Think tank: Assessing the Industrial Design learning environment

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Abstract

In higher education, it is imperative to equip students with both simple and complex skills required for their future professions. Skill required of a professional Industrial Designer includes the ability to find creative and suitable solution to what are often complex problems, as well as more general problem solving and decision making. In essence, that is the true core of design as a discourse as stated 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." As decision-making and problem-solving are key elements of a professional industrial designer's practice, these elements should be developed and encouraged as part of the tertiary programme. The trend towards 'learner-driver investigation' and research as well as interactive mixed methodologies, have facilitated many projects requiring thinking skills. But does the learning environment support and develop these skills?

The Ennis-Weir Critical Thinking test was used to evaluate current Industrial Design students' critical thinking ability and results highlight the need for further critical thinking trainings. This paper, delivered at the first annual Research & Innovation in teaching and Learning (RITAL) conference, takes into account current research pertaining to critical thought and investigates the relationship between critical thought and Industrial Design. The paper was presented in the conference's Developing Responsive Curricula stream as the ultimate goal of the *Think Tank* project, of which this paper forms a part, is to initiate curricular changes.

Introduction

The International Council of Societies of Industrial Design 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). The Industrial Design course at the Cape Peninsula University of Technology, aims to equip students with the knowledge and skills to apply the design process to problems related to mass-produced products, to produce conceptual sketches, technical specifications, rendered images and physical or virtual 3D-models to communicate proposed solutions in a professional way. The graduate should be able to participate in debate around current design thinking and movements, based on historical reference and position the results of their work in the business framework that generated the need for the design input (CPUT, 2008). In short, an Industrial Design graduate must be able to make appropriate and informed decisions, whether they are practical design decisions or decisions based on abstract discussion. But does the Industrial Design learning environment support and develop these skills? The Ennis-Weir Critical Thinking test was completed by a focus group of students to evaluate their ability to think critically. These findings and a review of

other sources, including a continuous digital discussion between international educators, are presented in this paper and clearly indicate the need for curricular changes which encourage a stronger focus on the development of students' critical thinking skills (Robyn, 2010).

What is critical thinking?

The key feature of critical thinking is the ability to understand and evaluate information. Critical thinking is described as higher order thinking, and also as "…reasonable, responsible, and skilful thinking that is focused on deciding what to believe or do. A person who thinks critically can ask appropriate questions, gather relevant information, efficiently and creatively sort through this information, reason logically about this information, and come to reliable and trustworthy conclusions about the world" (Schafersman, 1991:3). Nickerson (1987, cited in Schafersman, 1991:4) suggests that individuals who use critical thinking would have, among others, the following characteristics:

- Uses evidence skilfully and impartially
- organizes thoughts and articulates them concisely and coherently
- distinguishes between logically valid and invalid references
- attempts to anticipate probable consequences of alternative actions
- applies problem solving techniques in domains other than those in which learned
- can learn independently and has an abiding interest in doing so (adapted from Nickerson, 1987).

The ability to anticipate consequences of actions is a key skill, in evaluating proposed solutions to design problems, as is the need to act upon one's evaluation. The need to decide what to do, think, or act upon is what is most challenging, as one needs to have come to a conclusion. Critical thinking thus relates to solving complex design problems using mental and actual visual imagery to solve problems. Critical thinking tests such as the Ennis-Weir Critical Thinking test are often in written format which can be problematic for practically-orientated design disciplines. So, while we recognise the importance of critical thinking skills and wish to cultivate these skills, we are limited by issues of language (particularly in the context of a country with eleven official languages, and students frequently studying in a second or third language), and an appropriate and relevant means of measuring or testing such skills.

Why is critical thinking important to the design process?

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 that are taught in a traditional large group lecturing style, design is taught in a design studio. The studio is a space of sharing, exploring, stumbling, reflecting and learning. It is the learning environment that 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).

Design education is characterised by not only a unique teaching method, studio-based education, but also a unique teaching process: using the design process itself as the teaching process. The entire design process reflects cycles of critical analysis and responsive adjustments. To understand the relevance of critical thinking to design it is important to understand the design process. There are many different interpretations and models relating to the design process. The design process, as explored in the Industrial Design department at CPUT, can broadly be divided into three main sections: 1) Context,

Calculation & Creative Exploration, 2) Selection & Production and 3) Reflection, Adaptation and Reflection.

