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Comparing a Hybrid Mathematics Course with a Conventional Mathematics Course: A Case Study at a University of Technology

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ABSTRACT This study compares student performance in an undergraduate mathematics education course using a Traditional Learning Model and a Blended Learning Model at the University of Technology. The control and experimental groups consisted of 150 students in each group. Student examination scores from both groups were analyzed quantitatively. A random sample consisting of 40 students, from the Blended Learning Model group, was clinically interviewed and a qualitative analysis was performed. The Theory of Connectivism informed the method used to analyze the data. The quantitative analysis indicates that the students performed better using blended learning. The qualitative analysis indicated that the students preferred the blended learning in terms of resources, communication and collaboration. The study has implications for both curriculum development and pedagogical considerations for the training of pre-service secondary school mathematic teachers in a 21st century undergraduate course at a University of Technology.

INTRODUCTION

The experience of the researchers at the University of Technology where the research was conducted is that students are taught mathematics using the lecturer-centered learning method. Naidoo and Naidoo (2007) found that lecture-centered methods used to teach mathematics at a University of Technology produced structural errors (principle or concept not understood) in algebra. Students are engaged in memorization and routine thinking. Additional contributing factors are the poor matriculation mathematics results and underdeveloped pre-knowledge frames in algebra and elementary differential calculus. In an earlier study Naidoo (1996) deduced that in a traditional classroom, first year mathematics students study by rules. They do not enjoy mathematics and end up being demotivated. Lecturers tend to teach mechanistically and produce standard type solutions to standard type problems. Mathematics is not a specialist subject at a University of Technology and little time and attention is given to the study of mathematics. This contributes to the "poor" understanding of critical concepts that are essential for extended learning, a type of understanding that is needed to support an increasingly advancing technological world. Further it has been noted that the lecturer's pace was at most times too fast for the average student. Little or no time was dedicated to revisiting basic concepts that may have been confusing to students. Students were kept busy copying items from the whiteboard or listening and noting oral discussions.

Research on the teaching and learning of mathematics using the computer laboratory gave a measure of success, especially in graph con-

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struction and numerical solutions Naidoo and Naidoo (2011). Although students were performing better than the traditional group, they were still making structural and executive errors (unable to carry out a calculation).

Assessment is a key indicator used by lecturers to identify the nature of students' understandings and possible misconceptions. Diagnostic tests can further assist lecturers to develop specific teaching strategies to address such problems and improve conceptual understanding.

Students who lacked pre-knowledge frames (Naidoo and Naidoo 2007) or process-object pairs (Rasmussen and Zandieh 2000) may be motivated to revisit the pre-concepts. Web based technology (WBT) and open education resources (OERs) provide a medium for disruption in pedagogical practice at a University of Technology. The University of Uyo (Awodeyi et al. 2014) adopted a blended learning pedagogy to teach a pre-algebra course and found that this strategy improved students' achievement. In another study in the Philiphines, Alday and Panaligan (2010) indicated that e-learning enhanced student interest and reduces math anxiety. The study by Manzano (2002) found that e-learning enhances individualization of the learner. Some reasons for choosing the Blended Learning Model (BLM) given by Graham (2006) include pedagogical richness, access to knowledge, social interaction, personal agency, cost effectiveness and ease of revision. Others like Reed (1993) mentioned that a BLM must encourage the learner the capacity to change and it must be learner centered. It must encourage the learner to be active rather than passive. The pedagogy of learner centered approach and a curriculum, which is resilient yields discovery learning. Discovery learning motivates students to construct their own knowledge as autonomous learners.

On the other hand, Chigona and Chigona (2013) claim that South African pre-service teachers are under prepared for the use of Information and Communication Technology (ICT) in schools. Students' teachers should be adequately digitally literate before they are to engage in technology enhanced learning of mathematics.

"Blended learning is a formal education program in which a student learns at least in part through online delivery of content and instruction with some element of student control over time, place, path, and/or pace and is at least in part supervised by a bricks and mortar location" (Watson et al. 2011: 11). BL is contextualized in the virtual, as well as the actual classroom, so that learning initiated in the classroom can continue at any time in any place where there is Internet access.

