# ENHANCING THE LEARNING EXPERIENCE OF PRIMARY SCHOOL LEARNERS THROUGH THE UTILISATION OF A HYBRID WEB-BASED LEARNING MODEL: A CASE STUDY OF LEARNING MATHEMATICS OF AREAS AND PERIMETERS

BY

NIRENDRAN NAIDOO

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## ABSTRACT

The use of web based learning in primary schools has been neglected. The aim of the study is the design of a hybrid web based learning model for primary school mathematics especially in the teaching and learning of perimeter and areas. It is indicated in a study in calculus teaching and learning at a higher institution by Naidoo (1998) that students have fundamental problems in understanding pre-concepts such as perimeter and areas which are taught in primary schools and that the Piagetian pre-formal and formal stages have not been developed.

Primary school learners' first encounters with mathematics in a traditional learning environment often create lifelong 'math phobia' (Papert, 1980). The situation in a country emerging from an oppressive education system designed to educationally disempower the majority of the population is much worse. The typical scenario in a previously disadvantaged South African primary school is a classroom filled beyond capacity with the educator struggling to establish an effective learning environment. Thus the educator resorts to rote learning, drill and practice and 'chalk and talk' methods of teaching. The individual needs and levels of learners are disregarded and blanket assessment methods are employed (Naidoo and Naidoo, 2006b). Collaborative learning is minimal or non-existent. These traditional teaching strategies often disregard cultural and social factors, and pre-knowledge frames of learners. Furthermore there is a dire shortage of qualified mathematics educators in the South African schooling system. Therefore there is an urgent need for alternative teaching and learning strategies to address the teaching of mathematics in primary schools. The introduction of networked computer laboratories to previously disadvantaged South African primary schools enables the use of computers as powerful tools to analyze the thought processes of learners during their early encounters with mathematics. The lack of innovative use of internet technology to design interactive learning experiences is addressed A blended learning approach using a networked computing environment and Logo mathematics to facilitate the teaching and learning of perimeter and area in a Grade five class produced a significantly enhanced learning experience for learners as compared to a second Grade five class utilizing traditional teaching and learning methods only.

## DECLARATION OF ORIGINALITY

I declare that 'Enhancing the learning experience of primary school learners through the utilisation of a hybrid web-based learning model' is my own work and that all sources consulted and quoted have been indicated and acknowledged by means of complete references.

Signed ________________ 15 January 2007

Nirendran Naidoo

**Statement by supervisor**

This dissertation is submitted with/without my approval.

Signed ________________

Dr R. Naidoo [PhD]

# DEDICATION

I dedicate this dissertation to my wife, Renuka Naidoo, whose assistance, tolerance, patience, interest and support was instrumental in me completing this study.

## ACKNOWLEDGEMENTS

The researcher wishes to express his sincere gratitude and appreciation to the following individuals/organisations:

- Dr R. Naidoo (Department of Mathematics: Durban University of Technology), the supervisor of this dissertation, for his encouragement, professional assistance and visionary insight throughout this study.
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# CHAPTER ONE

# INTRODUCTION TO THE STUDY

## 1.1 Introduction

This study utilizes a hybrid web-based learning model to enhance the learning experience of primary school learners through the learning of mathematics. This chapter will highlight the background and purpose of this study (Section 1.2), the conceptual and theoretical location of the study (1.3), the research aims (1.4), the research questions (1.5), the research method (1.6), and mark out the structure of the report (1.7).

## 1.2 Background and Purpose of Study

With the introduction of information technology in South African primary schools, it has become necessary to explore avenues to maximize the use of computer assisted learning. There exists an abundance of research into the effectiveness of this learning medium and the manner that it can be implemented (Karuppan, 2001). A key area of computer assisted education is web-based learning. Due to the rapid advances in internet technology over the last few years the higher education sector has seen a revolution in internet based learning with the spawning of virtual campuses throughout the world (Chen et al, 2005). However it is evident that the primary school sector has been neglected as far as web-based learning is concerned. Most public primary schools are bound by financial constraints and the disadvantaged socio-economic circumstances of learners. Therefore there is a need for a web-based learning model that would assist in overcoming these limitations with the minimal use of financial resources. Furthermore many existing primary school web sites feature dated technology with a lack of interactive features, databases, communication media and collaboration tools.

Dovetailing with the above is the fact that primary school learners' first encounters with mathematics in a traditional learning environment often create lifelong 'math phobia' (Papert, 1980). This is most evident at tertiary level where students experience difficulty due to a poor grasp of basic mathematical concepts. One of the results of a study performed at the Durban University of Technology on first year university students understanding of elementary calculus is that students do not have a basic understanding of area, volume and perimeter. They remembered basic formulae. It is clear that these concepts were not understood at the primary school level (Naidoo, 1998). The typical scenario in a previously disadvantaged South African primary school is a classroom filled beyond capacity with the educator struggling to establish an effective learning environment. Thus the educator resorts to rote learning, drill and practice and 'chalk and talk' methods of teaching. The individual needs and levels of learners are disregarded and blanket assessment methods are employed (Naidoo and Naidoo, 2006b). Collaborative learning is minimal or non-existent. These traditional teaching strategies often disregard cultural and social factors, and pre-knowledge frames of learners. Furthermore there is a dire shortage of qualified mathematics educators in the South African schooling system. Therefore there is an urgent need for alternative teaching and learning strategies to address the teaching of mathematics in primary schools. The introduction of networked computer laboratories to previously disadvantaged South African primary schools enables the use of computers as powerful tools to analyze the thought processes of learners during their early encounters with mathematics. Such a learning environment lends itself to the teacher being a facilitator thus addressing the problem of the dearth of qualified mathematics educators in South Africa. The researcher sought to maximize the opportunities provided by a networked computing environment to enhance the learners' experiences and interaction through discovery learning in a mathematics classroom, the latter being a computer laboratory.

To achieve the aforementioned objectives a case study was performed in a primary school. Two groups comprising twenty Grade five learners each were exposed to the teaching and learning of perimeter and area with one group using Logo mathematics in the computer laboratory and the other group using traditional classroom based teaching and learning. The reason for perimeter and area being chosen is that educators often find learners having difficulty with these concepts at primary school level. This may be due to misconceptions, confusing area with perimeter and vice versa or a total lack of knowledge of the concepts (Leung, 2001). Furthermore the Annual Report of Her Majesty's Chief Inspector of Schools (2005) found that there was a need for the use of computer applications in the teaching of area and perimeter. A study in New Zealand found that even at grade ten level learners did not have a clear understanding of perimeter and area. (New Zealand Maths, 2005). Therefore the types of errors made by learners were analysed with the aim of using the VNC Viewer as a medium to correct them (Donaldson, 1964 as cited by Kogan, 1966).

In addition, the researcher used a blended learning approach due to the fact that computers, and especially a networked computing environment, were relatively new phenomena to South African primary school learners. Thus a combination of face-to-face interaction encompassing conventional learning strategies, and the use of computers as teaching/learning media would be most suitable (Naidoo and Naidoo, 2006a).

The study proposes a hybrid web-based model that would benefit learners and educators at primary schools through the teaching and learning of area and perimeter, using Logo, in a networked computing environment.

### 1.3 Conceptual and Theoretical Location of Study

This study is set within a constructivist framework with collaborative learning playing an integral role. Inherent in both the constructivist approach and collaborative learning are characteristics that facilitate the improvement of social skills. According to the constructivist approach a key aim in any learning situation is that the learner should actively seek to make sense of the world (Jolliffe et al, 2001). Furthermore learning is seen as a constructive process with the learner building an internal representation of knowledge. Since the learning process is dynamic and unpredictable, learners may develop their own learning tasks. Thus the learner would have to engage both social and cultural elements to complete activities and tasks. Collaborative learning is a method of learning in which learners are placed in small groups or pairs in order to achieve a common academic goal (Gokhale, 1995). This implies that learners are responsible for the learning of other group members as well as their own. Thus success, or failure for that matter, is shared. The proponents of collaborative learning claim that shared learning enables learners to be epistemologists, become critical thinkers and engage in discussion, which would invariably lead to an improvement in social skills (Totten, Sills, Digby and Russ, 1991 as cited by Gokhale, 1995). In order to improve social skills it is imperative that learners communicate with other learners and academics. This can be done by incorporating collaborative learning in the use of web-based learning. The very nature of the internet with its various communication technologies facilitates collaborative learning (French, 1999).

This study is guided principally by the theory of Seymour Papert in which the child is seen as an epistemologist (Papert, 1980). The process of learning is transformed because the child becomes an active learner collaborating with fellow learners in constructing learning experiences. This is relevant to the model being proposed in this study in that the knowledge being acquired is for a relevant and recognisable personal purpose. The content of the lessons themselves are personalised rather than mere instructions from the computer. Furthermore, as also espoused by Papert, the impact of culture on providing the materials necessary for developing the learner's construction of certain components of logical and numerical thinking plays an integral role in this study. Reference is also made to Piaget's theory of cognitive development to place the learners' stages of development in perspective (Berk, 2000).

Furthermore cognitive pre-mathematical frames are regarded as essential in determining the manner in which learners approach the solving of mathematical problems later in life (Davis, 1984). Therefore this study will show that the learning approach learners are exposed to plays a significant role in determining the pre-mathematical frames learners form. In addition reference is made to Chomsky (1968) to show how the use of Logo in web-based learning influences deep structures of the mind.

### 1.4 Research Aims

The fundamental aims of conducting this study were as follows:

i. To identify the shortcomings of existing computer assisted learning technologies in primary schools.

ii. To investigate how learners' mathematical skills can be improved through the use of web-based learning.

iii. Explore and describe learners' experiences and perceptions of an alternative hybrid web-based learning model.

### 1.5 Research Questions

Based on the aforementioned research aims this study focused on the following key questions:

a. What are the shortcomings of existing internet technologies used by South African government primary schools?

b. What is the alternative to the current technologies being utilized?

c. How can learners' mathematical skills be improved through the use of web-based learning?

## 1.6 Research Method

Discussion in this section includes the research approach, the research site, sources of data, research instruments, ethical issues, data analysis and limitations of the study.

### 1.6.1 Research approach

This study will utilize both qualitative and quantitative aspects. The qualitative approach enables 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 (McRoy, 1995 as cited by Fouche and Delport, 2002). In other words the key feature is to understand the phenomenon from the participant's experience.

Analysis includes frequency counts and the use of tables and graphs to illustrate averages, distribution of scores and difference.

### 1.6.2 Research Site, Population and Sample

The study was conducted in a primary school in Durban, South Africa. Being a government school servicing an impoverished community the school typified the historically socially and economically disadvantaged yet culturally diverse nature of South Africa's learner population. All participants had limited prior access to the internet and to the use of computers in general as they were from disadvantaged socio-economic backgrounds. This study opens the foundations of mathematics to sociological examination by allowing the 'objectivity' of mathematical reasoning to be seen as fundamentally social in nature (Martin, 1998).

Two groups of Grade five learners from separate classes were selected through purposeful sampling, with one group exposed to traditional teaching methods and the other using the hybrid web-based model.

### 1.6.3 Sources of Data

The primary sources of data were the learners at the specified school. The secondary sources included the literature as per listed references.

### 1.6.4 Research Instruments

Data was collected by means of questionnaires and a focus group interview as well as the activities on area and perimeter which the learners completed. Furthermore a freeware networking program called VNC Viewer 4 was used for 'real-time' observation of learners' activities at their workstations. Through the 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: 233).

Pre-tests of the questionnaires and activities on perimeter and area were conducted to identify ambiguities and to improve or revise the instruments if necessary. The researcher ensured a pre-contact session with the participants to outline the purpose of the study and request cooperation.

To obtain rich data focus group interviews were conducted with a group of the participants. Purposive sampling was used thereby selecting participants according to gender.

With reference to the key research questions as outlined earlier, the researcher used the information obtained from the questionnaires and activities on perimeter and area as well as the information gathered from the focus group interviews to address research question [c]. The literature review, together with data obtained from the questionnaires and the focus group interviews, helped provide answers to research questions [a] and [b].

### 1.6.5 Ethical Issues

With regard to ethics, permission from the Department of Education and the parents of participants were sought. The participants and their parents were informed that participation in this project was voluntary and that even those who participated were free to withdraw from the research at any time. They were also assured of confidentiality and anonymity. However, permission was sought for their perceptions and experiences to be used in the study.

### 1.6.6 Data Analysis

Analysis of the data was carried out predominantly through content analysis of the responses from the open-ended questions in the questionnaires, and answers in the activities as well as the focus group interview. Direct quotations were used where necessary. Closed questions in the questionnaires were analysed through frequency counts and the use of tables and graphs to illustrate averages, distribution of scores and difference.

### 1.6.7 Limitation

The study was limited to one school only as a case study.