The first section (Context, Calculation & Creative Exploration) relates to the identification of a design problem or need, and is followed by a thorough investigation of the topic. Following this investigation a design brief is created. The design brief is a detailed document between the designer and the client outlining all the information relating to a design project. It outlines what is required of the design and the timeframe in which the project should be completed, and may also include additional information such as material restriction, technology specification, intermediary deadlines, budgetary information, etc. After both parties have agreed to the details outlined in the brief, the designer will find as many feasible solutions to the design problem, drawing on past experiences and knowledge. The design solutions should always adhere to the specifications detailed in the project brief and the designer must thus have a critical understanding of the project parameters whilst exploring possible design solutions.

The second section of the design process, Selection and Production, relates to the selection of an appropriate design solution and the production of the design. In terms of constructivist learning theory, this section corresponds to the learner deciding which information and past experiences are relevant to understanding new knowledge. In his book *In Search of Mind,* Jerome Bruner, states (Bruner cited in Clabaugh, 2009):

> "Learning is most often, figuring out how to use what you already know in order to go beyond what you currently think. There are many ways of doing that. Some are more intuitive; others are formally derivational. But they all depend on knowing something "structural" about what you are contemplating – how to put it together. Knowing how something is put together is worth a thousand facts about it. It permits you to go beyond it ."

A learner may decide that their original selection of experience and viewpoints do not fully explain the new knowledge, and they may review additional opinions or experiences. The process of evaluating what is known, and extracting appropriate information which informs further action, clearly indicates the need for critical analysis and thinking skills throughout this section of the design process. Donald Schön (1987) refers to this process as *reflection-in-action* because learners are reflecting on what they are doing as part of the learning process and making adjustments based on this reflection.

Reflection is an important part of the design, during the design process and at the end of the project. The final review of the project refers to the third stage of the design process: Reflection, Adaptation and Reflection. Reflection as part of the design process (reflection-in-action) is a natural process during which designers continuously review what they are doing and how it could be improved. Once a design in 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 design learner must be able to gauge the success of the final design and critically review the process as a whole to identify positive aspects which can be built upon and negative aspects that should resolved or avoided. In each of the design process stages the learner must evaluate, critically, new knowledge and design choices – making critical thought a key skill for successful design.

Table 1.1 Comparison of the Design and Critical Thinking Process

Design Process	Critical Thinking Process
Context, calculation and creative exploration:	Identify problems
	Gather related information

Design Process	Critical Thinking Process
• identify the problem • investigate the topic • generate possible solutions to problem	Analyse and creatively sort through information
Selection and Production: • evaluating and selecting of a particular solution	Offer conclusions and solutions: • seeing other possibilities • evaluating the other possibilities
Reflection • continuous review of the chosen solution	
Adaption	
Reflection	

Barnes, 2011.

Comparison of the Design and Critical Thinking Process

What is *design thinking* and how does it relate to critical thinking?

Design thinking has become a buzz-word in many fields outside design, representing a combination of intense situation analysis with creative solution exploration. Design thinking is a method of approaching problematic situations, then analysing that situation and establishing or suggesting actions to create a more beneficial scenario. It differs from other ways of thinking in that it represents a wide range of creative components which are often overlooked in scientific ways of thinking and other methods of thought and inquiry (Owen, 2007:16).

As an approach, design thinking taps into capacities we all have but that are overlooked by more conventional problem-solving practices. Not only does it focus on creating products and services that are human-centred, but the process itself is also deeply human. Design thinking relies on our ability to be intuitive, to recognize patterns, to construct ideas that have emotional meaning as well as being functional, and to express ourselves in media other than words or symbols (Brown and Wyatt, 2010). The link to expression without text and words, with critical thinking, *is* design thinking. Design thinking allows for a critical evaluation of situations and possible solutions with an outcome which is not based in a written format.

