AN EVOLUTION IN PEDAGOGY: THE LEARNING OF AREA AND PERIMETER IN A TECHNOLOGY ENHANCED CLASSROOM

Nirendran Naidoo
School of Education

Dr R. Naidoo
Department of Mathematics
Durban University of Technology
South Africa

Abstract

Advances in Information and Communication Technology provide infinite stimuli for enhancing mathematics education. This study utilised a technology enhanced learning environment together with human consciousness to enable learners to explore the dynamic relationship between area and perimeter. A control group consisting of forty grade 5 learners used conventional teaching /learning methods while an experimental group comprising the same number of learners in the same grade utilised the technology enhanced learning environment. Both groups answered questionnaires and completed similar practical activities. While initial activities yielded similar results, learners exposed to technology enhanced learning exhibited deeper levels of thinking in the complex activities.

Background

Recent studies of the South African education system and mathematics in particular, have revealed an education system in a state of crisis. Studies conducted at higher institutions of learning and statistics of evaluation and assessment at schools paint a bleak picture. A result of a study on first-year university students' understanding of elementary calculus at the Durban University of Technology revealed that students did not have a basic understanding of the concepts of area, perimeter and volume (Naidoo, 1998). Statistics reveal that of the 1.7 million learners enrolled in public schools for grade 1 in 1995 only 500 000 reached grade 12 in 2006, and of those only 25 000 got mathematics exemptions (Hazelhurst, 2007). It has been asserted that learners who struggle with mathematics do not understand fundamental concepts that ought to have been in place at elementary level (Daniels, 2007). In addition, the 2006 Department of Education Systemic Evaluation Report revealed that 8 in 10 children were not achieving in mathematics, with achieving referring to attaining 50% or more in a grade 6 assessment task (Pandor, 2006). This supports the theory that the reasons for the lack of performance at higher institutions lie in the poor foundations acquired at primary school level. These poor foundations may be attributed to archaic teaching methods and/or an outcomes-based approach which fails to address the conscious entity in learners (Naidoo & Naidoo, 2006). Furthermore, there is a dire shortage of qualified mathematics educators with mathematics being taught mostly by educators who are not qualified to teach it (Daniels, 2007). The latter assertion is quantified by Hazelhurst (2007) who provides the statistic that only 15% of mathematics educators are qualified.

In an attempt to redress the aforementioned imbalances, the researcher took cognisance of the rapid advances in Information and Communication Technology which have provided infinite stimuli for the enhancement of learning in all fields of education, mathematics being no exception. However, the fact that learners are conscious beings could not be ignored. The significance of consciousness may be gleaned from the view that, “consciousness is the key element of higher human cognition and in fact. . .would be what separates us from...machines” (Haikonen, 2003, p. 144).Therefore the model of learning proposed in this study constitutes a pedagogical approach utilising technology enhanced learning and human consciousness as integral components.

