Using Moodle to enhance Mathematics learning in Grade 10 classrooms in South Africa

Nicholas Mlotshwa & Agnes Chigona
Cape Peninsula University of Technology
South Africa
nichomlotshwa@gmail.com chigonaa@cput.ac.za

ABSTRACT

Teaching and learning in the 21st Century demands integration of digital technologies into curriculum delivery. Research has shown that integration of digital technologies into Mathematics classrooms has proved in many instances to enhance the teaching and learning of the subject. In this paper, a Learning Management System (Moodle) was for Grade 10 mathematics curriculum delivery, in particular, to develop the learner' conceptual understanding of Functions. In order to understand impact of using Moodle for teaching Mathematics, this study used an experimental research design where two different classes of Grade 10 learners participated as control (the class was exposed to traditional chalk and talk teaching method) and experimental (the class integrated Moodle in the learning process) groups. While the two groups were exposed to the same content of mathematics, it was discovered that the functionalities of the Moodle platform made the learning of the content easier. It was conclude therefore, that Moodle enhanced the conceptual understanding of functions in mathematics.

Keywords: Moodle, Constructivism, Mathematics, Functions

INTRODUCTION

Mathematics and Science are crucial to emerging economies like South Africa. According to Pia (2015:822) "Mathematics has a vital role in the classroom not only because of direct application of the syllabus material but because of the reasoning processes the student can develop". However, with South Africa struggling with learner performance in Mathematics as shown in the 2015 Trends in International Mathematics and Science Studies (TIMMS) report, there is a need to identify other useful ways of improving the teaching and learning of the subject. Studies have shown that integration of digital technologies into Mathematics classrooms has proved in many instance to enhance the teaching and learning of the subject (Joshi 2017; Hegedus et al 2016).

With the use of technology, educators and learners seek to simplify and enhance the performance of tasks. New and improved forms of educational digital technologies offer a great deal of potential, and some educational policy makers and implementers have started warming up to the idea (Howie and Blignaut, 2009). Groff (2013:1) argued that it is commonplace today for many educators not being satisfied with the traditional forms of education that have evolved through the end of the last century because they are adequate to successfully prepare learners for the 21st Century skills.

In response to the need to enhance the teaching and learning of Mathematics, in South Africa, the Western Cape Education Department (WCED) e-Learning Unit initiated the use of the Moodle (Modular Object Oriented Dynamic Learning Environment), an online Learning Management System (LMS). This Moodle platform can be used for free by any school in Western Cape, but the system has not yet been fully utilised by all schools. Furthermore, Moodle has a lot of functionalities that can be used by both educators and learners in a classroom environment. In 2013, a changed strategy by the WCED saw the Moodle platform rolled out in selected schools in the Western Cape Province as a Moodle focused pilot school project. Training and advocacy of the system was done with these schools, and some began using this platform in May 2014.

This paper aims at exploring the benefits of integrating Moodle into Mathematics classroom for the development of conceptual understanding of Functions. The question the study is answering are:-

What are the benefits of integrating Moodle into mathematics classroom in particular the development of conceptual understanding of Functions?

How better is the integration of Moodle into mathematics classroom than chalk and talk method?

To answer the questions, the study used an experimental research design where two different classes of Grade 10 learners were conveniently picked, one as a control group (the class was exposed to traditional chalk and talk teaching method); and the other as experimental group (the class integrated Moodle in the learning process). The two groups were exposed to the same content of mathematics. However, it was discovered that the functionalities of the Moodle platform made the learning of the content for the experimental group easier. The learning was enhanced as the learners were able to make use of the Moodle functionalities that simplified the learning of functions in mathematics.