Testing the waters

Industrial Design students at CPUT are required to make informed decisions throughout the design process. Although the process is supported by lecturer consultation and group feedback sessions, students are expected to develop an understanding of the design process and required decision making. Over the last few years the authors have noticed a decline in the student's ability to assess design situations and make appropriate decisions. Students also struggle to identify which information is relevant to a specific problem or project. The effect of this situation is that students seem unable to make a decision without affirmation from a lecturer at every stage of the project.

This characteristic seems to agree with findings of research on Generation Y students, also known as "the Millennial Generation" and "Generation D, the Net Generation, Digital Natives, Echo Boomers, and Nexters" (Bracey, Bevill & Roach, 2010:21). Generation Y students are those born from 1980 onwards, acceptable dates seem to be 1977 – 1982 (Bracey *et al*, 2010:21). In addition, in South Africa, these students are also among the first to have had an entirely outcomes-based school education. These are confident student, street smart students. They are techno-savvy, and have excellent multi tasking capabilities, and they "bore easily"(Bracey *et al.*, 2010:22). In fact, Bracey *et al.* (2010: 22) also state that one of the "most significant characteristics of Generation Y… is their attachment to, understanding

of, and comfort with technology". This is echoed by Weiler (2005: 46) in his article, *Information-Seeking Behaviour in Generation Y Students: Motivation, Critical Thinking, and Learning Theory*:

> "The students currently on college campuses, as well as those due to arrive in the next few years, have grown up in front of electronic screens: televisions, movies, video games, computer monitors. It has been said that student critical thinking and other cognitive skills (as well as their physical well-being) are suffering because of the large proportion of time spent in sedentary pastimes, passively absorbing words and images, rather than in reading."

Industrial design students were observed in the classroom and notes were also made regarding informal interaction with students (impromptu discussions as well as question & answer sessions). The main aim of this project was to establish the level of critical thinking exhibited by design students in their everyday classroom activities. To this end an ethnographic approach was used to document student activities through observation. Research methods were mostly 'emic' in nature as the lecturer concerned formed part of the classroom situation being observed.

From the field notes and observations, one could note that students required a substantial amount of attention and often look to the lecturer for guidance without any initial personal exploration of the situation or problem. This is significant in the educational context. They need additional support to enable them to make their own decisions, as they struggle to do this confidently. The changes in the students have been observed in the last few years. Examples of changes noticed in Generation Y students, are detailed in these three examples, from the History of Art and Design Department at CPUT (Barnes & Du Preez, 2010):

> *Example 1:*
> The project brief is a thorough document outlining all the project requirements and deadlines. This document is introduced and explained in class and students have the opportunity to read through the brief more than once, and ask questions regarding the project. During 2009 and 2010, the researchers observed a noticeable change in how students 'use' or 'read' their project briefs. Student would approach the lecturer, with the brief in their hands, and ask questions regarding the project that are addressed in the brief. These instances, noted in field and discussion notes, became more frequent. When students are asked why they are asking questions, when they are holding the document which has the answer, their response usually is that they simply thought they would "make sure".
>
> *Example 2:*
> From class observation and field notes it has also been notes that many first year students, who form part of Generation Y, lack the ability to identify information relative to a project. Students would, for example, review a section from a website or book and not be able to see how the information relates to their project. The information is mostly in clear, accessible language, and often has headings which indicate the relevance of the information, but many students seem to struggle making the connection.
>
> *Example 3:*
> When given a reading, (Gen Y) students struggle to identify the main themes or the point of the reading. Often students simply rephrase the main points from every single paragraph and offer these as the main point without considering repetition, elaboration or hierarchy of ideas. This scenario is noticeable in, for example, the answers students supply in comprehension exercises.

As the gathering and selection of appropriate information is key in critical thinking, and with the above mentioned examples in mind, Weiler (2005) sounds a warning about the "information seeking behaviours in Generation Y students" that are, or soon will be, part of our educational institutions:

> "Critical thinking is a process that is widely acknowledged in the literature to be crucial to the learning process, to cognitive development, and to effective information seeking. Most college faculty and librarians are painfully aware of how often students seem to be incapable of thinking critically about course work in general, and about information needs or information resources in particular. Evaluation and effective use of information in any form is impossible without the use of critical thinking, and so the level and quality of critical thinking are of primary concern when speaking of information seeking behaviours in Generation Y students." (Weiler, 2005:46).