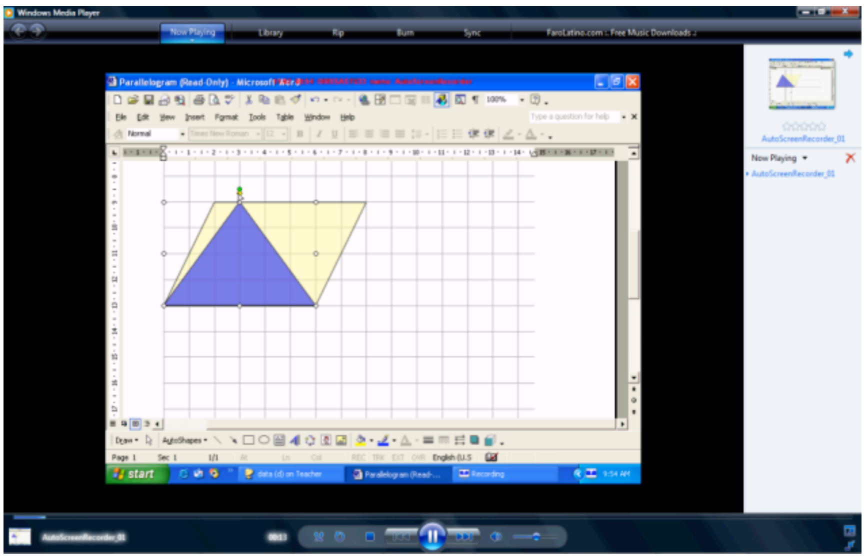
Key Elements of the Study

Before proceeding with the mechanics of the research, an examination and justification of important components of the study follows.

Technology

The use of technology enhanced learning is an essential component of this study. The advantages of technology enhanced learning are well documented and there exists a plethora of research into the effectiveness of this learning medium and the manner in which it can be implemented (Karuppan, 2001). For the purposes of this study, features in basic software allowed learners to experience mathematical concepts differently when compared to conventional teaching methods. This study utilised a technology enhanced learning environment to grant learners the opportunity to explore area and perimeter as dynamic and related concepts. Learners used the grid and auto-shape features in Microsoft Word within an interactive local area network to discover the dynamic relationship between area and perimeter. They were able to manipulate quadrilaterals and triangles within the confines of the grids they created to calculate area and perimeter, thus discovering their dynamic relationship. The researcher employed networking software, VNC Viewer 4, to facilitate collaborative learning and AutoScreen Recorder (Figure 1), to assist with assessment. Technology is of utmost importance to the teaching of mathematics because, “Children learn about shapes and space most effectively through active engagement with toys, puzzles, manipulatives, drawings and computers” (Clements, 1999, p. 48). Furthermore technology is inextricably linked to consciousness in that it plays an integral role in providing the stimuli to influence learners' perceptions of space and shape in this study.

Figure 1: Screen dump of AutoScreen Recorder



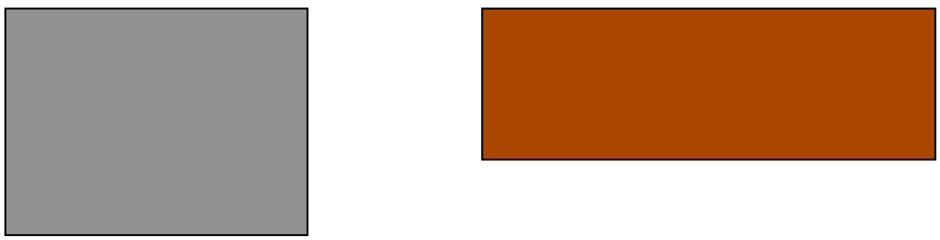
Area and Perimeter

The concepts "area and perimeter" as teaching/learning aspects were selected for a number of reasons. Firstly, educators often found that learners had difficulty with it. This may be attributed to misconceptions, confusing area with perimeter, or a total lack of knowledge of the concept (Leung, 2001). In addition, understanding how the concepts of area and perimeter are used in everyday life become difficult for learners to grasp (Hernandez, 2008). Thirdly, a study on first year university students' understanding of elementary calculus at the Durban University of Technology revealed that students did not have a basic understanding of the concept of area (Naidoo, 1998). Finally, knowledge of shapes and their measurements play an important role in determining the foundations of mathematical thinking in a child. Spatial thinking is integral to making sense of problems and in representing mathematics in different forms such as diagrams and graphs (Owens & Perry, 2007).

The activities on area and perimeter in this study required learners to construct grids in Microsoft Word and to manipulate rectangles, parallelograms and triangles to calculate area and perimeter. In so doing, learners discovered the relationship between area and perimeter. Figure 2 and Figure 3 are excerpts from these activities.

Figure 2: Activity on the relationship between area and perimeter of a parallelogram

Examine these rectangles. Draw the grid lines and compare their areas.