It is important for the lecturer to consider the web based resources (WBR) and how to combine WBL with face-to-face and then consider the motivation factors. The motivation factors maybe:

- Interactive tutor or mentor approaches such as classroom instruction, live virtual classes, webinars or discussions.
- Text-based material, web-based site, simulations and portals.

There should be a balance between experiential learning, guided mentoring and collective reflection, developing nonlinear and associational links in resources, design of experiences that match individual needs and preferences.

Researchers have found that motivation, communication, and course design are three factors that contribute to the overall success of blended learning courses and students' satisfaction with blended learning courses (King and Arnold 2012). Others found that blended learning courses have the potential to incorporate the strengths of synchronous (real time interactive communication) and asynchronous learning (not real time such as emails) (Ho et al. 2006; Vaughan 2007).

Khan (2005) refers to BL as a combination of students' needs, technological feasibility, and a professional preference toward face-to-face instruction to provide a perfect environment that combines the best features of face-to-face, videoconferencing, and online instruction. These media are designed to complement each other and promote learning processes.

Blended learning can be defined as a delivery method that combines a variety of traditional and non-traditional instructional techniques, tools, and approaches to design, develop, manage and evaluate the learning process; and a blended program is one where between (30-79%) of the program content is delivered online (Allen et al. 2007). There are three approaches to BL (Valiathan 2002)—skills driven, attitude driven and competency driven all of which are flexible, accessible, feasible and economically viable. This type of approach could assist in preparing pre-service teachers to meet with the challenges of

secondary school mathematics both at university and school.

Bonk and Graham (2012) emphasize the central role of computer-based technologies in blended learning models where both traditional and distributed learning systems are combined. The transition must use a suitable blend to cater for student adjustment to new learning spaces.

The introduction of a BLM at the University of Technology, School of Education to teach undergraduate mathematics (MTMC 101) is influenced by the University Strategic Plan Durban University of Technology(2013). The key challenge was to increase the number of online courses offered at the University in the next three years. At the School of Education, staff and students have been involved in extensive training to use online courses on Blackboard (BB), the Learning Management System (LMS) of choice at the University of Technology. Pratt (2005) researching writing skills at a University of Technology indicated that communication using text in an online setting is equally effective as discussions in a face-to-face setting. Mathematics education can be fast-tracked provided discussions focus on academic rather than social chitchat (Makhubu 2015). "Social" refers to social mores or conventions governing knowledge construction, rather than interpersonal social interactions (Gutteridge 2013). The Internet extends these from parochial mores in local college contexts to those of the global learning community. There are more resources available via the Internet than in the physical classroom or library, and thus more data in which ideational content can be generated (Shaughnessy 1979). Finally, use of the Internet affords students a far wider range of feedback on their academic performance, as not only local peers but also external peers and subject experts can be drawn into giving advice and support. Blended learning can thus combine the best features of traditional instruction with the enhancements offered by online resources. Referring to blended learning at a University of Technology, Pratt (2005) states that the challenge in mix-mode delivery is to arrive at a blend of resources and activities, which has the potential to enhance learning. The blended learning environment combined face-to-face sessions together with computer interaction to complement traditional lectures. The blended learning resources have capacity to shape resources and approaches to the unique needs of the learner and to match their learning styles to the process of learning.

Theoretical Framework

Trends in learning show that the parameters of learning are now defined by:

- Learners entering into unrelated learning fields over time.
- Informal learning is like learning through communities of practice, personal networks, and through completion of work-related tasks (Siemens 2005).

Social network analysis (SNA) (Wasserman 1994) is an additional element in understanding learning models in a digital era. An individual student can make connections with particular members in the group and the problem at hand. By raising issues using the discussion forum to communicate with each other, a network is formed. The connectivist theory offers four key principles for learning of autonomy, connectedness, diversity, and openness (Tschofen and Mackness 2012). These principles apply to the BLM and provide the essential elements to test pedagogy and support student-centered learning.

Learners are active in constructing their knowledge and making meaning to concepts. The LMS encourages connectedness, socially adept networks and collaborations and this pedagogy allows learners to construct their own meaning by transforming experiences. The learners' sharing of points of view allows for greater capacity to build knowledge using this interactive model. Connectivism is the thesis that knowledge is distributed across a network of connections, and therefore that learning consists of the ability to construct and traverse those networks (Downes 2012).