LITERATURE REVIEW

Many studies have been done to harness learners' interest in Mathematics. However, it is evident that most studies concentrate on evaluating the ability of learners so that they are stimulated by ICT to become attracted to the subject. The ICT resources are used to unwind their negative attitude towards the subject as it is known that most of the digital natives are highly interested in technology (Leendertz, Blignaut & Niewoudt, 2013). Notable study of using DVD in classrooms were conducted in 2010, (Padayachee et al., 2011). Learners used DVD to blend with learning and remarkable results were obtained. Technological advancements have greatly affected the way teaching and learning is conducted in various learning institutions (Chigona & Dagada, 2011). Frankl and Bitter (2012:80) note that "today's learners are more (inter-)active and engaged in the virtual world". Hence teachers need to take advantage of the available technologies to reach out to the learners within their social spaces (Chigona, 2015)

E-learning Theories

Although the spread of digital resources has been uneven across countries and within communities, the use of e-mails, chat rooms, blogs and a variety of social networking software has increasingly become a main feature of youth culture (Frankl & Bitter, 2012). In order to achieve results in the integration this learning process, education specialists have been exploring the pedagogical advantages and disadvantages of e-Learning practices. They came up with different e-learning theories that support the phenomena of using technology in classroom. A constructivist approach, as outlines by Sultan, Woods and Koo (2011), asserts that learners construct their knowledge based on their interpretation of events and using previous experiences. The foundations of this approach can be traced back to the work of Vygotsky and Piaget. Piaget developed the theory of cognitive constructivism after observing that: "Children are active thinkers constantly trying to construct more advanced understandings of the world" (Siegler & Ellis 1996: 211). Through constant observation, it was observed that instructors in e-Learning should strive to develop strategies and learning set-ups that create a constructivist environment for learners in the classroom. It was discovered that it would be incomplete when the concept of scaffolding is not incorporated into the construction of knowledge. Scaffolding entails the provision of tools (digital and conceptual) that learners can use to solve certain tasks or understand topics studied. Technical scaffolding might entail the provision of online-based resources, such as websites, online tutorials or videos, which learners can resort to when they need assistance with a particular topic, reading, concept or any given task (Kalina & Powell, 2009). At its most basic form, scaffolding might include a set of systematic instructions to guide the learners, or breaking the tasks into smaller chunks that allow for easier understanding, boosting the confidence and learning capabilities of learners, and sets them up for good assessment outcomes. Scaffolding allows learners to apply their mind before moving into the next learning level.

The Student Centered Technology Rich Learning Environment (SCenTRLE) model.

The Student Centered Technology Rich Learning Environment (SCenTRLE) Framework was developed by Hirumi in 2002. According to model developer learner-centered learning principles such as: generative learning, situated cognition, problem-based learning and performance assessment form the pedagogical foundations for the SCenTRLE (Hirumi, 2002:11). Such pedagogical approach stress the importance of learners' past experiences, exploring individual needs and interests, promoting active participation, stimulating higher-order thinking, and encouraging life-long learning". This study is underpinned by SCenTRLE whereby the three levels of the model influenced the design of the treatment to be given to the experimental group. The three levels and their constitutive elements were used because they were found suitable for a 21st Century technological classroom environment set up. The 3 levels are summarized below in Figure 1.

LEVEL	TARGET	NOTES
LOWER LEVEL	Learner instruction	This level deals with instructions that the leaner acquires from the instructor of what the section or aim of learning is about and what is expected of them
MIDDLE LEVEL	Learner Human Interaction Leaner Non-Human Interaction	The learner acquires knowledge from humans around them for example, instructor and peers. Learners also gain information form non-human gadgets like computers and smartphones.
UPPER LEVEL	Learner self-Interaction	The learner uses the instructions from the two levels above to self-educate, motivate and ascertain readiness to tackle complex tasks without any assistance from the environment around him.

Figure *1*: Three levels of Hirumi's e-Learning framework

Technology in Mathematics

Literature has shown that when ICT is integrated in Mathematics teaching, it becomes very effective and helpful in delivering content. The use of Internet and audiovisual instruments that are embedded within the ICTs programs motivates learners towards learning, helping learners to become independent (Joshi, 2017). Software developers have since made it easier for learners to present their work with the development of graphing tools like Geogebra, which assist learners to accurately draw and interpret graphs within a short space of time, (Joshi, 2017). Applications that are designed to work with other ICT tools, like Geogebra, help learners to observe, represent and interact with Mathematical concepts (Joshi, 2017). Chrysanthou (2008) ascertained that Geogebra in Mathematics makes graphs and other shapes look 'pleasant' and practical. In their book, Hegedus *et al*.(2016) described Geogebra learners who were drawing Euclidean and Cartesian diagrams as "Mathematical cyborgs who like to express themselves through tools". Teaching and learning using technology is very beneficial in saving time. Currently lessons in Mathematics are averaging 40 minutes, making it difficult for an educator to attend to all learners in a particular lesson. Pachler (2001) stated that computers allow very quick storing, displaying, analyzing and synthesizing, allowing learners to have more time to think about what they have learnt.