Area = L x B

= 4cm x 3cm

= 12cm²

Area = L x B

= 6cm x 2cm

= 12cm²

Now compare the perimeters.

Perimeter = 2(L + B)

= 2(4cm + 3cm)

= 2 x 7cm

= 14cm

Perimeter = 2(L + b)

= 2(6cm + 2cm)

= 2 x 8cm

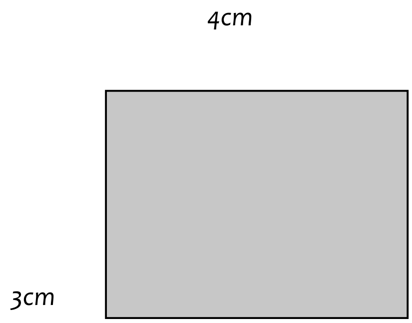
= 16cm

Therefore the ***relationship between area and perimeter*** *is demonstrated. Area remains constant while perimeter is dynamic.*

PS. Learners can physically manipulate the shapes by clicking on and dragging them to alter the area and perimeter.

Figure 3: Activity on the calculation of area of a triangle

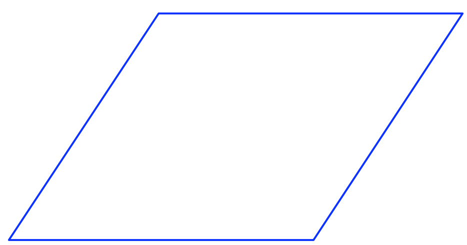
*Now that you have discovered that area of a rectangle is l x b, look at the **parallelogram** below.*



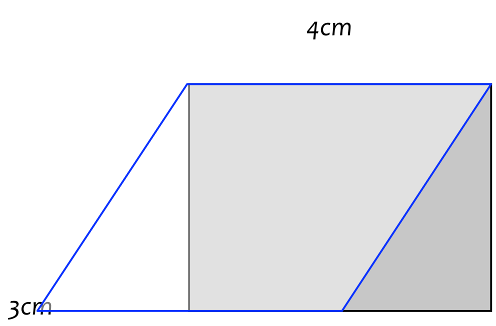
Area = l x b

= 4cm x 3cm

= 12cm^2



*Calculate the **area** of the **parallelogram.** Find the shortest method. You may move the shape around.*



Consciousness

In the context of this study, literature regarding the study of consciousness requires closer examination, especially in relation to technology enhanced learning and the teaching of mathematics.

Therefore a key question that needs to be answered is: What is consciousness? Of particular significance and relevance to this study is the view that consciousness is "the capacity of a system to respond to stimuli" (Bentov, 1978, p. 77). The system being referred to is the human nervous system. It is of relevance to this study in that stimuli are used to influence learners' perceptions of space, shape and time. In this regard, the theory of relativity emphasises the "notion that no matter what we observe, we always do so relative to a frame of reference that may differ from someone else's, that we must compare our frames of reference in order to get meaningful measurements and results about the events we observe" (Bentov, 1978, p. 4). This blends in with the mechanics of this study which address the different perceptions of space, shape and time and how technology can be used to influence them. According to a prominent figure in the study of philosophy and the human mind, "Consciousness is the central fact of specifically human existence because without it all the specifically human aspects of our existence — language, love, humour, and so on — would be impossible" (Searle, 1984, p. 16). This postulation is in line with the basic tenets of this study as mathematics is regarded as a language. Therefore consciousness is integral to the study of mathematics.

Correlating with the postulation of language as an indicator of consciousness is Chomsky (1968) who espoused that deep structures of the brain are inborn. One implication of this is that learning new languages does not change the way you think or what you think about, as this would be a surface structure, but learning new concepts would do this. In essence he is implying the existence of an innate universal grammar. This in turn,

> . . .implies the existence of some genetically determined neural machinery capable of providing the restrictive framework within which the acquisition of an actual language can occur. Ultimately, we may hope to understand the nature of the neural machinery and its behaviour, but meanwhile there is no reason to doubt its existence. (Glynn, 1999, p. 290)

The latter points of view reinforce the notion of the existence of consciousness and the framework it provides for learning. Although emphasis is placed on the acquisition of language, as previously mentioned mathematics is regarded as a language in this study.