## 1.7 Structure of the study

This study was structured so as to logically and systematically utilize a hybrid web-based learning model to enhance the mathematical learning experience of primary school learners through the use of Logo to calculate area and perimeter.

Chapter 1 has highlighted the background and purpose of the study, conceptual and theoretical location of the study, the research questions and the research method employed in the study.

Chapter 2 reviews pertinent literature and provides a theoretical and conceptual framework for the study.

Chapter 3 provides an account of how the study was designed and conducted. It describes the research method employed, the research instruments, ethical issues, data analysis, and limitation of the study.

Chapter 4 presents and discusses the findings acquired from the questionnaires, activities on perimeter and area and focus group interview.

Chapter 5 summarizes the main findings of the study. This chapter also outlines recommendations based on the findings and theories discussed in chapter two. Finally recommendations for future research are considered.

Papers, by this researcher, based on aspects of this study have been presented in 3 conferences and published in the refereed conference proceedings. They are as follows:

- Naidoo, N. and 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. ISBN: 1-880094-58-4.
- Naidoo, N. and Naidoo R. (2006) Improving Visual and Verbal Skills of Primary School Learners Through Effective Web-Based Learning. In *Proceedings of the International Conference on e-Learning,* p. 347. ISBN: 1-905305-23-0.
- Naidoo, N. and Naidoo R. (2007) Using Blended Learning to Facilitate the Mathematical Thought Processes of Primary School Learners in a Computer Laboratory: A case study in calculating simple areas. In *Proceedings of the College Teaching and Learning Conference.* ISBN: 1539-8757.
- A paper entitled 'Collaborative Computing as a Means of Overcoming Math Phobia in Primary School Learners: A Case Study in Calculating Simple Perimeters' has been submitted to the journal, *African Education Review*, for

publication.

### 1.8 Conclusion

Having provided an introduction to the study through a brief discussion of the background and purpose of the study, conceptual and theoretical location of the study, research aims, research questions, research method and structure of the study, the next chapter focuses on the literature review that helped inform these.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Introduction

Integral to the hybrid web based learning model proposed in this study are the constructivist approach and collaborative learning. Furthermore the learner is perceived as an epistemologist and culture is viewed as having an indelible impact on the manner in which the learner interacts with the learning experience. Theories concerning the developmental stages of the learner as well as pre-knowledge frames and deep and surface structures are central to this study. In addition the types of errors made by learners are discussed. Finally since learners actively engage with a link, the Logo mathematics program, the theoretical relevance of the latter is explored.

## 2.2 Web-Based Learning: Guiding Perspectives

As with most concepts or terms, web-based learning is open to varying interpretations and definitions. Furthermore the term web-based learning is often used interchangebly with the terms e-learning, internet-based learning, internet-based training, web-assisted learning, web-based instruction and online learning. However the term web-based learning in this study has been guided by certain perspectives. The ensuing paragraph examines these perspectives in relation to the requirements of this study.

Web-based learning incorporates internet technologies with the use of traditional teaching and learning methods. This approach is relevant to the South African primary school scenario in that most learners and teachers have not been exposed to the internet as a teaching medium as yet. This postulation is supported by various authors. Web-based learning is suitable to primary school learners in that it incorporates traditional classroom teaching and learning as the main mode of learning with web-based support in the form of independent work after school hours (Alessi and Trollip, 2001). A further view adding support is that e-learning can be used as the main method of delivery of education/training or as a combined approach with face-to-face classroom-based teaching (Asgarkhani 2004). Elaborating on this point is the exposition that e-learning comprises hybrid courses that integrate face-to-face and online components (Oblinger and Hawkins, 2005). The nature of web-based learning in primary school lends itself to augmented teaching. Augmented teaching is based on the assumption that educators can enrich current teaching styles by augmenting classes with aspects of Internet-based learning (French, 1999).

Thus the view of web-based learning in this study is guided by the aforementioned perspectives. In a nutshell web-based learning is seen as a combination of both traditional classroom teaching and learning and the use of internet technologies in such a way as to maximise the learning experience of the learner.

### 2.2.1 Advantages and Disadvantages of Web-Based Learning for Primary School Education

Web-based learning for the primary school sector has both advantages and disadvantages. However upon closer examination it becomes obvious that the former is prevalent. Some of the advantages are as follows:

- The use of time and resources can be maximized through remediation and enrichment exercises as well as projects being done on the web site after school hours. Furthermore less class time is taken up if learners can post queries on bulletin boards or through e-mail or chat.
- Web-based learning can be either synchronous or asynchronous.
- Learners can always access activities or lessons that they may have missed.
- It caters for different skill levels as learners may work at their own pace.
- Opportunities for individual and team based learning are provided (French, 1999).
- It exposes learners to the multitude of information available on the internet. This, as illustrated in this study, develops and consolidates learners' pre-knowledge frames.
- The learning experience is mostly learner-centred.
- It allows for real-time interaction through the use of chat or video-conferencing.
- The learning programs/activities are enhanced through the use of multimedia (Horton & Horton, 2003).
- It caters for problem based learning.
- Help features may be embedded to facilitate the learning experience.
- Communication may be archived for later use (Alessi & Trollip, 2001).
- Teachers are able to diagnose errors, misunderstandings and misconceptions and provide feed back.
- Through tracking via web-based learning each student can be treated uniquely.

The disadvantages of web-based learning are relatively few and include the following:

- The initial cost of developing a web-based learning environment may be an inhibiting factor for many primary schools. Hardware, software and developers costs need to be taken into account.
- Many learners may not have access to the internet after school hours.
- Bandwidth may restrict the type of web-based learning environment being established (Jolliffe et al, 2003).
- Learners tend to believe the computers and not interrogate the concept.

The advantages of web-based learning for primary school education far outweigh the disadvantages. Furthermore the disadvantages listed above are not insurmountable and may be overcome with assistance from the wider school community and thorough planning, implementation and control of the web-based learning environment.

### 2.2.2 Shortcomings of Existing Internet Technologies

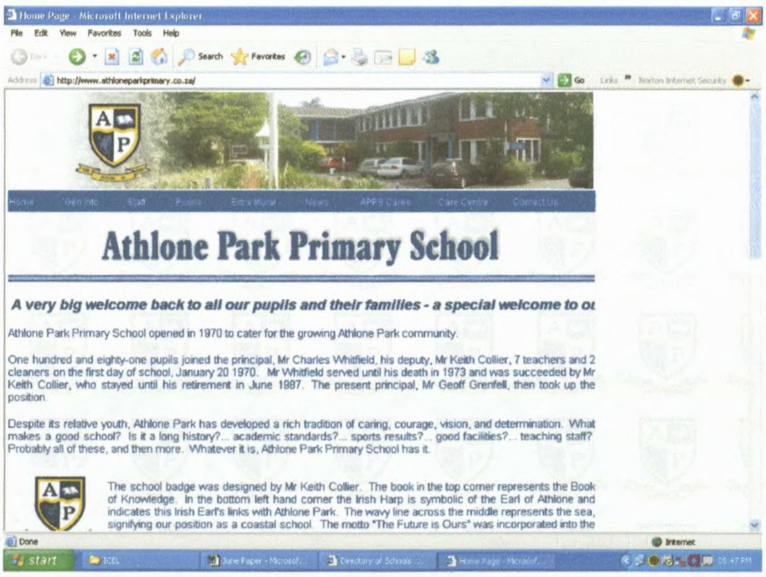
This study has in part been prompted by the shortcomings of traditional teaching methods and existing internet technologies utilized by primary schools that have websites or access to the internet. These shortcomings include the lack of interactive web pages, lack of the use of databases and little evidence of interaction or avenues for communication through the design of web-based learning environments. A web search for South African primary schools' websites on Google returned twenty initial websites. An analysis of the features of these websites follows (Tab. 1).

*Table 1: Use of web-based learning features in South African primary school websites*

| Feature | Percentage of Websites Utilizing Feature |
|---|---|
| Web-Based Learning | 0 |
| Databases | 0 |
| Communication e.g. E-mail | 30% |

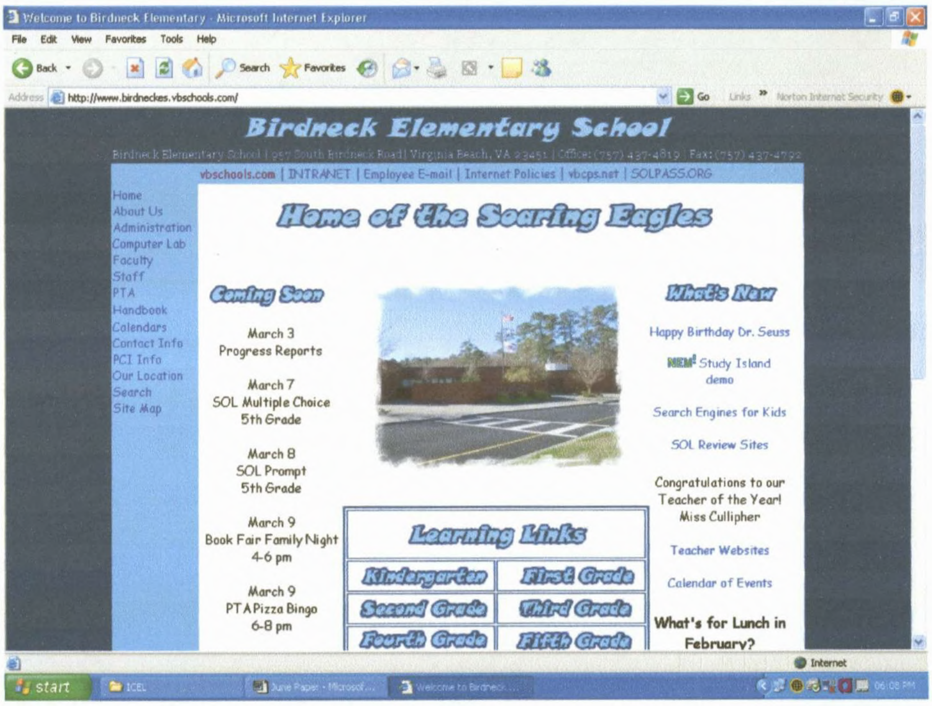
The fact that only 30% of the websites display evidence of communication tools and the omission of databases and web-based learning from these websites is indicative of the need for the development of a web-based learning model. The only evidence of collaboration tools was the use of e-mail in certain websites. An example of one of these web pages is illustrated below (Fig. 1).

***Figure 1:** A Typical South African Primary School Web Site*




A Google search of international elementary school web sites revealed a number of schools using various internet technologies in their web pages. Apart from e-mail as a means of communication with the schools, links were provided to tutorial web pages and to other schools in the district. Some of these elementary school web sites feature the use of collaboration tools which attempt to improve the visual and learning skills of learners (Fig. 2).

***Figure 2:*** *An American Elementary School Web Page*




An important consideration in the formulation of this model was the need to blend traditional teaching methods with web technologies since this would be a totally new experience for most learners and especially, educators. Hence the hybrid nature of the model.

## 2.3 Constructivist Approach

According to the constructivist approach a key aim in any learning situation is that the learner should actively seek to make sense of the world (Jolliffe et al, 2001). Furthermore learning is seen as a constructive process with the learner building an internal representation of knowledge. Since the learning process is dynamic and unpredictable, learners may develop their own learning tasks. The preceding table (Tab. 2) illustrates certain characteristics of the hybrid web-based learning model and their corresponding features in the constructivist approach (Alessi and Trollip, 2001), (Jolliffe et al, 2001) and (French, 1999).