RESEARCH DESIGNS

In this study a quasi-experimental design of non-equivalent pre-test/post-test design was used , where according to Jackson (2014: 146), *quasi* means "having same but not all features", and *experiments* means it resembles even though it is not following the proper experimental procedures. In this case, this design best suited the classroom set up as the researchers selected learners who populated the experimental and the control groups as units, and the groups were not split randomly as is normally done in the typical experimental design. This is because it was impossible to split a standard set of learners in a classroom into randomly assigned groups. The underlying feature here is that the protocol borrows from and approximates an experimental design. A quasi-experimental design also necessarily involves the application of an intervention in the experimental group and the following of events in the control sample. An intervention involves any set of protocols or programs closely, observed for their effects.

Two groups of learners in two classrooms doing Grade 10 were therefore selected. The groups were considered non-equivalent as groups were randomised (Cohen, Manion & Morrison, 2007). Non-equivalent groups mean that the learning in class may not be balanced equally among the control and experiment group. In addition, non-equivalent groups mean that participants' experiences during the study may differ. Some will fit in the experiment, while others will think otherwise. These two sampled classes had an equal chance of being selected for traditional teaching model and the experimental teaching model (Moodle). As school authorities equally distributed the classes at the beginning of the year, one class was chosen to be the experimental class and the other a control class, without using any characteristics. These two classes were then colour coded, with one class of 36 learners named 10 *BLUE (control)* and the other one of 39 learners named 10 *GREEN (Moodle).* With this kind of design, it was assumed, for instance, that the differences in the extent of learning that would result in each of study population groups would depend on the effectiveness of the two teaching methods, namely the traditional method of "chalk and talk" versus the one

where the Moodle platform is used for learning. The two groups were given identical assessments and marks were equally evaluated and deviations and differences were analysed and compared before (Pre-test) and after the intervention, the same process of analysis was repeated (Post-test). The mean differences were analysed using statistical analysis of the t-distribution and the analysis of variance (ANOVA), in order to establish the impact of the intervention. The t-distribution was analysed with the software *QuickCalcs* (online). This was used to analyse the two classes that wrote the pre- test. The pre-test/ post-test allows researchers to analyse the differences that can exist between the two groups. Additional data was extracted from the Moodle surveys, class participation and the login patterns in Moodle. All these data sources were used to reach conclusion in this research.

The main data collection method was extracted from quantitative methods from pre-tests and post-tests and other data sets were extracted from within the Moodle platform. Learners were able to complete surveys about what they had experienced when lessons were conducted and possibly what they felt could be improved. The tests were written in stages, the initial stage (post-test stage), where learners were tested based on prior knowledge so as to establish whether the two groups where similar. When treatment was administered in one class and the other class taught the traditional way, learners were tested (the pre-test stage), and the results were compared using the tests mean to ascertain whether there was a significant difference between the two methods. Communication with the facilitator was non-formal, learners consulted when the teacher moved from around in class, checking on the progress of work. Learners would also use instant messaging which was embedded within the Moodle interface. All the records were automatically saved and were retrievable for analysis.

Analysis of data

A hypothesis was developed where

$\mathbf{H_O: \mu_1=\mu_2}$ (Null Hypothesis that the two means are equal)

$\mathbf{H_1: \mu_1\neq\mu_2}$ (Alternative Hypothesis that the two means are different)

The decision between H_o and H_1 was based on examining the two mean values to see whether the discrepancies were caused by the effect of the experiment or were they simply different because of sample variability (Peck, Olsen & Devore, 2012: 836). The F- distribution statistic was used to analyse the variance of the two samples and as 75 learners were used, the degrees of freedom of 73 was used to calculate the value that, If the F value is more than the critical value at 73 degrees of freedom, then it was to be statistically significant to reject the null hypothesis and conclude that the mean values were different. If the F value was less than the critical value, then there would be no significant difference between using Moodle and the traditional method of teaching (Wiersma et al. 2005:387). Online survey was analysed using a Likert scale, results where shown graphically, and interpreted using a key that was available within the Moodle platform.