Certain theories draw a concrete relationship between consciousness and mathematics. This is line with the aims of this study and explains the reciprocal relationship between consciousness and mathematics taught in an enhanced environment, in this case technology enhanced:

> Consciousness has a finite logical or mathematical structure. This structure does not exhaust its essence. It hardly touches on it, but it is an essential aspect of conscious experience. Mathematical limits are limits on structural possibilities and these in turn are limitations on consciousness. These limits include boundary conditions for creativity. Within those boundaries and with sufficient physical resources, consciousness can expand without limit. (Budnik, 2005, p. 2)

Recent advances have encouraged neuroscientists to examine the relationship between mathematics, technology and consciousness in a different light. Stanislas Dehaene recognises that mathematics is simultaneously a product of the human mind and a powerful instrument for discovering the laws by which the human mind operates (Holt, 2008). He also acknowledges the role of new technology in addressing the ancient philosophical (and mathematical) questions of shape, space and time. This is of direct relevance to this study and also places the significance of this research in context in terms of contemporary value.

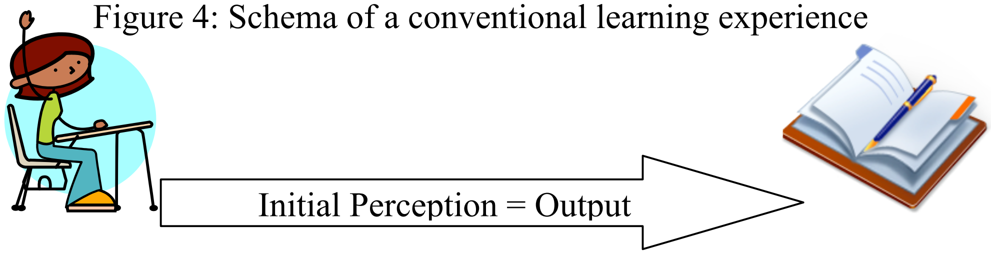
The Mechanics of the Conscious Approach to Pedagogy

This study utilised a case study scenario with the control group using conventional teaching strategies as practised in a typical South African mathematics classroom, and the experimental group being exposed to technology enhanced learning in a local area network environment. Therefore the latter has to be illustrated in relation to the former.

Conventional Learning Environment

The learner reacts to the learning material or activity, which is usually paper-based, by responding with their initial perceptions (Figure 4). This is mainly due to the static nature of the learning media.