***Table 2:*** *Constructivist features of the Hybrid Web-Based Learning Model*

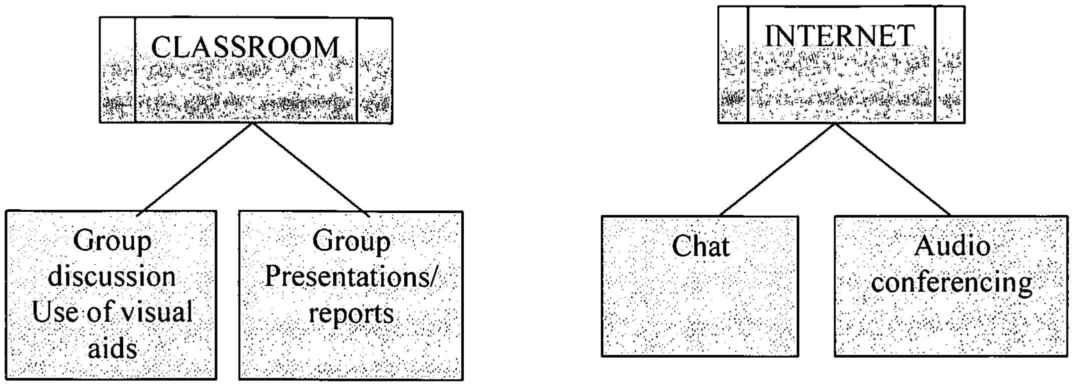
| Constructivist Approach | Hybrid Web-Based Learning Model |
|---|---|
| Learning tasks occur in a non-linear fashion | Learners are able to learn in non-linear fashion by using hypermedia. |
| Emphasizes active learning | Learners interact with databases to access important concepts, participate in chat rooms and use e-mail. |
| Use of guided discovery approach | The use of hyperlinks guides learners to relevant solutions and information. They can use software to experiment with a concept. |
| Use of problem-based scenarios | All web-based activities require finding a solution to a problem that is posed initially. Preknowledge frames and problem strategies scaffold students. |
| Collaborative learning | Chat rooms are used as a medium for learners to collaborate with their peers and educators on certain activities and tasks |
| Use of technology resources | Learners are encouraged to use search engines to access relevant information and to conduct research on the internet. Furthermore databases, chat rooms, java applets and e-mail are utilized. |
| Activities are of personal relevance to learners | Learning programs are designed to be meaningful and relevant to learners. |

### 2.4 Collaborative Learning

Collaborative learning is a method of learning in which learners are placed in small groups or pairs in order to achieve a common academic goal (Gokhale, 1995). This implies that learners are responsible for the learning of other group members as well as their own. Thus success, or failure for that matter, is shared. The proponents of collaborative learning claim that shared learning enables learners to be responsible for their own learning, become critical thinkers and engage in discussion (Totten, Sills, Digby and Russ, 1991 as cited by Gokhale, 1995). Learners are able to express themselves to their peers more confidently than they would be able to their teacher. Therefore social interaction would be improved. Furthermore they would be able to solve problems as a group and lessen the extent to which learners would become frustrated at not being able to find an answer. Learners would also be able to build on ideas by interacting with other learners through their computers in a networked environment.

The use of collaborative learning in the hybrid web based model thus follows logically. The very nature of the internet with its various communication technologies facilitates collaborative learning. The following diagram (Fig. 3) illustrates some of the ways in which collaborative learning and web-based learning go hand in hand.

*Figure 3: Common Collaborative Learning and Web-Based Learning Techniques*



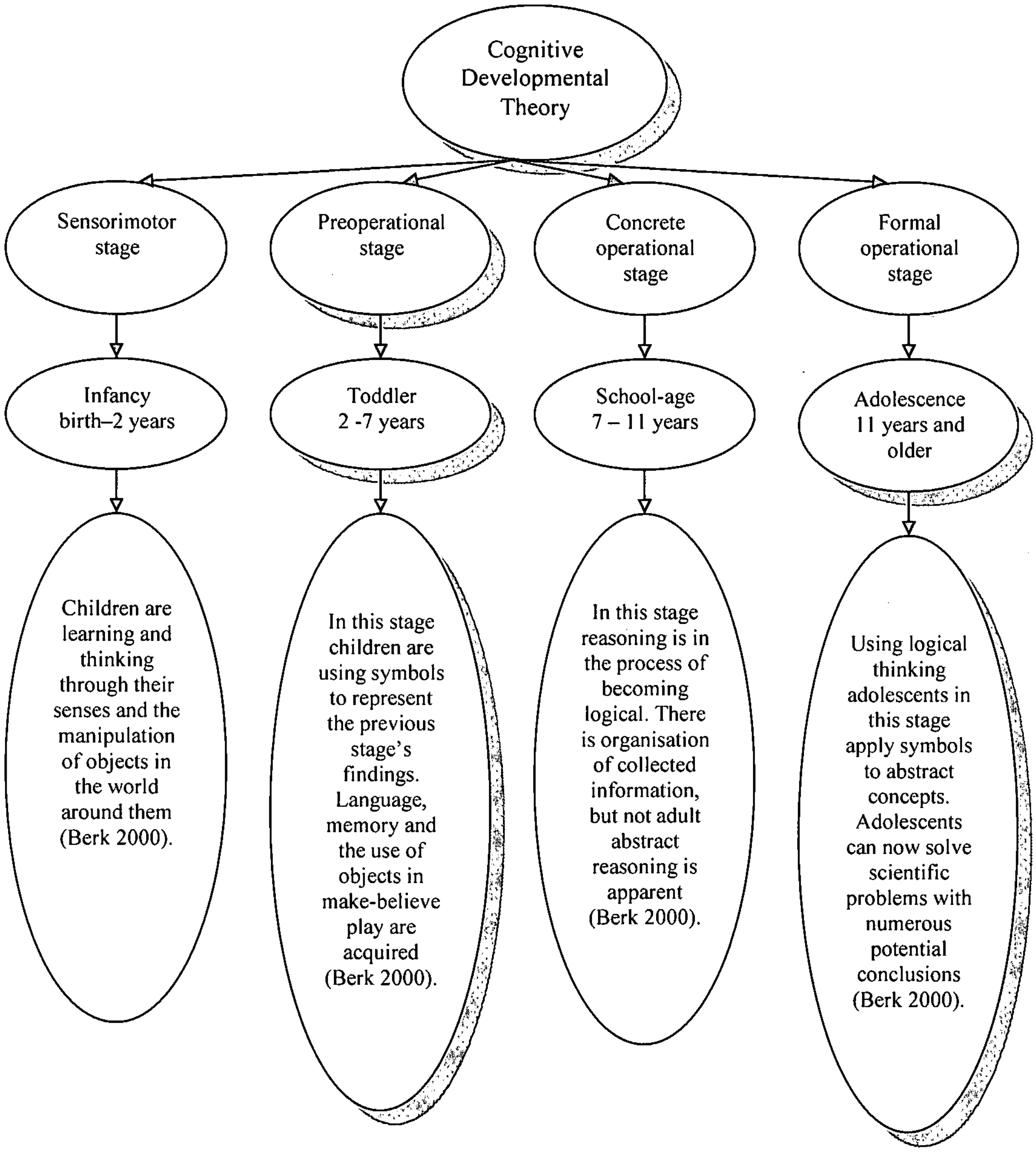



**2.5 The Learner as an Epistemologist**

As recently as the past century it was generally accepted that children's thoughts were less sophisticated, less complex but qualitatively similar to adults. However this idea has gradually evolved into one that espouses that children think in a different way from adults and reach distinct conclusions from the same data. One of the most influential theorists in this regard was Jean Piaget.

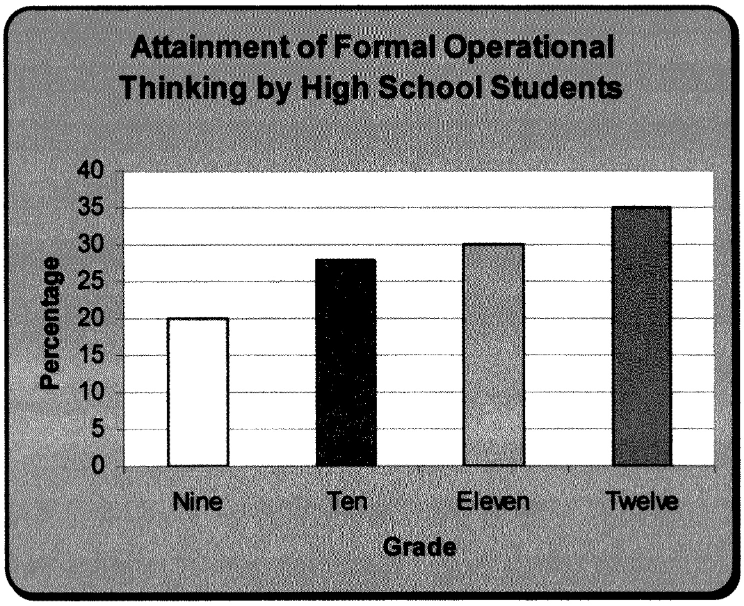
The cognitive-developmental theory developed by Piaget states that children and adolescents continuously construct intelligence as they operate and discover their world. The theory further proposes that hereditary and environmental factors determine the underlying causes of child development (Berk, 2000). However, the environment affects how and what the child learns while the process of development is determined from within the child depending on the stage of the cognitive structure. Thus the underlying belief is that biological development drives the movement from one cognitive stage to the next (Huitt and Hummel, 2003). Piaget identified four distinct stages of cognitive development (Fig. 4).

*Figure 4: Piaget's stages of cognitive development (Berk, 2000)*




Piaget's theory is open to criticism in that his research methods were primarily based on case studies, thus being descriptive. Data from cross-sectional studies of adolescents are not supportive of his view that individuals will automatically progress to the next stage of cognitive development as they mature biologically. A body of research (Kuhn et al, 1977) indicates that only 30 to 35% of high school seniors attain the cognitive development stage of formal operations (Graph 1). Furthermore the converse may be true in that learners may attain the formal operational stage of cognitive development before they reach adolescence.

***Graph 1:*** *Attainment of formal operational thinking by adolescents (Renner et al, 1976)*




Papert (1980), like Piaget, views children as builders constructing their own intellectual structures. Children acquire a vast quantity of knowledge well before going to school and without being taught. However Papert differs with Piaget in the area of why some learning occurs so early while others have to be deliberately imposed as formal instruction later on (Papert, 1980). He postulates that the surrounding culture of the learners as a source of materials for the construction of their intellects is the critical factor in the development of children as epistemologists. Often the culture that the learner is in displays a lack of formal materials and a cultural block, as in the case of formal mathematics.

> We shall see again and again that the consequences of mathophobia go far beyond obstructing the learning of mathematics and science. They interact with other endemic "cultural toxins," for example, with popular theories of aptitudes, to contaminate peoples' images of themselves as learners. Difficulty with school math is often the first step of an invasive intellectual process that leads us all to define ourselves as bundles of aptitudes and ineptitudes, as being "mathematical" or "not mathematical," "artistic" or "not artistic," "musical" or "not musical," "profound" or "superficial," "intelligent" or "dumb." Thus deficiency becomes identity and learning is transformed from the early child's free exploration of the world to a chore beset by insecurities and self-imposed restrictions (Papert, 1980: 8).

Papert proposes the use of computers in mathematics education as a means of overcoming these cultural barriers. He postulates that children can learn to use computers in a masterful way and that learning to use computers can change the way they learn everything else (Papert, 1980: 8). To this end the use of Logo mathematics is central. As opposed to the traditional learning environment where the educator instructs and the learner follows, in this learning environment the learner assumes the role of instructor and programmer. Furthermore the learners' interaction with Logo via the computer is not a one-way process. The program provides feedback in such a manner as to provide learners with a choice as to how they want to react to it. Logo is a computer programming language designed for learning. It allows the learner access to creating screen effects and to the mathematical concepts which underlie those (Noss, 1988). There have been a number of longitudinal studies which have sought to analyse the power of this environment from a mathematical perspective, and which have illustrated that children are able to explore and use a variety of mathematical ideas in a wide range of contexts (Papert, 1985; Hoyles, 1985). The body of research suggests that learners working with Logo, by creating and interacting with objects that are visible, quantifiable, and adhere to conventional mathematics, build connections between spatial and algebraic thinking. Mathematics becomes more concrete to learners and algebraic formalization is supported through Logo procedures. Furthermore learners are afforded opportunities to try out ideas and modify plans, which are essential elements of mathematical problem solving. Students can make and test conjectures, a vital component of mathematical reasoning (Jones, 2005). These studies have confirmed Papert's claim that by learning Logo the child is behaving as a mathematician. Papert proposes that active learning brought about through Logo is based on the theories of Piaget. However Bruner's work is closer to Logo in that he postulates that learning is enactive, iconic and symbolic. Firstly learners physically manipulate the Turtle, then they direct the pictorial Turtle on the screen and thirdly they write procedures in Logo which is symbolic (Ernest, 1989).

A view opposing that of Papert is provided by Kurkland and Pea (1985: 241) who refer to Papert's theory as "idealistic individual Piagetian learning." They suggest that self-guided discovery needs to be "mediated within an instructional context" (ibid.).

Algebra is important in formulating perimeters and areas. An aspect of learning algebra is a variable. A body of research suggests that learners have difficulty in understanding that a letter can represent a range of values (Booth, 1984; Collis, 1974; Kuchemann, 1981). Furthermore they do not accept that the different letters can represent the same value. However the use of Logo seems to overcome this obstacle. Studies have indicated that learners perceive a variable in Logo as representing a range of numbers (Noss, 1986; Sutherland, 1989). Within a Logo environment they have little difficulty in accepting that any variable name can be used and that different names could represent the same value.

Following from the previous paragraph it can be argued that the use of Logo entails the learning of concepts which affect the understanding of deep structures. Chomsky (1968) 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. This is also relevant to mathematics as Wittgenstein espouses that mathematics is a language (Hardwick, 1971).