The starting point of connectivism is the individual. Personal knowledge is comprised of a network, which feeds into organizations and institutions, which in turn feed back into the network, and then continue to provide learning to individual (Downes 2005). In a sense the constructivist based pedagogy is similar to connectivism, which develop learning processes for connecting specialized nodes or information sources, encouraging learning and knowledge in a diversity of opinions and developing a capacity to know more rather than focus on what is known. The connections will facilitate continual learning. The learner will inculcate the potential to relate fields, ideas and concepts. The

learning space is transformed into a more connectivist one which is unconstrained to the traditional narrative in its knowledge transfer. It is potentially mobile, more strongly collaborative, with a flexible design. Group problem solving and collaborative tasks leading to hands on learning activities with an experiential focus are the aims of the blended learning system.

METHODOLOGY

A control group and an experimental group were selected for the study. The control group was taught using the Traditional Learning Model (TLM) based on five lectures per week for twenty-eight weeks. The experimental group was taught using the Blended Learning Model (BLM). The sample size for the control was 150 students and experimental group was also 150 students. The learner profile of the students at the School of Education indicated that learners were between 18 and 22 years of age, digitally literate and mobile, flexible and socially collaborative in their learning.

The researcher used mixed methods (Creswell 2013) to analyze the data sets. The examination scores were analyzed quantitatively using line graphs. Forty students were randomly selected from the BLM group and clinically interviewed. Participants were asked about their experience, attitude and collaboration using open-ended questions.

The levels for questioning, according to Bloom's Taxonomy (Huitt 2004), for each of the cognitive levels knowledge (5%), comprehension (10%), application (25%), analysis (25%), synthesis (25%) and evaluation (10%).

The scoring procedure used followed the marking memorandum of each examination and the student scripts were subject to external moderation, the usual requirement of all assessment at the School of Education where the project was located. The final marks after moderation were used for the quantitative analysis. Moderation of examination scripts was done externally by an appointed moderator. The external moderator confirmed consistency of the marking and indicated areas of concern regarding student performance. The quantitative data was arranged in the intervals of 0-9, 10-19, 20- 29, 30-39, 40-49, 50-59, 60-69, 70-79, 80-89 and 90-100.

RESULTS

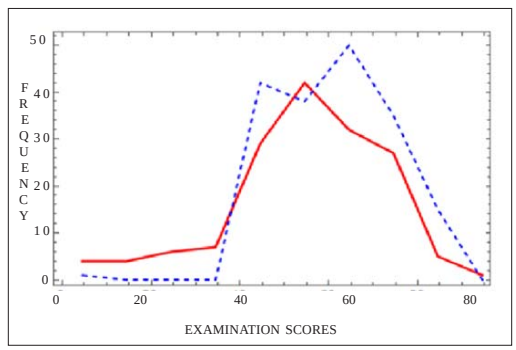
Table 1 shows the data from the examination analysis for both groups.

Table: 1 Mean and standard deviation for TLM and BLM groups

(100% teaching and learners)	*(40% traditional teaching and 60% blended learning)*
Mean X=55.00 SD=17.40	Mean X=61.01 SD=13.19

Hypothesis Test

A hypothesis test was performed on both the TLM and BLM groups to determine whether the scores were significantly different. The hypothesis test indicates that at a ninety percent level of confidence the scores were significantly different. Above a ninety percent level of confidence (95%) the results suggest that TLM and BLM scores are not significant. Figure 1 shows the percentage scores for both groups:



Key: Complete Line: TLM Broken Line: BLM

Fig. 1. Frequency graphs of examinations scores for TLM and BLM groups

The qualitative data considered student attitude and opinion about the BLM. The responses were categorized into communications, resources and collaboration.

Below are some excerpts exhibits, Online Distance Learning (ODL) categories and comments:

"I found that BB helped me check out problems with others in the class. It was easy to send messages and get instant feedback, unlike waiting for the lecturer."

[Communication and collaboration]

Tracing this student performance to the score intervals shows a mark in the interval 50-59. This indicates that collaboration is beneficial and peer assistance is important in the learning process.

"You can learn a lot this way because you can ask others when something is confusion."

[Collaboration]

This student had a score in the interval 60-69. The student used the collaborative tools to improve learning and clear doubt. This can be also associated with autonomy and connectedness. Although the student is responsible for their learning they need assistance from others to support their learning. Collaboration was good and easy and this encouraged learning.