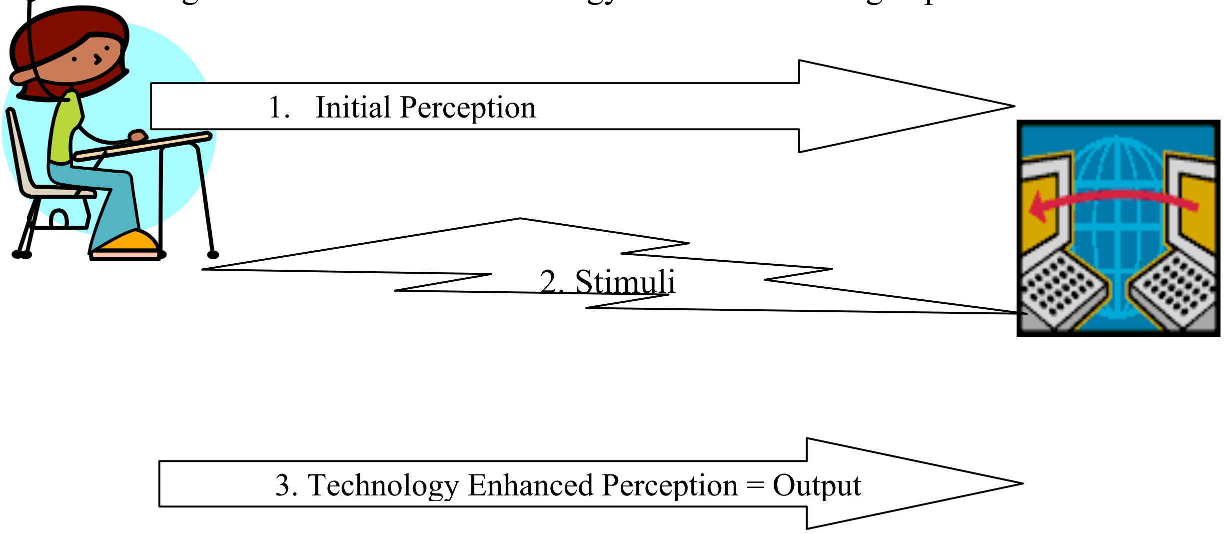
Figure 4: Schema of a conventional learning experience



Technology Enhanced Learning Environment

The learner interacts with the learning activity via the software. The stimuli provided by the interactive nature of the learning activity and the different options it affords the learner, enables the learner to engage his/her cognitive processes to formulate alternative perceptions of the activity at hand (Figure 5).

Figure 5: Schema of a technology enhanced learning experience



Methodology

Following is an indication of, and justification for the methodology used in this study.

Research Approach

This study utilized both qualitative and quantitative aspects. The qualitative approach enabled a better understanding of the experiences, opinions and perceptions of participants. This is qualified by the view that the qualitative research approach elicits participant reports of meaning, experiences or perceptions (Fouche & Delport, 2002). The emphasis was on the interpretative paradigm.

The quantitative approach used certain statistical methods. These included frequency counts and the use of tables and graphs to illustrate averages, distribution of scores and difference. A case study methodology was used to gain an in depth understanding of the perceptions and experiences of learners in their interaction with the Technology Enhanced Learning Model. Stake (1995 as cited by Creswell, 2003) and Merriam (1998) provide more detail with regard to the use of case studies by suggesting that case studies allow for in depth exploration of an event, an activity, a process, an individual or a group of individuals. At the same time a control group was established. The control group consisted of forty grade five learners who were exposed to conventional teaching methods. The experimental group consisted of forty grade five learners who used the Technology Enhanced Learning Model. Using a control group allowed the researcher to control for the effects of the experiment itself (Babbie, 1989). In simple terms, the control group also provides a yardstick to measure the success or failure of the experiment. In addition to the above, detailed information was collected through the use of a variety of procedures which were the questionnaires, the activities and the recordings gleaned from the AutoScreen Recorder. Therefore the researcher was able to increase validity of this research. Through triangulation of these research strategies cross-validation was achieved: "Triangulation is part of data collection that cuts across two or more techniques or sources. Essentially, it is qualitative cross-validation" (Wiersma, 1991, p. 233).

Two questionnaires were used to collect data on participants' perceptions and experiences. The first questionnaire was directed at the learners in the experimental group. The respondents for the second questionnaire were the learners in the control group. The researcher opted for the use of the questionnaire because it has less bias possibilities. The questionnaires ensured anonymity, were cost effective and permitted data collection from a large sample (Gay, 1992).

Sampling

Purposive sampling was used to select the research site. This sampling method was used because the sample was likely to provide information-rich data about the phenomena being investigated (White, 2003). Due to the nature of the research the selected school had to meet certain criteria. These criteria were:

- A fully networked computer laboratory with at least 40 computers.
- A server to handle the appropriate software.