Papert's theory is of particular relevance to the previously disadvantaged learners in South African primary schools. Given the oppressive educational system and socio-economic circumstances that their communities and especially the immediate adults that they interact with on a daily basis come from, the materials for constructing their intellects that their cultures provide them with are both insufficient and perfect for perpetuating cultural block. Therefore Papert's proposition of using computers to overcome these cultural barriers to learning is a central focus of this study Papert, 1980).

**2.6 Pre-mathematical Frames**

Acquisition of conceptual understanding is influenced by prior knowledge (Kintsch, 1988). For example, prior knowledge is expected to facilitate the acquisition of conceptual understanding by enhancing students' abilities to assimilate and integrate new information and distinguish relevant from irrelevant information (Alao and Guthrie, 1999).

This study refers to prior knowledge as pre-mathematical frames, as espoused by Davis (1984). In order to deal with abstract and complex concepts learners make use of their cognitive pre-mathematical frames which were developed in their early years. In part we do this by constructing cognitive 'collages', metaphors based on simple ideas that children learn early in life. In their elaborated form these collages embrace categorical algebra and non-standard analysis and all the rest of modern mathematics (Davis, 1984: 177). Therefore these collages play a major role in shaping our thinking. Web-based Learning plays a significant role in enhancing and developing these pre-mathematical frames. By accessing the internet to research mathematical concepts learners construct and consolidate pre-mathematical frames. This study will show how pre-mathematical frames influence the learning process.

### 2.7 Errors

Donaldson (1964) as cited by Kogan (1966) distinguishes three types of basic errors made by learners during problem solving. These are arbitrary, structural and executive errors. In arbitrary errors the learner often applies concepts from his/her real life experiences which breach the constraints of the problem. Structural errors occur when the learner fails to grasp a basic principle of the problem. Executive errors arise when there is a failure in performing the manipulations required. This study will illustrate some of the types of errors made by learners and attempt to correct them through the medium of the VNC Viewer software (Kogan, 1966).

### 2.8 Conclusion

The various theories examined in the paragraphs above provide a broad theoretical framework within which this study is based. Web-based learning is interpreted and implemented as a combination of traditional learning methods and the use of computers and the internet to enhance the learning experience of learners. The constructivist approach is used in the sense that the learners are the central focus of the learning process and are given every opportunity to build their own learning experiences. Furthermore collaborative learning is integral to this learning model as learners are social beings thus necessitating working together as teams to construct ideas and solve problems. Piaget's stages of cognitive development are used as a point of reference as to the actual intellectual capabilities of learners. More importantly, the assumption that a learner's ability to handle mathematics and learning in general is affected by cultural elements, is integral to this study. Following from this is the use of Logo as an effective means of learning mathematical concepts such as variables which proved difficult to grasp for primary school learners. The idea of deep and surface structures is a progression from the previous point in that concepts are being learnt. Finally the theory that pre-mathematical frames affect the way learners approach more abstract and complex mathematical problems forms an important component of this study.

# CHAPTER THREE

# RESEARCH DESIGN AND PROCESS

## 3.1 Introduction

This chapter highlights the research design and process of this study. To elaborate on the term research design Le Compte and Preissle (1993:30) maintain that research design focuses on what the research purpose and questions will be, "what information will most appropriately answer specific research questions, and which strategies are most effective for obtaining it." Following the same line of thought is Wiersma (1991) who also refers to research design as a plan or strategy for conducting the research, and as such it will focus on various issues which include the selection of participants for the research and the analysis of data obtained.

Given the preceding definitions of research design, the ensuing presentation lists the study's research aims (3.2) and the research questions (3.3), provides insight into the method of research that framed this study (3.4) with reference to the research approach (3.4.1), sampling (3.4.2) the instruments used to gather data (3.4.3) and the pilot study (3.4.4). In addition, the presentation includes information on data gathering (3.5), the ethical issues considered in this research (3.6), techniques that were used in analysing the data (3.7) and limitations of this study (3.8).

## 3.2 Research aims

As indicated in chapter one, this study utilised a hybrid web-based learning model to enhance the learning experience of primary school learners. The fundamental aims of conducting this study were as follows:

The fundamental aims of conducting this study were as follows:

i. To identify the shortcomings of existing computer assisted learning technologies in primary schools.
ii. To investigate how learners' mathematical skills can be improved through the use of web-based learning.
iii. Explore and describe learners' experiences and perceptions of an alternative hybrid web-based learning model.

### 3.3 Research questions

In attempting to achieve the aforementioned aims of this study, the researcher explored the following questions.

a. What are the shortcomings of existing internet technologies used by South African government primary schools?
b. What is the alternative to the current technologies being utilized?
c. How can learners' mathematical skills be improved through the use of web-based learning?

### 3.4 Research Method

#### 3.4.1 *Research Approach*

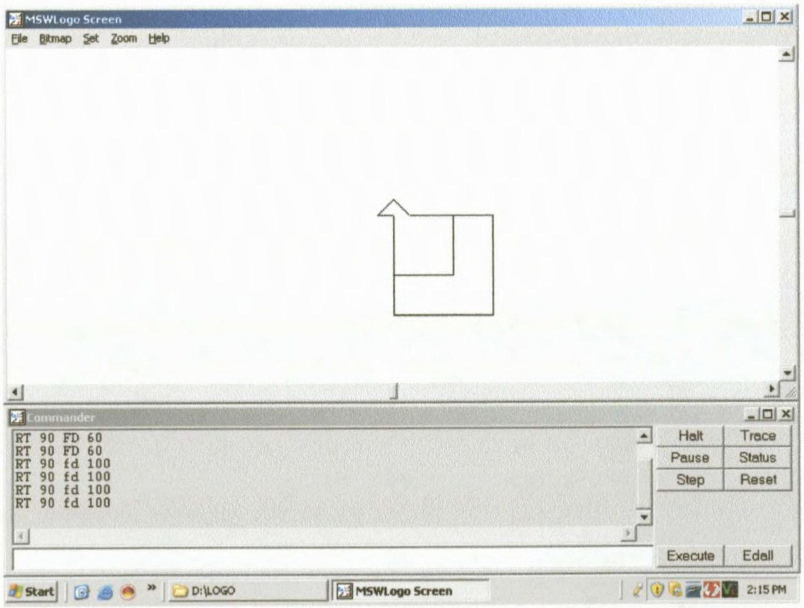
This study utilized both qualitative and quantitative aspects. The qualitative approach enabled a better understanding of the experiences, opinions and perceptions of participants. This is qualified by the view that the qualitative research approach elicits participant reports of meaning, experiences or perceptions (McRoy, 1995 as cited by

Fouche and Delport, 2002). In other words the key feature is to understand the phenomenon from the participant's experience. The emphasis was on the interpretative paradigm.

The quantitative approach was used due to utilisation of certain statistical methods. These included frequency counts and the use of tables and graphs to illustrate averages, distribution of scores and difference.

In the qualitative research design a case study methodology was used to gain in depth understanding of the perceptions and experiences of learners in their interaction with the hybrid web-based model. Stake (1995), as cited by Creswell (2003) and Merriam (1998), provides 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 twenty Grade five learners who were exposed to traditional teaching methods as far as the learning of perimeter and area was concerned. The experimental group consisted of twenty Grade five learners who also studied area and perimeter, but they used a hybrid web-based method. Using a control group allows the researcher to control for the effects of the experiment itself (Babbie, 1989: 215). 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. Through the use of the data collection procedures which were the questionnaires, the focus group interview and the activities on perimeter and area the researcher was able to increase validity of this research. What this means is that through the 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: 233). Furthermore the researcher was also able to gather further data on the actual thought processes used by learners through the use of a computer program called VNC Viewer 4 which enabled the researcher to remotely access the learners' computers while they were doing their activities (Figure 5). It was assumed that the learners were operating at the concrete operational stage as espoused by Piaget (Berk, 2000). The researcher aimed at showing that the learners could function at the formal operational stage through the use of the hybrid web-based model.

***Figure 5:*** *Screen dump of VNC Viewer in use*



Having provided discussion on the research approach it is imperative to outline how the key research questions as identified in section 3.3 were addressed. The questionnaires, activities on perimeter and area and the focus group interviews were used to address question [c]. The literature review and all the data collected in this study were used to address questions [a], [b] and [c].

### 3.4.2 *Sampling*

(i) School

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 20 computers.
- A server to handle the appropriate software.
- VNC Viewer 4 to enable the researcher to remotely access the learners' computers.
- Internet access.
- The school population had to be drawn from a disadvantaged socio-economic community thus reflecting the wider South African scenario.

The school that met these criteria is situated in Isipingo, Phumelela Circuit, Umlazi District in the Ethekwini Region. This school serves the surrounding socio-economically disadvantaged communities of Orient Hill, Lotus Park, Umlazi, KwaMakhutha, Umbumbulu, Malukazi, Folweni, Illovo and Adams Mission. The school had a newly installed fully equipped computer laboratory which met all of the aforementioned requirements.

(ii) The Participants

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 and 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). Samples of twenty learners each were selected for the experimental and control groups respectively.

The participants were from disadvantaged socio-economic communities with minimal or no access to computers. Furthermore the participants received negligible academic stimuli from their immediate families. The teaching methods employed at the school were strictly traditional and adhered to the Department of Education guidelines.

### 3.4.3 *Research Instruments*

For the purpose of this study three research instruments were used for collecting data. These included questionnaires (Appendices A and B), a focus group interview (Appendix

C) and activities on perimeter and area that the learners completed (Appendix G). Furthermore the researcher was also able to gather data on the actual thought processes used by learners through the use of a computer program called VNC Viewer 4 which enabled the researcher to remotely access the learners' computers while they were doing their activities on area and perimeter (Appendix G). Figure 6 and figure 7 illustrate how VNC Viewer promoted collaborative learning by facilitating educator-learner interaction and learner-learner interaction respectively.

***Figure 6:*** *Educator-Learner collaboration*

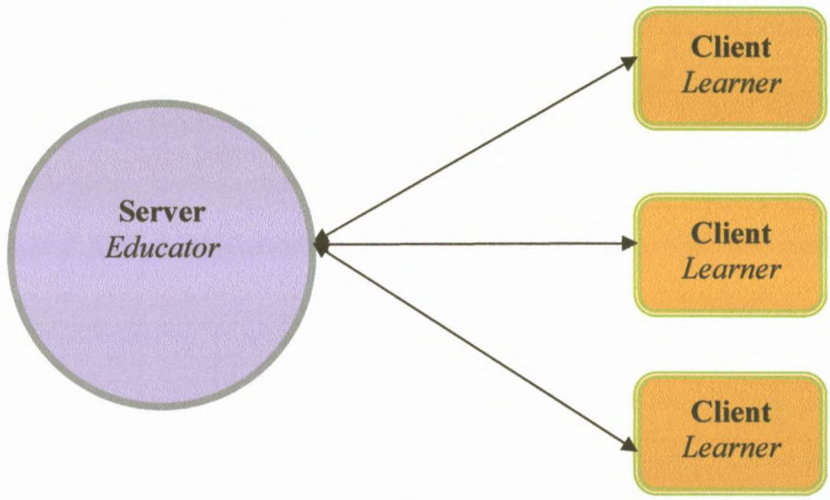
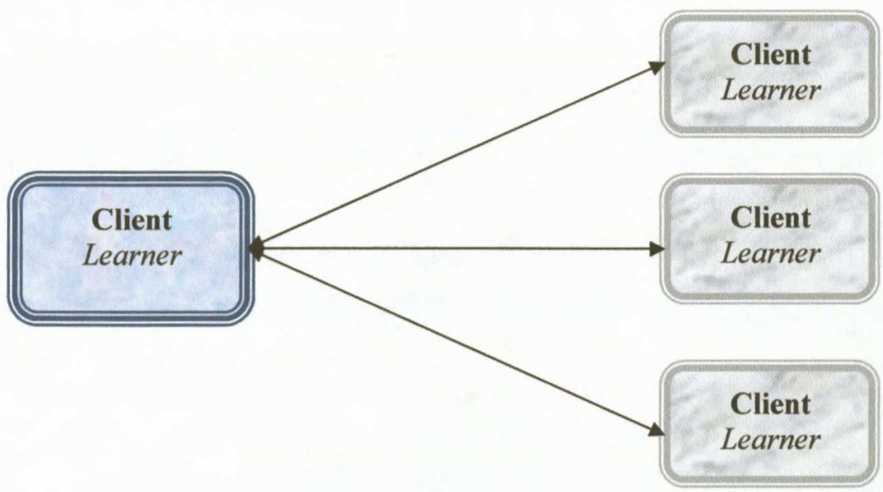



***Figure 7:*** *Learner-Learner collaboration*



*Questionnaires*

Two questionnaires were used to collect data on participants' perceptions and experiences. The first questionnaire (Appendix A) was directed at the learners in the experimental group. The respondents for the second questionnaire (Appendix B) were the learners in the control group. With the intention of preventing a low response rate from the participants the questionnaires were delivered personally to the learners. Initially the principal and then the learners and their parents, the latter via written communication (Appendix C), were briefed on the aims of this study. A date for the collection of the questionnaires was established. A time frame of one week for completion of the questionnaires was agreed upon. The researcher collected the questionnaires personally from each learner. This was done to assure the learners that the questionnaires would be handled only by the researcher and they did not have to fear that their responses would be read by other individuals.