There appeared to be similarities between literature concerning Generation Y students and classroom observations made by Industrial Design lecturers regarding the inability of students to make decisions or identify appropriate information. In order to establish whether Industrial design students were in fact struggling with critical thinking, as one of the modes of thinking required by the design process, a group of first year students completed the Ennis-Weir Critical Thinking Test (1985). This test, designed by Robert H. Ennis and Eric Weir, is aimed at learners from secondary school level through to tertiary level but can also be used as a teaching resource. The test is formulated within an essay structure and requires the respondent to write an appropriate response based on a mock letter. The essay response is evaluated against a framework designed as part of the test. The test has a number of focus areas (Ennis, 1999):

- "getting the point",
- seeing the reasons and assumptions,
- stating one's point,
- offering good reasons,
- seeing other possibilities (including other possible explanations),
- and responding to and avoiding equivocation, irrelevance, circularity, reversal of an if-then (or other conditional) relationship, overgeneralization, credibility problems, and the use of emotive language to persuade.

The Ennis-Weir test's focus areas (indicated above), correspond to specific criteria of the design process (Table 1.3). Although the design process is not based in a written format,

Table 1.3: Focal Criteria of the Ennis-Weir Critical Thinking test at the Design Process

Ennis-Weir Testing Focus Area	Design Activities and Processes
• "Getting the point".	Understanding the design 'problem' and what is being asked of the designer.
• "Seeing the reasons and assumptions".	Analysing the reason for the design activity and identifying project constraints and details. Developing the design brief.
• "Stating one's point".	Analysing the design brief and formulating appropriate proposed solutions. Evaluating all proposed solutions to identify the most suitable design solution for the context and other criteria. Being able to visually and verbally communicate these proposals, and the reasoning for the final selection, to clients and fellow designers.
• "Offering good reasons".	
• "Seeing other possibilities (including other possible explanations)".	
• "Responding to and avoiding equivocation, irrelevance, circularity, reversal of an if-then (or other conditional) relationship, overgeneralization, credibility problems, and the use of emotive language to persuade".	

Barnes & Du Preez, 2011.

Focal Criteria of the Ennis-Weir Critical Thinking test at the Design Process

which is used as the medium in the majority of critical thinking tests, the link between cognitive skills tested are similar.

To evaluate the basic skill of thinking critically, nine diverse (- in terms of gender, culture and home language) Industrial Design students were requested to take the Ennis-Weir test (- the Cornell Critical Thinking Test (Level Z), which is completed electronically, comprises multiple choice sections aimed at testing various aspects of critical thought). The results are indicated in the graph below (Figure 1.1):

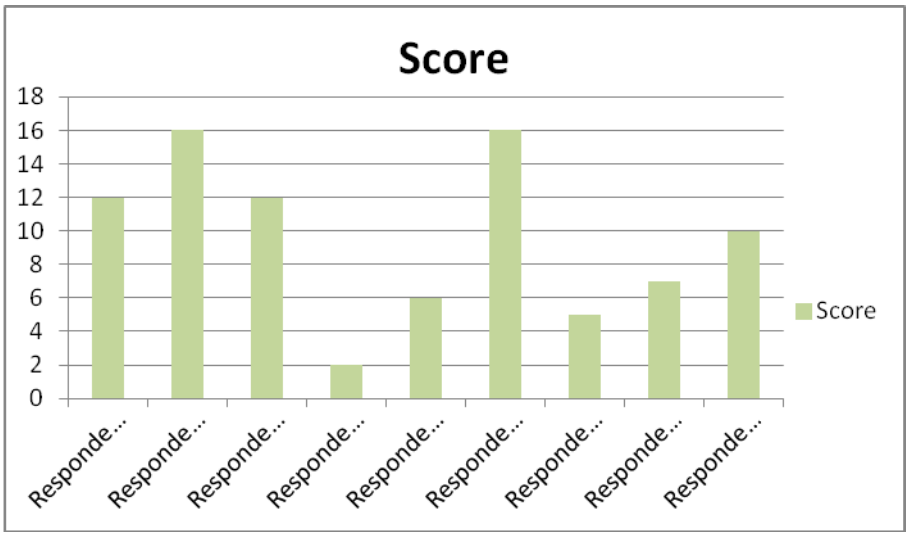

Figure 1.1: Industrial Design Student's Ennis-Weir Test Scores
Du Preez, 2010.
Industrial Design Student's Ennis-Weir Test Scores