The participants were selected through a process of purposive sampling. The sample was composed of elements which contained the most characteristic and representative attributes of the learner population (McMillan & Schumacher, 1997). Age was not a significant factor in the sampling process due to the participants being in the same grade. It follows naturally that learners in Grade five would fall in the 10–11 year age group. However the researcher had to ensure that there was fair representation as far as gender was concerned as studies have shown that there is a discrepancy in performance in mathematics between boys and girls (The Annual Report of Her Majesty's Chief Inspector of Schools, 2005).

Findings and Discussion

The findings of this study are based on the analysis of the activities on area and perimeter, and the questionnaires. The results are presented in the form of a comparison between the experimental and control groups.

Activities

Figure 6 compares the percentage of learners who were able to calculate the areas of a square, rectangle, parallelogram and triangle in the control group and experimental group respectively. An examination of the data reveals a difference of 10% and 2.5% in the percentage of learners that were able to calculate area of square and rectangle respectively. This may be attributed to the fact that these were fairly basic calculations and did not require much external stimuli. However analysis of the data regarding calculation of area of the parallelogram and triangle reveal differences of 30% and 60%, respectively, in favour of the experimental group. Therefore these significant discrepancies may imply that technology enhanced learning provides stimuli which influences the perceptions of learners.

Figure 6: Comparison of the calculation of area

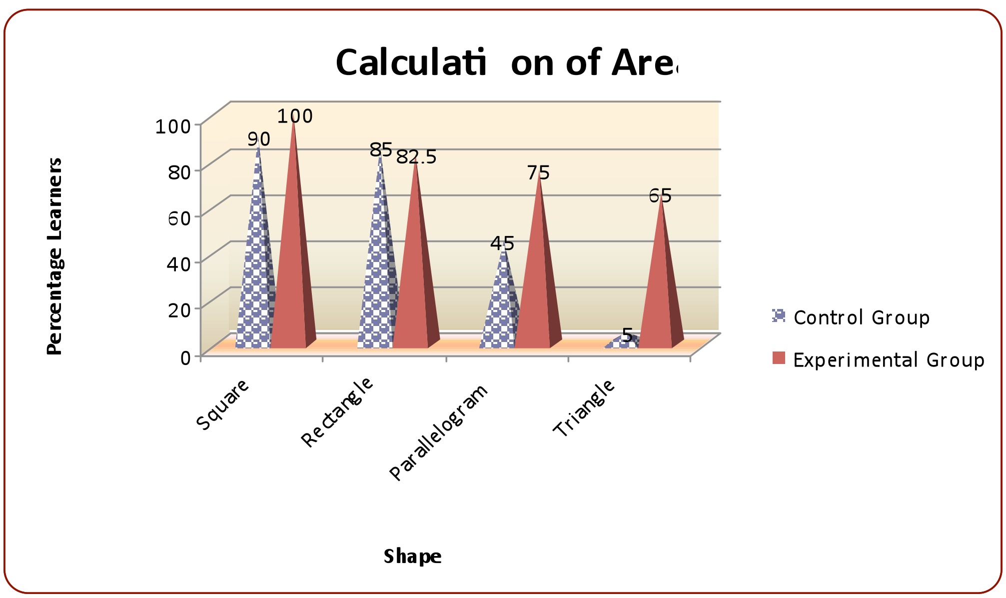
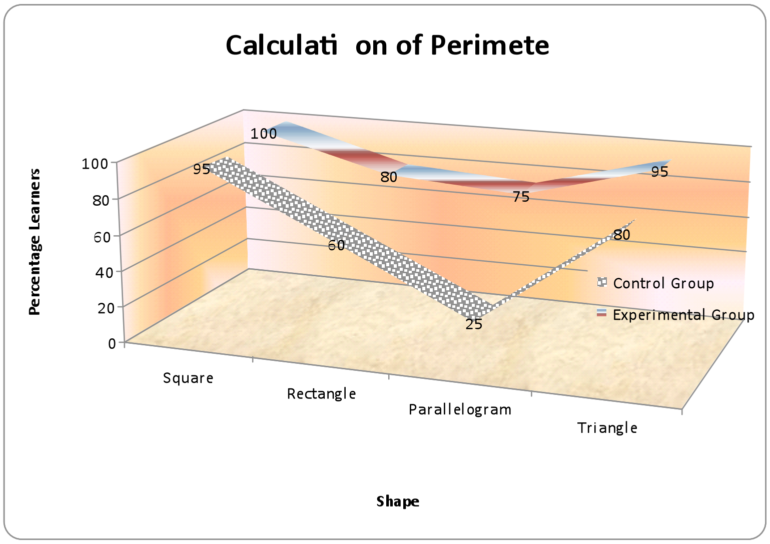