The researcher opted for the use of the questionnaire because it has less bias possibilities. This is because the researcher is less likely to influence the responses of the subjects, for example by asking questions in a particular tone which may lead the respondent towards a particular line of thought. The questionnaires therefore ensured anonymity, were cost effective and permitted data collection from a large sample (Gay, 1992). In spite of the advantages of the questionnaire as outlined above, the researcher was aware of its inherent limitations which included the respondents being unable to clarify issues when completing the questionnaire. This was because the researcher could not, "face-to-face", probe the respondent to clarify issues. It was for this reason that data was further collected through focus group interviews.

With regard to the questionnaire design, instructions to the respondents were simple and concise. This was aimed at facilitating the completion of the questionnaires. The researcher made every attempt to ensure that the questions were simple and straight forward so as to avoid ambiguity.

The first questionnaire, which was aimed at the experimental group, was divided into four sections. Section A was designed to elicit biographic information from the respondents. These included questions on age and gender. Section B included both open and closed questions that looked at the concepts of square, rectangle, perimeter and area. Questions were also structured to elicit responses about learners' prior knowledge and if and how it influenced their ability to perform calculations. The open ended questions were designed for the respondents to express their ideas and feelings about specific issues. It was the researcher's intention for these questions to provide "rich information" to enhance the findings of this study. Section C comprised closed questions about specific aspects related to learners' perceptions about using web-based learning, Logo mathematics and a networked computing environment. The final section (Section D) consisted of two questions which were aimed at obtaining a list of additional mathematical concepts that learners may have learned during their activities.

The second questionnaire, which was aimed at the control group, was also divided into four sections. Section A was designed to elicit biographic information from the respondents and comprised questions on age and gender. Section B included both open and closed questions that looked at the concepts of square, rectangle, perimeter and area. Questions were structured to elicit responses about learners' prior knowledge and if and how it influenced their ability to perform calculations. The open ended questions were designed for the respondents to express their ideas and feelings about specific issues. Section C comprised closed questions about specific aspects related to learners' perceptions about learning perimeter and area in a traditional teaching/learning environment. The final section (Section D) consisted of two questions which were aimed at obtaining a list of additional mathematical concepts that learners may have learned during their activities.

*Focus Group Interviews*

Although there are various definitions of focus group interviews, it must be pointed out that in general a focus group is a broad term that is given to a research interview conducted with a group, as is apparent in the following conceptualisation of the term by different authors. "A focus group is typically a group of people who share a similar type of experience, but that is not 'naturally' constituted as an existing social group" (Terre Blanche and Kelly, 1999: 388). Powell et al (1996), as cited by Gibbs (1997), also concur that a focus group comprises individuals selected by the researcher to discuss and comment on, from personal experience, the topic that is the subject of the research. Given the preceding definitions it follows that the group of people involved in the interviews for this study were the learners in the experimental group and the common experience shared by these learners was that they were involved in the process of learning through a hybrid web-based learning model.

A factor that persuaded the researcher to use focus group interviews is that, compared to one-to-one interviews which aim to obtain individual attitudes, beliefs and feelings, focus groups elicit a multiplicity of views and emotional processes within a group context (Gibbs, 1997). In other words several perspectives can be obtained about the same topic. The researcher's choice for the use of focus group interviews was also influenced by expectations that the participants would communicate freely their experiences and perceptions. This is because individuals can also feel intimidated during one-to-one interviews and this intimidation can be avoided through the use of focus group interviews as the participants in the group generally share some commonality. Furthermore, people "feel relatively empowered and supported in a group situation where they are surrounded by others" (Greeff, 2002).

Focus group interviews also have limitations. It can be intimidating for those participants who lack the confidence to articulate themselves in groups. Gibbs (1997) highlights an important point by arguing that focus groups are not fully confidential or anonymous. This is because the information in the group is shared. However, the researcher did regularly emphasise the need to keep the experiences and opinions of other participants confidential. In other words, after the interview participants should not discuss what was said in the group. Another claim against the use of focus group interviews "rests with social posturing, the desire for people to be polite and fit within the norm, or forced compliance" (Greeff, 2002:319). In addressing this limitation the researcher made numerous attempts to ensure that a comfortable, non-threatening setting was created. Participants were encouraged to be themselves during the interview and not to feel inhibited in any way if they felt like airing their opinions

One focus group interview was conducted. The interview was approximately 15 minutes. The interview was conducted in a classroom away from the administration block so as to avoid any disruptions. Participants were given prior notice of the date, time and venue of the interview. In determining the size of the group the researcher considered Greeff's (2002: 311) argument that "smaller groups ...are preferable when the participants have a great deal to share about the topic or have intense or lengthy experiences with the topic of discussion." With this in mind the researcher opted for a group of eight participants.

Although the groups were homogenous in that all participants were in the same age range and all were in the experimental group, the researcher also looked at heterogeneity. Gender was represented in proportion to the learner population with five males and three females being used. This was necessary to elicit diverse opinions and experiences so as to increase the quality and richness of the data obtained. Many authors like Greeff (2002), McMillan and Schumacher (1997), Terre Blanche and Kelly (1999) advise that focus groups need to rely on purposive sampling where the researcher looks for particular participants so as to obtain a wide range of opinions and experiences.

The interviews were recorded on tape. This is because recording is convenient and also assists in reducing distraction to both the interviewer and the participants because the interviewer does not have to impede the flow of discussion to make copious notes. Furthermore, "Interviews recorded on tape may be replayed as often as necessary for complete and objective analysis at a later time" (Best and Kahn, 1989:2002). In other words reliability checks can be facilitated.

The researcher was aware that the presence of a tape recorder could cause some uneasiness amongst some participants. However the participants were guaranteed of anonymity and did not see this as a threat. Although the interviews were audio recorded, brief notes were also taken on paper during the interviews by the researcher to record non- verbal cues.

As previously mentioned, the focus group interviews were used to probe certain issues. Thus the questions were open ended. This aimed at eliciting responses from the learners about their perceptions and experiences regarding web-based learning and the learning of perimeter and area through the use of Logo (Appendix F).

*Activities on Perimeter and Area*

The learners in the experimental group had to complete four activities on area and perimeter (Appendix G) using Logo, Microsoft Word and VNC Viewer. The activities were presented in the form of a worksheet as a word document. Learners had to access it on the server and complete the activities using Logo. Collaborative learning was encouraged, but learners were also asked to provide their own ideas before collaborating with their peers (Jolliffe et al, 2001). The activities comprised the following sections:

- ◊ Perimeter
- ◊ Area
- ◊ Patterns with perimeter and area – with emphasis on perimeter
- ◊ Patterns with area and perimeter – with emphasis on area

Learners were required to calculate perimeter and area as well as find formulae to calculate the aforementioned concepts.

### 3.4.4 *Pilot Study*

According to Babbie (1990) pre-test refers to the initial testing of one or more aspects of the research design, such as the questionnaire. Authors like Cohen, Manion and Morrison (2000) refer to this pre-testing as piloting. The questionnaire and the activities on perimeter and area were piloted amongst the experimental group. Necessary adjustments were made to the questionnaire and the activities. This process was to check the clarity of the instruments. It also assisted in eliminating ambiguities in the wording of questions.

## 3.5 Data Gathering

A total of forty questionnaires were distributed to all the participants. All questionnaires were returned, providing a response rate of 100%. Berdie (1990) and Gay (1992) as cited by Mertens (1998), maintain that a response rate of approximately 70% is a numerically significant proportion of the sample and is therefore acceptable in terms of generalisability. Thus the response rate of 100% was adequate to ensure meaningful conclusions. All twenty (100%) learners in the experimental group completed the activities on perimeter and area and saved their work on the school computers.

### 3.6 Ethical Issues

Before conducting the research the relevant persons in the education department were contacted to obtain official permission and approval to pursue the research project (Appendix D). A letter of consent from the Department of Education to conduct this research was received. A list of terms and conditions were also provided by the Department of Education for the researcher to abide by (Appendix E). On receiving approval from the Department of Education, KwaZulu-Natal the researcher obtained permission from the principal of the sample school to proceed with the study.

Having obtained permission to conduct the research other ethical issues that were considered included anonymity and confidentiality. According to Cavan (1977) as cited by Cohen, Manion and Morrison (2000: 56), ethics can be defined as "a matter of principled sensitivity to the rights of others." What this means is that in pursuit of knowledge and truth respecting the dignity of participants takes precedence. With the above statement in mind the researcher assured the participants of anonymity and confidentiality. "The essence of anonymity is that information provided by participants should in no way reveal their identity" (Cohen and Manion, 1995: 366). For this reason the learners were asked not to append their names to the questionnaires.

With regard to confidentiality, the researcher reassured the participants that all information disclosed would be treated in the strictest of confidence and would be used solely for the purpose of this study.

### 3.7 Analysing the data

With regard to the questionnaires, the closed questions were analysed through frequency count. Frequency count refers to the system of transforming information obtained from the questionnaires "into numbers or quantitative data...by counting the number of respondents who give a particular response" (Tuckman, 1998: 213). Responses to open ended questions were addressed through frequency counts and content analysis. The taped interview was transcribed. The researcher organised the data into themes and categories. During the process of developing themes, the data were coded and reviewed repeatedly. The data from the activities on perimeter and area were analysed according to themes. The learners were allocated marks for each answer they provided. The questions were graded according to degrees of difficulty and the marks were rated as 1, 2 and 3 with 1 being for the least difficult question.

### 3.8 Limitations

Limitations refer to the potential weakness(es) of the design of the study. This study was conducted in one school only as a case study. Therefore the findings cannot be generalised as representative of all schools in the country.

### 3.9 Conclusion

This chapter has highlighted the various aspects of the research design. It also emphasised how the research design was planned and executed, focussing on the research instruments, the sampling of the schools, the techniques employed in analysing the data as well as the limitations of the study. The next chapter discusses findings in this study.

# CHAPTER FOUR

# PRESENTATION AND DISCUSSION OF FINDINGS

## 4.1 Introduction

The purpose of this chapter is to present and discuss findings emerging from data collected in this study through the questionnaires and focus group interview as well as observations gleaned through the VNC Viewer software. As indicated in chapter three, two questionnaires were administered: one was aimed at the experimental group and another was directed at the control group in the sample school. Also, as already indicated, the questionnaires comprised a series of closed and open-ended questions. The closed questions were analysed through frequency counts and percentages. The percentages were rounded-off to one decimal place and where necessary graphic representation is given. The open-ended questions in the questionnaires and the interviews were addressed through elementary content analysis. The presentation of findings from such analysis is supplemented with direct quotation, where relevant. The presentation of the findings is discussed in the context of the relevant literature, as outlined in chapter two.

## 4.2 Analysis of the Experimental Group Questionnaires.

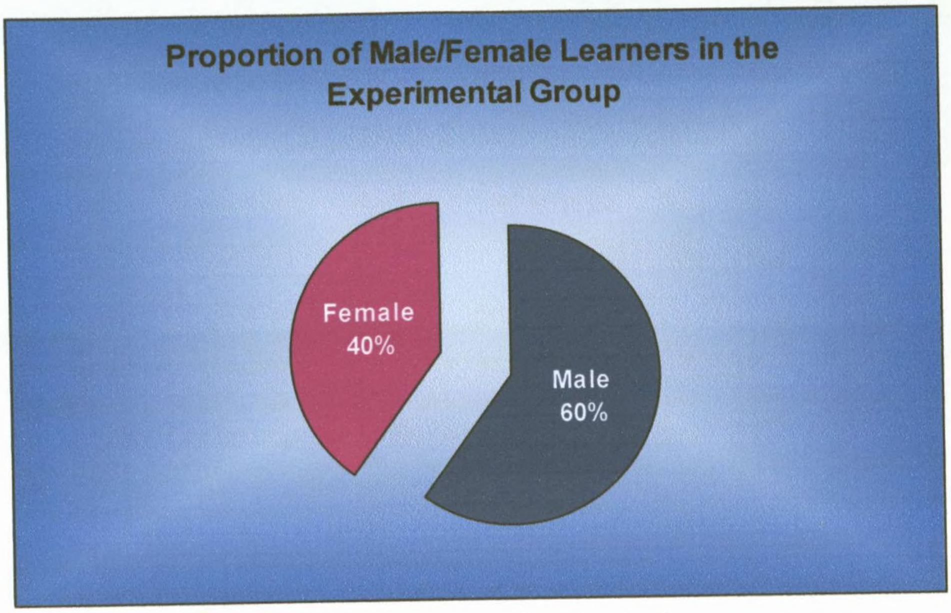
Twenty questionnaires were distributed and all were returned. Thus there was a 100 % response rate. The findings and discussion follow the order of the questionnaire.