The average score of the first year test group of Industrial Design student at CPUT was 9.6, out of a possible top score of 29. The variability of the result, measured as a standard deviation, is 4.9. The relatively low standard deviation means that the score of each individual respondent was not far from the average of the group (the mean) and supports the validity of the findings.

The average of the 2010 CPUT findings, when compared to those of a Midwestern University (USA) study documented in 1993, is quite low. The Midwestern University's Ennis-Weir study resulted in an average score of 14.6 (Ennis, 2005). Although the average score is significantly higher than that of the Industrial Design students at CPUT, the standard deviation is also higher, at 6.1 (Ennis, 2005). The higher standard deviation implies that the individual scores, achieved at the Midwestern University, were more varied. Results of a 2000/2001 study completed at a community college in Florida (USA) also reported a higher group average than CPUT's students – a mean of 11.91 was recorded in the undergraduate test group with a standard deviation of 8.61 (Reed & Kromley, 2001).

The link to critical thinking and design, as documented in this article, highlights critical thinking as one of the modes of thinking required of a successful designer. The relatively low score of first year Industrial Design students highlights a need for curriculum development which supports a focus on critical thinking skills, as well as further research to investigate the impact of generational attributes.

Reflecting on the muddied waters

In the course of the research, studio-based learning, problem-based learning, design process and critiques technique were all reflected upon as influencing factors. The role that the Generation Y students played in the Industrial Design environment had also been considered. The results of the pilot Ennis Weir test were, however, unexpected. The result of this was a serious consideration of the direction of the project, which had begun as the pursuit of critical thinking skills. While critical thinking is described as a higher-order thinking skill, solving complex design problems using mental and actual visual imagery is also described as higher order thinking. The conclusion was, therefore, that it was not possible to isolate just one form of thinking in the design process. All modes of thinking, aligned to the design process, require investigation.

Optimum thinking conditions in the mud

In her 1999 book, *Time to Think*, Nancy Kline's premise is this: the mind has grappled with or identified the problem, that same mind has the capacity to solve the problem. She firmly believes that solutions to problems identified can be found by the same person, by creating an optimum environment for thinking. One needs to create the best conditions for people to think for themselves, in order to solve problems creatively. According to Kline (1999:35), conditions that foster a "Thinking environment" include:

- Attentive listening – listening with interest and respect
- Asking incisive questions – this cuts through mental blocks that limit ideas
- Treating each other as thinking peers
- A working ratio of 5:1 of appreciation/ positives: criticism (this is been used in schools with excellent results)
- Encouragement - as opposed to competition
- Diversity – differences create quality

South African society, and particularly the education landscape, has changed radically over the last 10 years in terms of access to education. Many previously homogeneous universities have a far more diverse student body. However, owing to the complex, discriminatory past of our country, increasing diversity presents its own challenges. Some courses have a more diverse student population than others, creating adjustment issues for the minorities. Kline (1999:91) refers to the issue of sexism, and suggests that the characteristics of a Thinking Environment are in direct opposition to male conditioning:

Table 1.5: Thinking Environment Compared to Male Conditioning

Thinking Environment	Male Conditioning
Listen	Take over and talk
Ask incisive questions	Know everything
Establish equality	Assume superiority
Appreciate	Criticize
Be at ease	Control
Encourage	Compete
Feel	Toughen
Supply accurate information	Lie
Humanize the place	Conquer the place
Create diversity	Deride difference

Kline,1999.

Thinking Environment Compared to Male Conditioning

The ideal situation would be for both male and female conditioning to be disregarded, while retaining the best features of each culture. Methods to create a thinking environment

embrace diversity in the learning environment – as value is given to each person's thinking/ proposals.