Figure 7 compares the percentage of learners who were able to calculate the perimeter of a square, rectangle, parallelogram and triangle in the control group and experimental group. An examination of the data reveals a difference of 5% in the percentage of learners who were able to calculate perimeter of a square. Again, this may be attributed to the fact that this was a basic calculation and did not require much external stimuli. However analysis of the data regarding calculation of perimeter of the rectangle, parallelogram and triangle reveal differences of 20%, 50% and 15%, respectively, in favour of the experimental group. These statistics place the utilisation of technology enhanced learning as a medium of stimulating consciousness in learners in a favourable light.

Figure 7: Comparison of the calculation of perimeter



Questionnaires

The responses to the questionnaires have been tabulated into six broad categories and presented in Table 1.

Table 1: Responses to the questionnaires

Categories	Control Group		Experimental Group	
	Yes	*No*	Yes	*No*
1. I answered spontaneously	*100%*	*0%*	20%	80%
2. I answered after experimenting with the shapes	*0%*	*100%*	80%	20%
3. Moving the shapes influenced my responses	*0%*	*100%*	70%	30%
4. I was able to see the difference in space and shape	*20%*	*80%*	95%	5%
5. When perimeter of a rectangle changes, area remains the same	*10%*	*90%*	65%	35%
6. When perimeter of a rectangle changes, area changes	*80%*	*20%*	35%	65%

The responses in Table 1 are clearly in line with the aims of this study. The first four categories illustrate the effects of technology enhanced learning in stimulating learners' consciousness. The fact that they were influenced to revisit their perceptions of shape and space contributed to their ability to successfully negotiate the mathematical problems at hand. This is line with the basic premise of this study that consciousness is the capacity of the human mind to respond to stimuli (Bentov, 1978). In addressing another important aim of this study, the responses to categories five and six elucidate the value of technology enhanced learning in enabling learners to grasp the dynamic relationship between area and perimeter.

Conclusion

Analysis of data gleaned from this study revealed certain discrepancies between mathematics taught in a conventional classroom environment and mathematics experienced in a technology enhanced environment. The word 'experienced' is used because it is evident that the latter method involves stimulation of learners' cognitive processes through the manipulation of space and shape. Apart from the mechanical aspect of enabling learners to grasp an understanding of the dynamic relationship between area and perimeter, the pedagogical approach postulated in this study also illustrates the intertwined nature of mathematics, technology and consciousness (Budnik, 2005; Holt, 2008). The research performed is very much at an exploratory level. This study opens up the possibility for further research incorporating other aspects of mathematics as well as other learning areas. Furthermore, more intensive research on how the cognitive processes interpret the stimuli provided by technology will serve either to enhance or refute the conclusions of this study.

References

Babbie, E. (1990). *Survey research methods* (2nd ed.). California: Wadsworth.

Bentov, I. (1978). *Stalking the wild pendulum: On the mechanics of consciousness.* London: Wildwood House.

Budnik, P. (2005). Applying mathematics to consciousness. Retrieved March 16, 2008, from http://www.mtnmath.com/whatrh/node85.html.