Responses to **Section A** provided biographical details regarding the learner sample.

**Question 1**: *Comparison of the number of male and female learners.*

The following graph indicates the gender of the respondents.

*Graph 2: Comparison of number of male and female learners in the experimental group*




A total of 12 males and 8 females responded to the questionnaires. In other words 60% of the respondents were male and 40% were female. The distribution was in line with the gender distribution of learners in this grade in the sample school. The distribution might imply that findings in this study may be transferable to other primary schools of similar contexts to that of the sample school. Furthermore the Annual Report of Her Majesty's Chief Inspector of Schools (2005) suggests that we ought to be concerned about the more limited progress of girls in mathematics, relative to boys. Therefore it is important to note the proportion of males to females in a study.

**Question 2**: *Age distribution of the learners.*

***Table 3***: *Age distribution of the learners.*

| **Age (in years)** | **10** | **11** | **12** | **Total** |
|---|---|---|---|---|
| **Number of Learners** | 9 *(45%)* | 10 *(50%)* | 1 *(5%)* | 20 |

It can be gleaned from table 2 that 95% of the sample in the experimental group fell within Piaget's concrete operational stage which comprises the 7 – 11 year age group (Saler and Edgington, 2006). According to Piaget children cannot contemplate and understand abstract problems in this stage (Moursund, 2006). However data from this study has indicated otherwise and will be discussed in greater detail in Section D, Question 2.

Responses to **Section B** provide details about the learners' perceptions of the concepts of square, rectangle, perimeter and area as well as learners' prior knowledge and if and how it influenced their ability to perform calculations.

**Question 1**: *What do you understand by the concept 'perimeter'?*

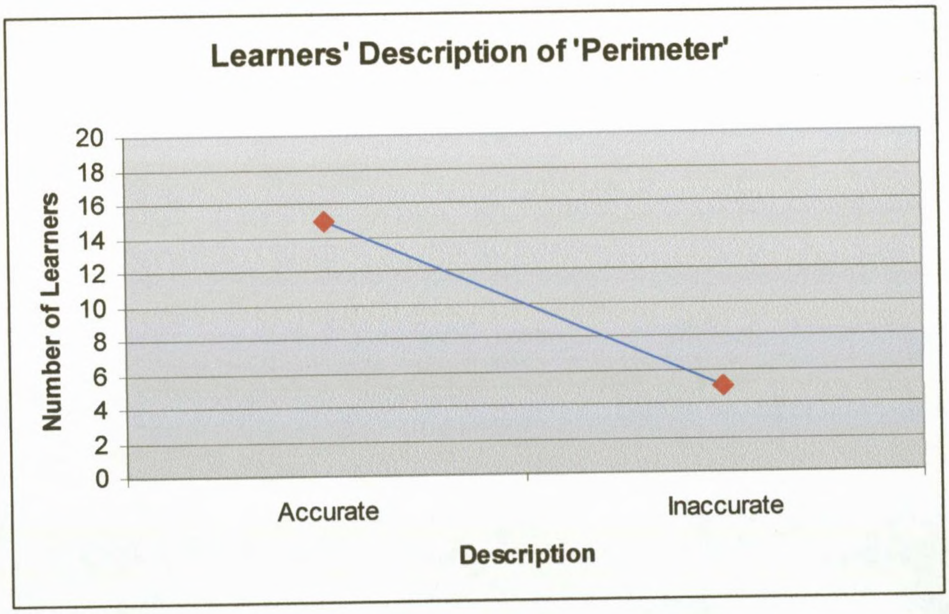
From the responses, 75% of the learner sample was able to provide an accurate description of perimeter. Some of their responses are depicted below:

- The distance around a shape or object
- The measurement of the boundary of a shape
- What you get when you measure around the outer part of a shape

However 25% of the respondents provided answers that were not related to perimeter. Their responses were based on distance only. These statistics are reflected in Graph 3.

The aforementioned data provide a positive indictment of the hybrid web-based model as the sample learners' response to this question stemmed from the activities using the former. Furthermore, as will be discussed in greater detail in the next chapter, the number of correct responses by the learner sample in the control group to this question in their questionnaire was much lower.

***Graph 3:*** *Learners' understanding of Perimeter.*




**Question 2**: *What do you understand by the concept 'area'?*

Satisfactory descriptions of the concept of area were provided by 85% of the respondents. Some of their responses are depicted below:

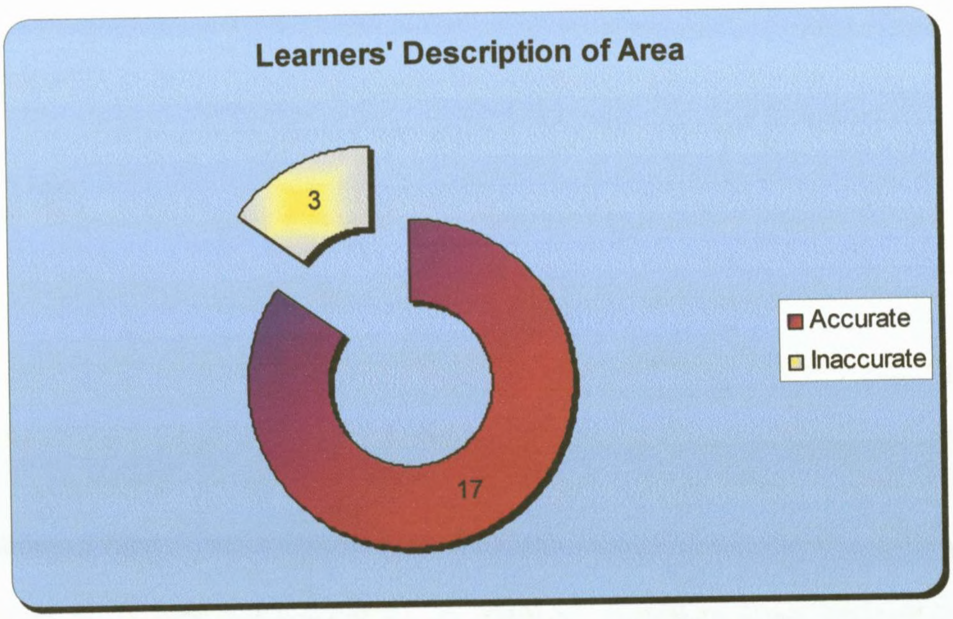
- The number of units in a shape.

- The amount of units covering a shape
- What you get when you measure the surface of a shape

The other 15% of the learner sample described area as being a specific location. These findings are illustrated by Graph 4.

The accurate descriptions of the concept of area by such a high percentage of the learner sample followed the activities on area using the hybrid web-based learning method. As in the case of perimeter, the responses of the learners in the experimental group were far superior to that of the control group.

***Graph 4:*** *Learners' understanding of Area*



**Question 3**: *Did you know what a square was before these lessons?*

100% of the respondents indicated that they had prior knowledge of a square. This response was of significance as one of the theories discussed in the literature review espoused that pre-knowledge frames played an important role in shaping learners' abilities to deal with more abstract problems (Davis, 1984).

**Question 4**: *Provide a brief description of what you understood a square to be.*

All 20 respondents (100%) provided satisfactory explanations of what a square was. The crux of their answers was that a square was a shape with 4 equal sides. Thus these learners have a solid pre-knowledge of squares. This is of significance, as espoused by Kintsch (1988) that acquisition of conceptual understanding is influenced by prior knowledge. Furthermore one of the theories discussed earlier espoused that pre-knowledge frames played an important role in shaping learners' abilities to deal with more abstract problems (Davis, 1984). Therefore this would impact on the ability of learners to formulate methods to calculate area and perimeter of a square. As will be discussed later it becomes evident that learners with a pre-knowledge of squares are better able to formulate ways to calculate area and perimeter. The developmental stage of the learners falls in line with Piaget's concrete operational stage (Saler and Edgington, 2006). Furthermore it is important to note that this pre-knowledge was gained from traditional teaching and learning methods in the earlier years of the learners' schooling. Thus the role of the traditional teaching/learning component of the hybrid web-based model is emphasised.

**Question 5**: *Did you know what a rectangle was before these lessons?*

100% of the respondents indicated that they had prior knowledge of a rectangle. This response was of significance, as in the case of question 3, as one of the theories discussed in the literature review espoused that pre-knowledge frames played an important role in shaping learners' abilities to deal with more abstract problems (Davis, 1984).

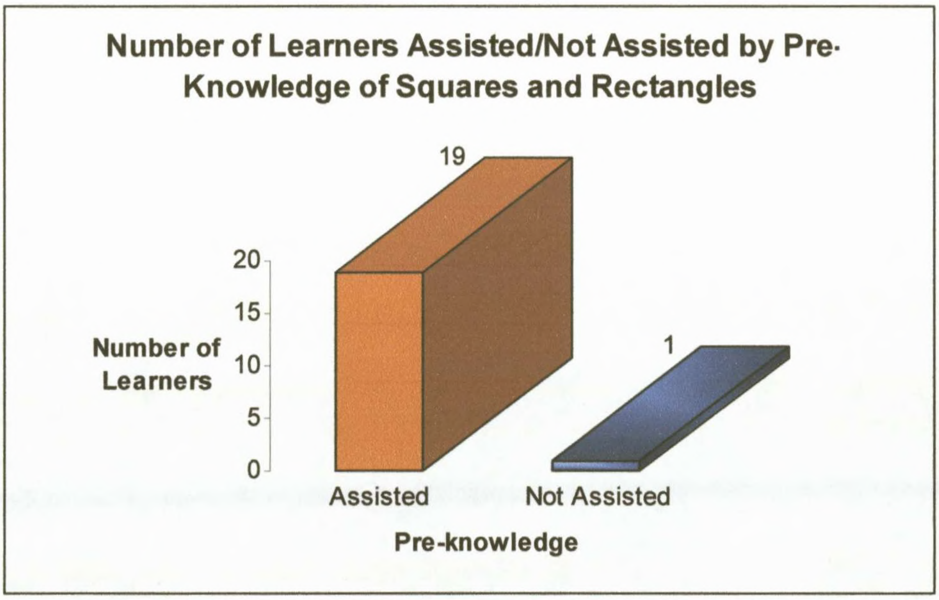
**Question 6**: *Provide a brief description of what you understood a rectangle to be.*

All 20 respondents (100%) provided satisfactory explanations as to what a rectangle was. The crux of their answers was that a rectangle was a shape with 4 sides, with each pair of opposite sides being equal in length. The developmental stage of the learners also falls in line with Piaget's concrete operational stage (Saler and Edgington, 2006). As in the case of the square this response was of significance as one of the theories discussed in the literature review espoused that pre-knowledge frames played an important role in shaping learners' abilities to deal with more abstract problems (Davis, 1984). Furthermore the analysis will show that learners with a pre-knowledge of rectangles were better equipped to formulate methods of calculating area and perimeter. Also as in question 4 this pre-knowledge was gained from traditional teaching and learning methods in the earlier years of the learners' schooling. Therefore the role of the traditional teaching/ learning component of the hybrid web-based model is emphasised. This finds reinforcement in the view that web-based learning comprises hybrid courses that integrate face-to-face and online components (Oblinger and Hawkins, 2005).

**Question 7:** *Did your knowledge of squares and rectangles assist you in finding a method of calculating the area and perimeter of these shapes?*

The responses to this question revealed that 95% of the sample learners felt that their pre-knowledge of squares and rectangles enabled them to find a method of calculating the area and perimeter of these shapes. 5% (1) indicated that the pre-knowledge did not assist in finding a method to calculate area and perimeter. This finding is vindicated by Davis (1984) who postulates that cognitive pre-mathematical frames play an integral role in enabling learners to deal with more complex concepts. The data gleaned from this question is presented in the graph below (Graph 5).

***Graph 5:*** *Number of learners assisted/not assisted by pre-knowledge of squares and rectangles*



**Question 8:** *How did your pre-knowledge of squares and rectangles assist you in finding a method of calculating perimeter and area?*

Following from the responses to question 7, this question was answered by 19 learners. 89.5% (17) of the respondents indicated that they used the properties of the square and rectangle to develop formulae. Following are exemplars of their answers.

- I knew that a square has 4 equal sides. Then if I know what 1 side measures all I had to do was to multiply it by itself.
- Since all the sides of a square are the same you multiply any side by itself.
- The rectangle has 2 long sides which are equal to each other and 2 short sides which are equal to each other. That is why you multiply 1 short side by 1 long side.
- I knew that a square has 4 equal sides. Then if I know what 1 side measures all I had to do was to multiply it by 4.
- Since all the sides of a square are the same you multiply any side by 4.
- The rectangle has 2 long sides which are equal to each other and 2 short sides which are equal to each other. That is why you add the 2 short sides and add the 2 long sides and then add all.
- Because the 2 short sides are the same and the 2 long sides are the same I added 1 long side and 1 short side then multiplied it by 2.