"I still feel that I need to see the lecturer to sort out my queries. I do not doubt my friends input, but what if they too are wrong."

[Communication]

Here it is seen that some students still see the lecturer as a key source of knowledge. It also shows how traditional methods have been entrenched into the student's mind over time. There are sufficient online resources for the student to elicit answers to questions. It may be that the student has insufficient digital literacy skills due to prior learning in a traditional mode only.

"The learning with computers has inspired my learning. I feel this is the way all our courses should be done. It is easy and a fun way to learn, provided there is no load shedding."

[Resources]

Working in a digital environment gives students inspiration and is seen as a fun way of learning. Students that are motivated tend to progress through course material with ease. The tools that aid the activity creating a rich microworld of experience for the student.

"I think that the lecturer must insist that all students have a laptop so we can learn anywhere on the campus with wireless access or we can save the files and open them when there is no Internet access."

[Resources]

The student embraces flexibility and asynchronous learning.

"There are a lot of resources to help us with our work. Google is easy to use as well. Most of us like this way of working, you can do the work anytime and slowly as well."

"I used other sites for examples to help me understand something. Also help from students made me learn more. The Online Classroom experience is a better way of learning"

[Resources, communication and collaboration]

The Blended component is time and place independent. It refers to the openness of the course providing additional resources to students.

DISCUSSION

In Figure 1, 25 students in the TLM group and one student in the BLM group scored less than forty percent. This shows that the TLM students had limited connections with each other and have not had access to a network that could have supported their learning. In the online environment students had ample opportunity to increase their network not only with members of the group but also creating new connections using the Internet. The one student from the BLM group rarely logged on to the online class. This significant shift in the BLM student scores at the lower end of the graph can be attributed to the social networks created by these students.

Relatively the students in the BLM obtained higher scores in the forty to one hundred percent range.

At the maximum point on the BLM graph at sixty-five percent the number of students was 50. At this point the TLM graph indicated 31 students, which is substantially lower. The maximum point for the TLM graph was at forty-one percent with 41 students and at this point the BLM graph indicated 38 students, which is approximately close.

The hypothesis test at a ninety percent level of significance indicated that there is significant difference in scores between the BLM and TLM students only. The mean for the BLM students were greater than the TLM. The standard deviation for the BLM was smaller than the TLM indicating less spread in the scores for the BLM students.

As part of the qualitative analysis, tracing student responses to their mark on the graph show that positive comments were given by those who enjoyed the BLM experience. The excerpts can be categorized as communications, resources and collaboration as suggested by the theory of connectivism as the key drivers of a BLM. It also extends the pedagogical domain of the face-to-face class by using digital strategies. The BLM gave students an opportunity to revisit concepts and also participate in the dis-

cussions. The 21st century student is responding positively to change in the learning environment.

CONCLUSION

The BLM pedagogy provides additional strategies for students to interact with course material. Through the creation of social networks, the learning space of the undergraduate teacher is broadened. By engaging with concepts outside classroom time in a safe virtual space, the BLM allows for mastery of some concepts and an improvement in others. Online assessments offer opportunity to test and check understanding at different stages of learning.

Collaboration in the online environment benefits the students in different ways. For some it helps with math anxiety and for others it enables solving queries with ease. Preference for working in a digital environment indicates the preferred learning styles of the students. It gave them opportunity to work with the variety of resources at their own pace and repeatedly too.

RECOMMENDATIONS

Digital literacy at higher education institutions should be seen as a fundamental requirement to support teaching and learning. Using a platform like BB students can identify and remedy any deficiency that they experience. It helps the undergraduate teacher create an environment for easy collaboration.

Best practice for teaching MTMC 101 at the School of Education will improve student throughput rate by making course delivery, interesting and motivating. The transition from the TLM to the BLM gives consideration to students' digital skills, flexible learning approach and promoting student-centered learning. A suitable intersection of a TLM and BLM is necessary to promote increased student learning. To be able to identify and adopt such a model one needs to get to the core of aspects that will excite learning and keep students motivated.

Whilst the TLM and BLM were similar the choice of BLM can be mitigated against cost, scalability and flexible use of pedagogic theories. Further research in subsequent levels of study will give indicators to improve such a model.

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