Chomsky, N. (1968). Linguistic contributions to the study of mind (Future). *Language and mind.* Retrieved August 28, 2006, from http://www.marxists.org/reference/subject/philosophy/index.htm.

Clements, D. H. (1999, October/November). Your child's geometric world. *Scholastic Parent and Child*, 48–54.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative and mixed method approaches.* California: Sage.

Daniels, G. (2007). SA – maths = crisis. *Mail and Guardian Online*. Retrieved March 16, 2008, from http://www.mg.co.za/articlePage.aspx.articleid=300522&area=/the_teacher/teacher_features/

Fouche, C. B., & Delport, C. S. L. (2002). Introduction to the research process. In A. S. De Vos, H. Strydom, C. B. Fouche, & C. S. L. Delport (Eds.), *Research at Grassroots*. Pretoria: Van Schaik Publishers.

Gay, L. R. (1992) *Educational research: Competencies for analysis and application.* (4th ed.). New York: MacMillan.

Glynn, I. (1999). *An anatomy of thought: The origin and machinery of the mind.* London: Weidenfeld and Nicolson.

Haikonen, P. O. (2003). T*he cognitive approach to conscious machines.* Exeter: Imprint Academic.

Hazelhurst, E. (2007). Teacher shortage will hobble future growth. *Business Report.* Retrieved February 23, 2008, from http://www.busrep.co.za/indexphp?fArticleId=3654711

Hernandez, B. (2008). Creative ideas for teaching area and perimeter: Ideas for teaching math. *About.com*. Retrieved March 2, 2008, from http://homeschooling.about.com/od/basicmath/qt/teachingarea.htm

Holt, J. (2008). Numbers guy: Are our brains wired for math? *The New Yorker.* Retrieved March 31, 2008, from http://www.newyorker.com/reporting/2008/03/03/080303fa_fact_holt

*Information and communication technology in primary schools. The Annual Report of Her Majesty's Chief Inspector of Schools 2004/05***.** (2005). Retrieved June 24, 2007, from http://live.ofsted.gov.uk/publications/annualreport0405/4.1.6.html

Karuppan, C. M. (2001). Web-based teaching materials: A user's profile. *Internet Research: Electronic Networking and Applications Policy, 11*(2), 181–194.

Leung, A. (2001). Mathematics lesson on perimeter and area. *Learning Study 5.* Retrieved November 29, 2007, from www.iediis4.ied.edu.hk/cidv/webdata/

McMillan, J., & Schumacher, S. (1997) *Research in education: A conceptual introduction* (4th ed.). New York: Longman.

Merriam, S. B. (1998) *Qualitative research and case study applications in education.* California: Jossey-Bass.

Naidoo, N., & Naidoo R. (2006). Enhancing the learning experience of primary school learners through the utilisation of a hybrid web-based learning model. In *Proceedings of the 17th International Conference of the Society for Information Technology and Teacher Education,* Vol. 4, (p. 2341). Orlando, FL: Society for Information Technology and Teacher Education.

Naidoo, R. (1998). Errors made in differential calculus. In *Proceedings of the 22nd Conference of the International Group for the Psychology of Mathematics Education*, Vol. 4, (p. 288).

Owens, K., & Perry, B. (2007). Talented students article. *Mathematics K–10 Literature Review.* Retrieved February 18, 2008, from http://www.boardofstudies.nsw.edu.au/manuals/

Pandor, N. (2006). Speech on systemic evaluation. *Department of Education Website.* Retrieved January 13, 2008, from http://www.education.gov.za/dynamic/dynamic.aspx?p[ageid=306&id=2181

Searle, J. (1984). *Minds, brains and science: The 1984 Reith Lectures.* London: Penguin Books.

White, C. J. (2003) *Research methods and techniques.* Pierre van Ryneveld.

Wiersma, W. (1991) *Research methods in education* (5th ed.) Boston: Simon and Schuster.