10.5% (2) of the respondents were not clear as to how their pre-knowledge assisted them in calculating perimeter and area.

The fact that 89.5% of the respondents were able to develop formulae based on their pre-knowledge illustrates the importance of the latter in enhancing learners' abilities to assimilate and integrate new information (Alao and Guthrie, 1999). Furthermore this finding is in contrast to Piaget's stages of cognitive development which places 10 – 11 year old learners in the concrete operational stage (Berk 2000). Since these learners were capable of developing formulae to calculate area and perimeter they are operating at Piaget's formal operational stage.

**Question 9:** *If you indicated in question 7 that pre-knowledge of squares and rectangles did not assist you in finding a method to calculate area and perimeter of these shapes, explain what method you used.*

Only 1 learner (5%) answered this question. The respondent indicated that perimeter was calculated by adding up the sides and area was calculated by counting the number of units. When comparing this respondent's method to those who used their prior knowledge, it is glaring that the latter were thinking mathematically while the former was not (Papert, 1980).

Responses to **Section C** reflect learners' perceptions about using web-based learning, Logo mathematics and a networked computing environment. Learners had to indicate whether they agreed with a statement by placing a tick next to it.

**Question 1**: *I was allowed to try my own methods to find answers.*

All 20 (100%) respondents agreed with this statement. This is a vindication of the use of web-based learning in primary schools as it promotes independent thinking by allowing learners to explore their own methods of finding solutions (Alessi and Trollip, 2001). Furthermore this finding is also in line with the constructivist approach in that learners are encouraged to develop their own tasks (Jolliffe et al, 2001). It also finds support in the theory of Papert (1980) who views children as builders constructing their own intellectual structures. Therefore they need to be afforded the opportunity to explore different avenues of finding solutions. Finally it blends in with use of Logo mathematics which allows learners to try out ideas and modify plans as well as make and test conjectures (Jones, 2005).

**Question 2**: *I felt comfortable trying my own method.*

100% (20) of the respondents agreed with this statement. This attitude of the respondents finds support in some of the advantages of web-based learning: Opportunities for individual learning are created, the learning experience is mostly learner-centred and it caters for problem based learning (Horton and Horton, 2003). Furthermore it is vindicated by the exposition of Papert (1980) that the use of Logo mathematics through the medium of computers overcomes cultural barriers. The fact that these learners are comfortable in trying their own methods to find mathematical solutions despite coming from a culture that provides minimal material resources as far as mathematics is concerned, further justifies the previous point.

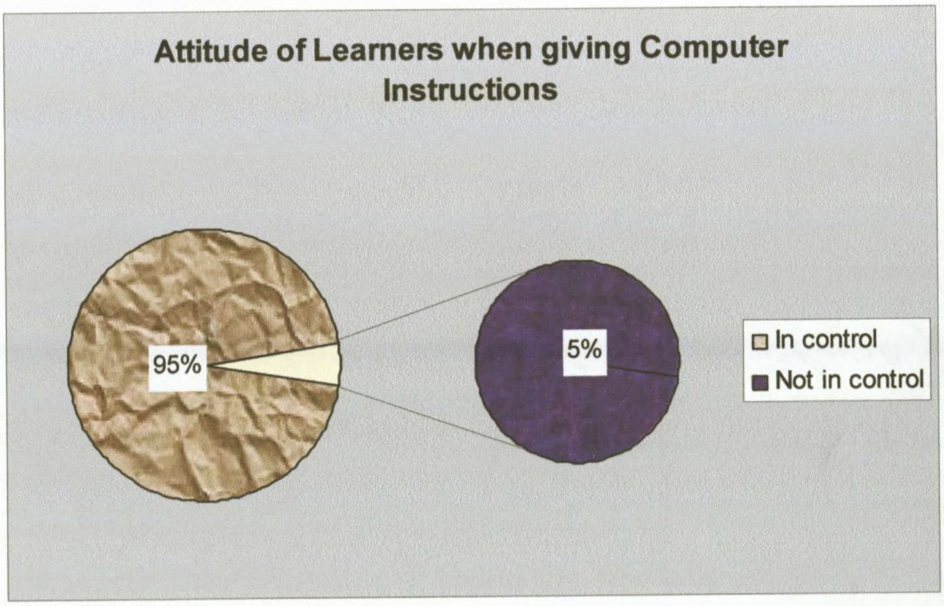
**Question 3**: *I did not fear getting answers wrong as the feedback from the computer made me feel at ease.*

All 20 (100%) respondents agreed with this statement. The learners' response to this question may be clarified through comparison with the views of Papert (1980). Central to Papert's postulation, and as evident in the findings in this question, is that the learners' interaction with Logo via web-based learning is not a one-way process. The program provides feedback in such a manner as to provide learners with a choice as to how they want to react to it (Papert, 1980).

**Question 4**: *Giving the computer instructions made me feel in control of the lesson.*

Of the 20 respondents, 95% (19) agreed with the statement while 5% (1) disagreed (Graph 6).

***Graph 6:*** *Whether learners felt in control when giving the computer instructions*



The finding in this question that 95% of the respondents felt in control when giving the computer instructions, through the use of Logo, is supported by the view that in the Logo environment the learner assumes the role of instructor and programmer (Papert, 1980). Furthermore these learners are overcoming cultural block through the use of Logo by feeling in control of a mathematical situation which is in direct contrast to their surrounding cultural influences.

**Question 5**: *I was able to work at my own pace*

All 20 (100%) respondents agreed with this statement. One of the most important benefits of web-based learning is that it caters for different skill levels as learners may work at their own pace (Horton and Horton, 2003).

**Question 6**: *Being able to work with other learners by sharing ideas on their/my screen improved my understanding of the lessons*

100% (20) of the respondents agreed with this statement. This finding is backed up by theory which views web-based learning as a provider of opportunities for team based learning (French, 1999). Furthermore proponents of collaborative learning claim that shared learning enables learners to be responsible for their own learning, become critical thinkers and engage in discussion (Totten, Sills, Digby and Russ, 1991 as cited by Gokhale, 1995). It is also important to note that shared learning can be attained by traditional learning also.

**Question 7**: *Being able to share my ideas with the entire class on the Local Area Network made me feel that my ideas were important*

All 20 (100%) respondents were in agreement with this statement. This finding is supported by theory which states that collaborative learning implies that learners are responsible for the learning of other group members as well as their own and as a result success or failure is shared (Totten, Sills, Digby and Russ, 1991 as cited by Gokhale, 1995). Furthermore it is evident that these learners are overcoming their cultural barriers to learning mathematics as they are learning to use computers, and a networked computing environment in particular, in a way that is gifting them with the confidence to share their ideas with others without fear (Papert, 1980).

Responses to **Section D** provide insight into additional mathematical concepts that the experimental group may have learned.

**Question 1**: *Did you discover any other mathematical concepts during this activity?*

All 20 (100%) respondents indicated that they had discovered additional mathematical concepts during the course of the activities. According to Papert (1980), using Logo mathematics through computers can change the way learners learn everything else. Furthermore this may imply that the use of Logo through the medium of computers enables learners to think on a deeper level by relating other concepts to their activities. Therefore Logo is affecting the way learners think and what they think about. This in turn can be linked to the theory of Chomsky (1968) because Logo is thus facilitating the learning of new concepts which affect the understanding of deep structures.

**Question 2**: *List the additional mathematical concepts that you may have discovered.*

The responses are listed in the following table (Tab. 4).

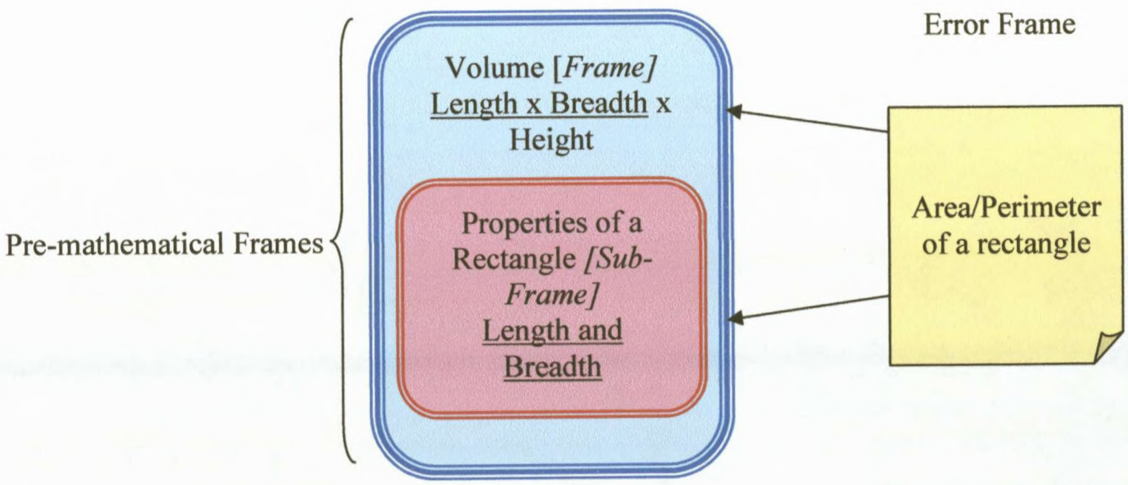
***Table 4:*** *List of additional mathematical concepts discovered by the experimental group*

| Concepts | Number of Learners |
|---|---|
| Formula | 15 (75%) |
| Polygons | 14 (70%) |
| Angles | 13 (65%) |
| Variables | 9 (45%) |
| Equations | 8 (40%) |
| Circle | 3 (15%) |
| Symmetry | 3 (15%) |
| Volume | 2 (10%) |
| Fractions | 1 (5%) |
| Measurement | 1 (5%) |
| Patterns | 1 (5%) |

The fact that significant percentages of learners listed concepts like formula and variables shows that these learners are operating at Piaget's formal operational stage yet their age group places them in the concrete operational stage (Berk, 2000). This can be attributed in part to the impact of Web-based Learning and Logo. A body of research puts forth the idea that learners working with Logo, by creating and interacting with objects that are visible, quantifiable, and adhere to conventional mathematics, build connections between spatial and algebraic thinking. Furthermore algebraic formalisation is supported through Logo procedures (Jones, 2005). An additional line of thought is that learners' awareness of more mathematical concepts may be attributed to their exposure to the internet, especially the search engines. The responses in this question also reinforce the notion that the use of Logo in conjunction with web-based learning contributes to dispelling the impact of cultural barriers to learning mathematics.

While the learning of additional concepts during the activities of area is positive, it is apparent that some of the concepts listed bear little relation to what was being learnt. Such an example is the concept of volume which was listed by 10% of the experimental group. This may be linked to the theory of pre-mathematical frames where learners construct collages from simple ideas that they learn early in life. These collages are then used to handle more complex mathematical problems later in life (Davis, 1984). Thus it follows that if an inaccurate understanding of a concept is inculcated along the way, a flawed collage will be created. It is possible that the aforementioned learners drew upon their pre-mathematical frames and associated length and breadth, which are also used in the calculation of volume, with area and perimeter. This may be explained diagrammatically (Figure 8).

***Figure 8:*** *Error associated with pre-mathematical frames*



Finally some of the concepts listed may be classified according to Donaldson's types of errors (Kogan, 1966). The discovery of a circle may be classified as an arbitrary error since it breaches the constraints of the activity.

### 4.3 Analysis of the Control Group Questionnaires.

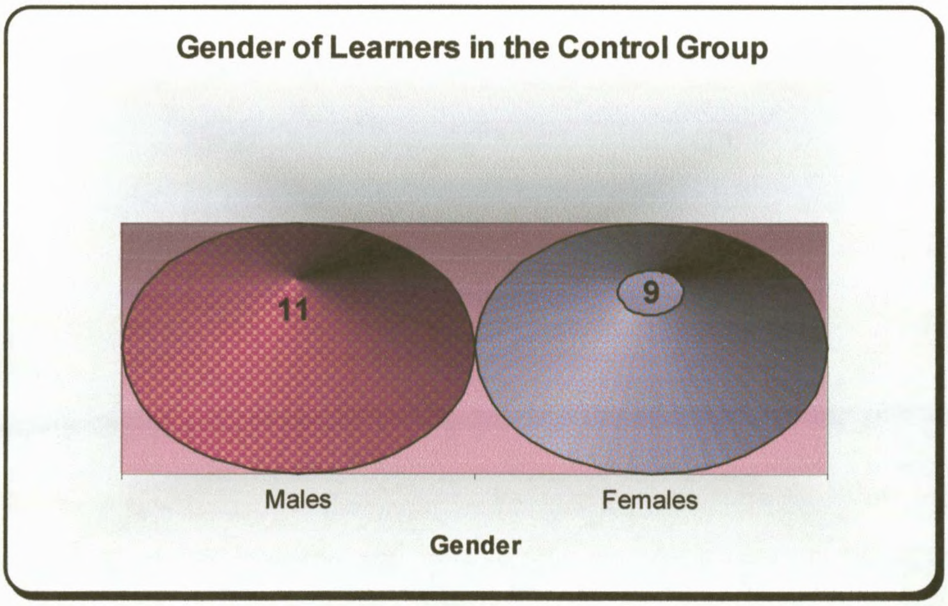
Twenty questionnaires were distributed and all were returned. Thus there was a 100 % response rate. The findings and discussion follow the order of the questionnaire.

