance their ability to change towards them (Lusch et al, 2007; Blincoe et al, 2008). The framework therefore design and PSS capacity building in SMEs with real designers on the ground instead of do it yourself manuals and other less effective ways that SMEs do not prefer. It adopts the learning by doing approach often preferred by SMEs in the form of workshops and contact with knowledge carriers during site visits (De Eyto et al, 2008; O'Connor and Cox, 2005). Addressing PSS adoption by SMEs through developing design capabilities is a gap in literature that this framework seeks to address. The framework is not intended to be used as a standalone product, nor should it be viewed as panacea to the transition of SMEs to PSS providers. Such limitations as the type of sector used in the study should be taken into consideration. Differing educational and literacy levels of SMEs in other sectors may yield totally different outcomes. However a process of continuous negotiations and interactions using design capabilities has been demonstrated through this framework.

Future research efforts in PSS and SMEs should focus more on the link between the transition and competitiveness since the primary aim of small businesses is to make profits. The institutional focus in the first phase (Figure 10) places emphasis of this issue by directly starting with company priorities in order to be able to translate them into business propositions. The importance of connecting SMEs with users early is also emphasised in order to understand market dynamics before any further investments are made. The infrastructural/institutional phase is where most activities occur in order to shape SMEs business perspectives in seeing value in less material offerings. Recognition of what SMEs know and how they can adapt it into a new context is crucial at this phase as it also makes them think innovatively. Institutional phase is the long term goal that SMEs could sustain and benefit from when early capabilities have been developed. It is important to note that these activities need to be undertaken repeatedly to ensure they reach a threshold level of practice. At this point SMEs could be able to stand on their own with less external help required from designers.

CONCLUSION

The shift towards product service systems can be effective in non-design led manufacturing SMEs when relevant design capabilities have been developed. This approach should be adopted to build capacity in SMEs to cope with new value creation requirements posed by product service systems. This is also imperative for supporting competitive heterogeneity in SMEs as they are likely to define different ways of deploying their resources and capabilities; both existing and new. Although this is a challenge for SMEs, a strategic design approach from the strategy research point of view is an advantage. In SMEs, the manager/owner is usually directly involved in the business as well as the main influential person in decision making. Their involvement in collaborations with designers benefits from their broad perspective of their business and passion of them in growing it. This paper proposes that developing a shift in mindset in SMEs should be targeted to SME owners/managers whose embracing of the concept may lead to successful adoption.

Based on SMEs involved in this study, it is too early to make conclusions on repetitions of activities undertaken during the short interactions SMEs had with designers to measure how much they have developed into capabilities. There is need for more time to be given to collaborations between SMEs and designers. A database with PSS exemplar success stories in SMEs should be built to provide inspiration. This conclusion was reached at as a result of activities which showed design engagement and design as influencing strategy development. This was particularly the case with activities resembling the third stage shown in Figure 10. The context of these examples should be taken into account as the orientation of users in appreciating PSS offerings may differ from country to country. SMEs involved in the workshops mentioned in section 3.3 found examples in the local context helpful. At a more advanced level targeted at making more impact, further testing of the framework with more SMEs may be used to inform PSS policy formulation.

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