RESEARCH FINDINGS AND DISCUSSION

The results of the pre-test

The two groups were given the same question paper, where learners were expected to use prior knowledge about Functions, (in Grade 9 known separately as Straight line Graphs and Patterns). The pre-test was marked out of 30 with the pass mark being 50%. 15 out of 36 learners in class Blue passed the test, while 17 out of 39 learners in class Green passed the test. The results of the two groups were analysed using the T-distribution to compare group average to determine whether there was any significant difference between these two classes. The results were summarised on the table below.

CLASS BLUE (Control) **CLASS GREEN (Moodle)**

MEAN	13,94444
PASS	15
FAIL	21
Pass Rate	41,66667
VARIANCE	26,99691
STANDARD DEV	5,195855

MEAN	14,71795
PASS	17
FAIL	22
Pass Rate	43,58974
VARIANCE	27,89481
STANDARD DEV	5,281553

Results from QuickCalcs website used to analyse the two classes that wrote the pre-test confirmed that, Group One (Mean 13.944444 Class Blue) and Group Two (Mean 14.71795 Class Green), the probability value (P-*value*) was greater than the significance level of 0.01 or 0.05, this led to a statement that the difference between the two means was not statistically significant to conclude that the means are different. As Triola, (2001:389) stated , we therefore fail to reject the hypothesis .This is possibly because the two classes were coming from a population in Grade 9. Their content knowledge of Functions at the beginning of this study was at the same level. This uniformity of these two classes made it possible for them to be used for this research.

Post-test results from control (traditional) group and Moodle (experimental) group

Normal lessons were conducted in control class, with lessons that were 40 minutes long (twice a week 80 minutes long) being held as per Curriculum and Assessment Policy Statement (CAPS) requirements. The *Classroom Mathematics Grade 10 Learner's Book* was used as a primary reference book. Interaction of peers in groups was also noted during lesson delivery, as learners assisted each other as they worked on complex Mathematics questions. Learners were then given tests periodically to evaluate their understanding on what they have been taught. Data from Moodle class was collected from the platform functionalities and applications that were embedded within the platform mainly, hot Potatoes, Screen-casting, Geogebra, Multiple Choice Quiz Maker and communication tools. Hot Potatoes allowed learners, after studying the content, to do the exercise by completing blank spaces. The advantage of Hot Potatoes tool was that, after completing the exercise, the results were immediately available to the learner. This meant that time was saved, as the learner who previously had to wait for their work to be manually marked by the educator, could see the results immediately.Screen-casting tool enabled the researchers to create content videos with voice over to be watched to understand concepts any time that they found suitable. Traditionally, lesson times are fixed, usually 40 minutes long. However, in a class with different learning abilities, the restless ones tend to miss most concepts during class time. The lesson was able to continue even during the absence of the educator, as learners were observed playing the videos even after the lessons for understanding. The classes with no videos relied on the presence of the teacher, making it difficult for the "quiet or reserved" learners to ask for clarification. Moodle also had Geogebra embedded within ,an interactive geometry software, which allows the user to enter equations directly and draw accurate graphs and diagrams (Hohenwarter & Fuchs 2005). The researchers created a link of Geogebra, which enabled learners to draw functions and practice for examination purposes. The learners were able to replicate diagrams accurately, made it easier to understand. The graphs drawn using Geogebra were more accurate compared to one that were drawn using free hand. The one drawn by Geogebra clearly showed detail of the graphs, whereas the free hand drawn graph is not very accurate. The time taken by learners to complete the task was also quicker as compared to the free hand drawn graph. More time was now channeled to other complex concepts of the topic than drawing. Communication between peer (learner) to peer and between peer to instructor (educator) was important throughout the research period. As Hirumi's framework (2002) outlined it, the three levels of integration play a pivotal role in teaching and learning. Learners used the non – human source (Moodle), the instructor and peers to construct knowledge at the rate at which they preferred. The learners were able to communicate with the educator when seeking clarification on concepts, and communicated with their peers, sharing information. Learners were able to complete the online survey, where questions on the following aspects were asked on:

i. Relevance- Did the platform play a pivotal role in teaching and learning?