The 2005 study by Laird at the University at Michigan, described in "College Students' Experiences with diversity and their effects on Academic Self Confidence, social agency and disposition towards Critical thinking", shows that all students with more experiences of diversity in the learning environment, have improved disposition to critical thinking and academic self confidence (Laird, 2005: 365). While the Industrial Design Department is not the most racially diverse environment on the CPUT campus, there are many different types of diversity – such as gender, levels of education, economic empowerment, age, as well as language, among others. Creating a thinking environment which embraces diversity should therefore be a goal, and will benefit the critical thinking disposition and academic development of all students.

Conclusion

The aim of this research project is to investigate whether the Industrial Design learning environment at CPUT supports and develops the skills that the students need for their profession. In this article, the skills required for the industrial design profession have been explained. The importance of critical thinking in the profession has been made clear, and this was further explored in relation to the design process. The explanation of the design process led to a discussion on the importance of design thinking methods, the use of which is becoming more widespread in a variety of industries. Given the importance of critical thinking, the pilot testing of the sample Industrial Design students was described, including the benefits and limitations of the Ennis-Weir testing method. The use of the test was further scrutinised in the light of the extensive use of visual imagery to solve problems, the characteristics of the Generation Y students, as well as the language limitations of the students in the South African context. While the results were surprising, the conclusion drawn was that all modes of thinking need to be considered in the design process. The optimum conditions to create a "Thinking Environment" were also described, with an explanation of the limitations of conventional thinking methods and gender conditioning. The three phase approach to the research was outlined, with a brief description of the pilot project planned for 2011.

The results of the planned pilot project could well be appropriate for many other areas of design, to enhance thinking in learning. There is no doubt it will benefit the indecisive Generation Y students, by equipping them with the thinking skills to properly evaluate information in order to make considered decisions. Therefore, the chosen methodology of relevant studio based research (the pilot project, the thinking in action, and appropriate cognitive research), in combination with the process of seeking out different thinking styles, theories and testing methods for high order thinking, should result in a responsive design learning environment – thus creating an optimum thinking environment, to best equip students to make decisions in the real world.

References

Clabaugh, G. K., ed. 2009. Jerome Bruner's Educational Theory. *New Foundations*. [online] Available at: http://www.newfoundations.com/gallery/Bruner.html [Accessed 2 October 2010].

CPUT, 2008. National Diploma Three Dimensional Design. *Cape Peninsula University of Technology*. [online] Available at: http://info.cput.ac.za/prospectus/qual.php?q=237&f=4 . [Accessed15 January 2008].

Du Preez, V., 2010. *Interview with Vikki du Preez.* Interviewed by V. Barnes. CapeTown, 4 August 2010.

Heskett, J., 2002. Design: A Very Short Introduction. Oxford: Oxford University Press.

Kline, N., 1999. *Time to Think: Listening to ignite the human mind*. London: Cassell Illustrated.

Laird, T.F.N., 2005. College Students' Experiences with diversity and their effects on Academic Self Confidence, Social Agency and Disposition towards Critical thinking. *Research in Higher Education,* 46(4):365-387.

Owen, C.L., 2007. Design Thinking: Notes on its Nature and Use. *Design Research Quarterly*, 2 (1):16-27.

Robyn, 2010. Critical Thinking Skills Lacking Among College Freshmen Around the World. Skipping Dinner. [online] Available at: http://www.skippingdinner.com/2010/07/01/critical-thinking-skills-lacking-among-college-freshmen-around-the-world/ [Accessed August 2010].

Salama, A. M. A. and Wilkinson, N., 2007. *Design Studio Pedagogy: Horizons for the Future*. United Kingdom: The Urban International Press.

Schafersman, S., 1991. An Introduction to Critical thinking. Free inquiry. [online] Available at: http://www.freeinquiry.com/critical-thinking. html [Accessed 16 October 2009].

Schön, D., 1987. *Educating the Reflective Practitioner*. San Francisco: Jossy-Bass
Weiler, A., 2005. Information-Seeking Behaviour in Generation Y Students: Motivation, Critical Thinking, and Learning Theory. *The Journal of Academic Librarianship*. 31(1):46-53.