ii. Reflective thinking- Did it allow learners to think critically? Were they independent thinkers?

iii. Interactivity- Did the platform give them the freedom to interact between their peers and educator?

iv. Tutor activity- Was the tutor helpful?

v. Peer support- Were they able to get or offer support from their classmates? Were they able to evaluate each other?

vi. Interpretation- Did the instructions of what to do, make sense to them? Were they able to interpret messages they received from their peers or educator?

The learners' responses showed:

Relevance: Learners chose above 'sometimes' level to just above 'often' level. This means that the learners viewed the use of Moodle as playing a major role in their studying of Mathematics. It appears to indicate that learners felt Moodle gave them the ability to be interested in the topic of functions.

Reflective thinking: The choice was between 'sometimes' level and slightly above the 'often' level. It shows Moodle assisted learners in thinking critically, thereby building the knowledge that enabled them to solve complex tasks. This was evident on the quizzes they attempted.

Interactivity: The choice was above the 'often' level, indicating that learners were able to interact between each other, it was evident during the Moodle session where learners were seen moving around assisting each other. This evidence of social constructivism from findings presented by Kotzer & Elran (2012) is reiterating that Moodle is a suitable tool of teaching and learning.

Tutor/Facilitator Support: As it is shown by the graph, the tutor support was scored slightly above the 'often' level. Learners were satisfied with the motivation they got from their tutor. The tutor monitored the learners, offering support to learners who had problems with the system, and most importantly, explained complex activities to them as individuals, and responded to their messages promptly.

Peer Support: The peer support scored below but above "sometimes" level. Learners did not have time to evaluate each other as they spent more time on their own work. They did however; get praise from the facilitator as he checked on the work they completed.

Interpretation: The participants scored the interpretation above the 'sometimes' level and slightly below the 'often' level. Learners were able to interpret messages they sent each other via the chat platform. Messages were simple and mostly directed to friends or the educator. These messages were content based and were most frequent when they were preparing for a quiz or a test.

Overall results of the online survey showed the enthusiasm in using Moodle and learners were able to score the platform above the 'sometimes' to 'often' levels. The choices by learners who took part in the online survey seem to suggest that was indeed evidence of learning within this group of learners. The survey showed that learners were motivated by the immediate feedback as their results were immediately available to them and they could easily go over the concepts they did not understand. The educator was able to receive messages even during after-hours. This became an advantage, as there was no need to wait for next day for the problem to be solved. The tests that were administered to the learners in both classes were analysed in two ways using the Analysis of Variance (ANOVA). The first comparison was comparing the test BEFORE the research and AFTER the research, whether there was any difference in marks between the two tests. The second comparison was comparing the performance of the two classes against each other, thus the two pre-tests BETWEEN each groups and the two post-tests BETWEEN the two groups. The table below shows the results of ANOVA conducted for the tests.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Before Moodle	36	502	13,94444	27,76825
After Moodle	36	719	19,97222	30,02778

Before Traditional	39	574	14,71795	28,62888
After Traditional	39	600	15,38462	28,40081

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1077,443	5	215,4885	7,620955	0,0000012711	2,255283
Within Groups	6192,397	219	28,27579			
Total	7269,84	224				

The ANOVA tables above compared the two tests that were written by the two groups, namely pre-tests (*before Moodle and before Traditional*) and the post-tests (*after Moodle and after Traditional*). The conclusion from the analysis based on the F-statistic of all the two tests after combining their variances, showed that the means of the tests were indeed different. The two tests after intervention (post-tests) were also analysed by ANOVA as shown below,

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
After Moodle	36	719	19,97222	30,02778
After Traditional	39	600	15,38462	28,40081

ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	393,9837	1	393,9837	13,50144	0,000452	3,972038
Within Groups	2130,203	73	29,18086			
Total	2524,187	74				

According to Triola (2001:618), conclusion of the analysis of variance was based on the following:
If P-value ≤ 0, 05 then reject the null hypothesis of equal means.
If P- value > 0, 05 then fail to reject the null hypothesis of equal means.
The results between the two groups' assessment after the research shows that the P-value (0, 00452) is less than 0, 05 and F statistic (13.50144) is excessively larger than F_{crit} (3.9720).The analysis suggests that the null hypothesis was rejected. The researchers concluded that, as the two means were different, the use of Moodle to teach functions was shown to be effective. The pre-test and post test results showed a marked difference. This appeared to indicate that learning took place. There was also a difference compared to the group that used the traditional ways of teaching. The tools of Moodle played a major role on these results as the learners who were frequently using the platform were seen to have better results. The findings in the study singled out a variety tools that were pivotal in the research, which made it possible for learners to get better scores than the traditional method. Learners were able to interact independently with the platform and the majority of them were able to use the tool easily. Learners were observed communicating with the peers and with their educators. Learners spent different times understanding a concept as they understood differently and there was no pressure on learners to move on to the next concept as they

had full control of how much they could study. The Moodle platform was also used to identify where learners experienced problems. The educator was able to track the sections where learners struggled by using the low marks that learners got on certain sections. This information was used to prepare remedial work, adding emphasis on unclear concepts. The learners were able to use chat tool mostly on content related issues, even though occasionally they used it for social communication. This tool was very useful for learners with barriers of communication in normal lesson. They presented their problems via the chats, ensuring that the learning process is not broken down. The chat platform was important, as there was no need to wait for the next lesson to understand a concept or to give other learners *hints*.

Towards the end of the experiment the learners were able to conduct an online survey. Learners were able to log in at any free time they had to answer the questions. Overall results of the online survey above showed the enthusiasm in using Moodle and learners were able to score the platform above the 'sometimes' to 'often' levels. The choices by learners who took part in the online survey seem to suggest that was indeed evidence of learning within this group of learners.

Benefits of using Moodle

Learners were found to be able to use the Moodle platform to construct knowledge independently with minimum supervision. The integration of the technology enabled learners to *discover* concepts, which assisted them to solve problems related to the topic. The implementation of Moodle in classroom saw learners have a one-on-one with their problems via the management system. The platform made the following learning processes easy:-

i. **Completion of tasks** -Moodle platform measured learning in various ways. The facilitator was able to trace how the learners completed exercises and quizzes, which areas in these tasks they struggled with. The rate at which learners completed tasks improved as learners knew that the results were available instantly.

ii. **Interaction with peers**- the use of communication forums made it easier for learners to consult each other without any barriers before engaging with the facilitator. Learners who understood concepts were seen sharing information during lesson time and discussion forums. Thus, they were able to form a community of practice (Chigona, 2013)

iii. **Testing of content**- As the researchers noted on the results of quizzes, scores were showing improvements as the lesson progressed. The results of post-tests also showed a great improvement in the understanding of the functions as compared to learners who only used the traditional method. This was possible because the learners were using the platform to re-teach themselves using videos etc., as it was easily available whenever they needed to learn.

The use of the platform allowed learners to be active authors within the environment by providing a platform from which to share ideas via individual and collaborative efforts (Ke & Hoadley, 2009 in Aranda, 2012:26).

Conclusion

Comparing the learner performance from the control group that was not exposed to the Moodle platform and experimental group that used the platform, The integration of Moodle to the mathematics classroom has shown that learners could be more engaged in the learning and be able to construct knowledge independently with minimum supervision. The implementation of Moodle in classroom encouraged the learners to form communities of practice where peer tutor and tutee relationships developed. The advantage of such relationship was that advice from the more knowledgeable peers on how to work out some problems was accepted readily by the other learners. This made the learning and development of conceptual understanding of functions in the mathematics class easy and quick among the learners who used Moodle. The findings of the study show that the integration of technologies into

mathematics curriculum delivery has the potential to enhance the learning. Therefore, teachers who have access to Moodle should integrate it into their curriculum delivery so many learners could benefit from the interaction among themselves on the platform.

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