Responses to **Section A** provided biographical details regarding the learner sample.

**Question 1**: *Comparison of the number of male and female learners.*

The following graph indicates the gender of the respondents.

***Graph** 7: Comparison of number of male and female learners in the control group*



A total of 11 males and 9 females responded to the questionnaires. In other words 55% of the respondents were male and 45% were female. The distribution was in line with the gender distribution of learners in this grade in the sample school and compares favourably with that in the experimental group. The latter point facilitates comparison of findings between the two groups. Furthermore as indicated earlier the Annual Report of Her Majesty's Chief Inspector of Schools (2005) suggests that we ought to be concerned about the more limited progress of girls in mathematics, relative to boys. Therefore it is important to note the proportion of males to females in a study.

**Question 2**: *Age distribution of the learners.*

***Table 5**: Age distribution of the learners.*

| **Age (in years)** | **10** | **11** | **12** | **Total** |
|---|---|---|---|---|
| **Number of Learners** | 8 *(40%)* | 10 *(50%)* | 2 *(10%)* | 20 |

It can be gleaned from table 5 that 90% of the sample in the experimental group fell within Piaget's concrete operational stage which comprises the 7 – 11 year age group (Saler and Edgington, 2006). According to Piaget children cannot contemplate and understand abstract problems in this stage (Moursund, 2006).

Responses to **Section B** provide details about the learners' perceptions of the concepts of square, rectangle, perimeter and area as well as learners' prior knowledge and if and how it influenced their ability to perform calculations.

**Question 1**: *What do you understand by the concept 'perimeter'?*

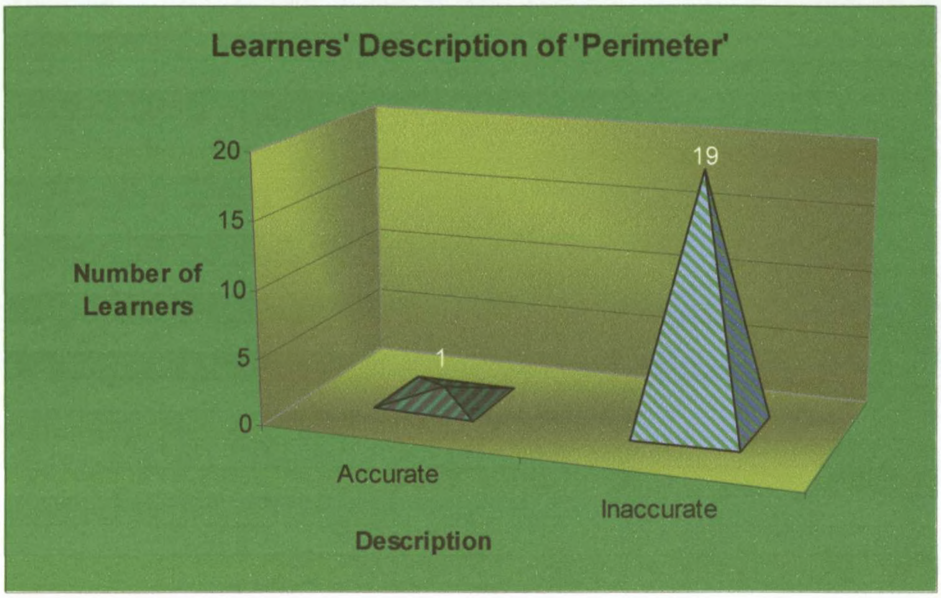
From the responses, 5% (1) of the learner sample was able to provide an accurate description of perimeter by referring to it as 'the measurement of the distance around an object or shape.' However 95% (19) of the respondents provided answers that were not related to perimeter. Exemplars of their responses follow:

- The length of something
- Size
- Something that is long
- Counting the centimetres of a shape
- Measuring length, breadth or height

Since this data was obtained after each group was subjected to the learning of perimeter using traditional methods (control group) and web-based learning through the use of Logo and a networked environment (experimental group), the analysis illustrates that the latter had gained a better understanding of the concept of perimeter.

The aforementioned data provide a negative indictment of traditional teaching methods compared to the hybrid web-based model as the sample learners' response to this question stemmed from the activities using the former. Furthermore the number of correct responses by the learner sample in the experimental group to this question in their questionnaire was significantly higher.

***Graph 8:*** *Learners' understanding of Perimeter.*




**Question 2**: *What do you understand by the concept 'area'?*

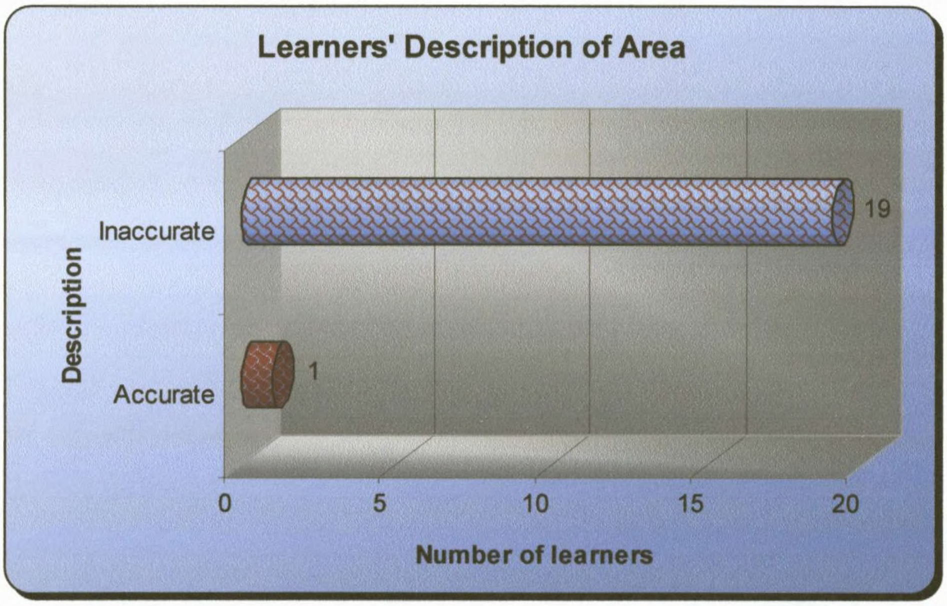
Satisfactory descriptions of the concept of area were provided by 5% (1) of the respondents with the crux of the answer being the number of units that covered the surface of a particular object or shape. The other 95% (19) of the learner sample described area as:

- A piece of land
- Where you live
- You times the length, breadth and height
- How long a shape is
- Measure in centimetres

Since this data was obtained after each group was subjected to the learning of area using traditional methods (control group) and web-based learning through the use of Logo and a networked environment (experimental group), the analysis illustrates that the latter had gained a better understanding of the concept of area. The errors that learners made in explaining the concept of area may be attributed to pre-mathematical frames (Davis 1984). These findings are illustrated by Graph 9.

As in the case of perimeter, the responses of the learners in the experimental group were far superior to that of the control group.

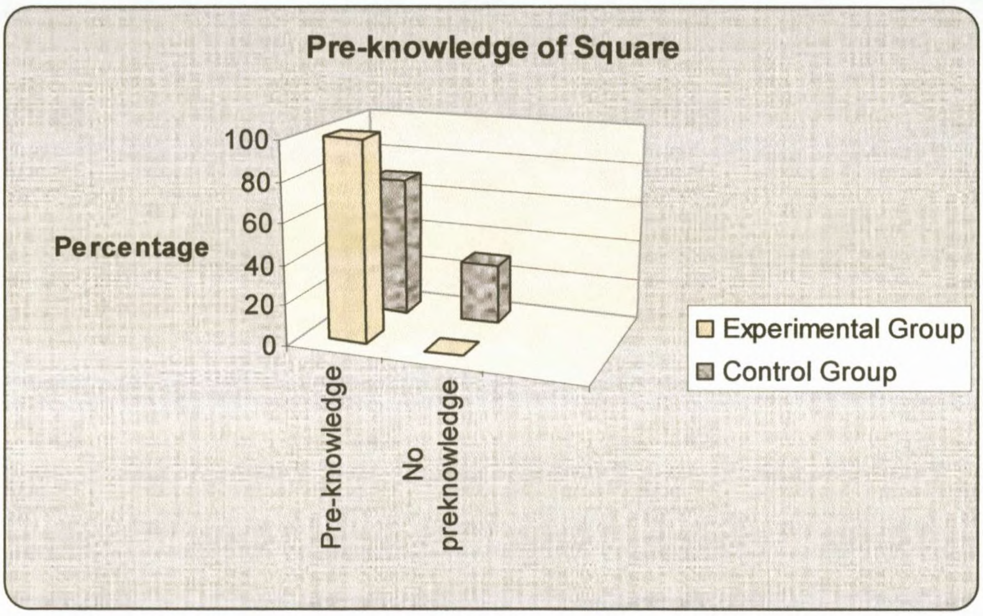
***Graph 9:*** *Learners' understanding of Area*




**Question 3**: *Did you know what a square was before these lessons?*

70% (14) of the respondents indicated that they had prior knowledge of a square while 30% (6) responded that they did not have prior knowledge. This is in contrast to the experimental group where 100% of respondents had prior knowledge of a square. This contrast is illustrated by graph 10. This response was of significance as one of the theories discussed in the literature review espoused that pre-knowledge frames played an important role in shaping learners' abilities to deal with more abstract problems (Davis, 1984). Therefore this would impact on the ability of learners to formulate methods to calculate area of a square.

***Graph 10:*** *Comparison of sample learners' pre-knowledge of square*

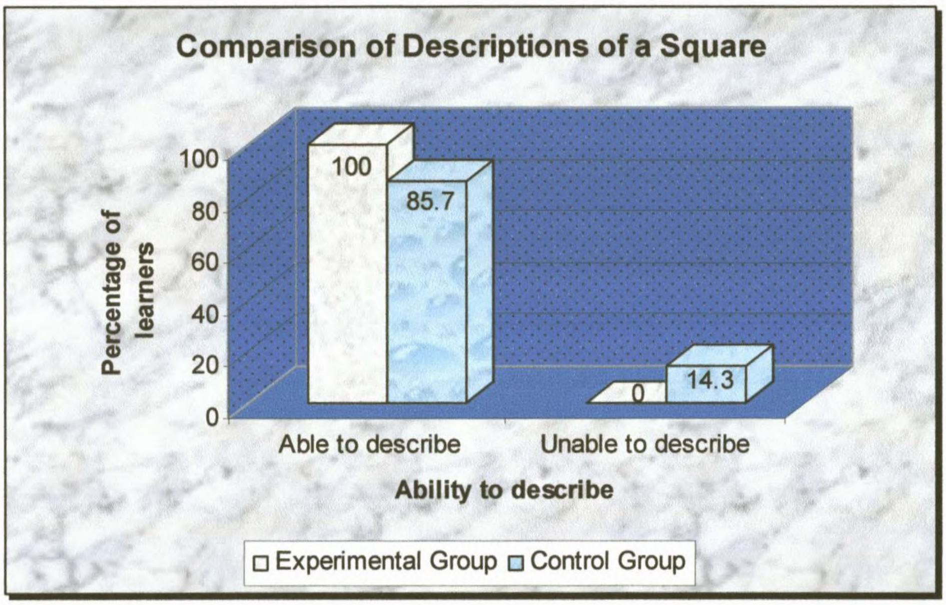



**Question 4**: *Provide a brief description of what you understood a square to be.*

This question was answered by 14 learners in the control group. Of these respondents 12 (85.7%) described a square as a shape with 4 equal sides while 2 (14.3%) were unable describe a square. Thus 85.7% of learners in the control group have a solid pre-knowledge of squares. This is of significance, as espoused by Kintsch (1988) that acquisition of conceptual understanding is influenced by prior knowledge. The developmental stage of the learners falls in line with Piaget's concrete operational stage

(Saler and Edgington, 2006). The importance of this finding is that a significant proportion of learners in both the experimental group and control group had a pre-knowledge of squares before embarking on their respective activities on perimeter and area (Graph 11). This would enhance the validity of the findings of this study.

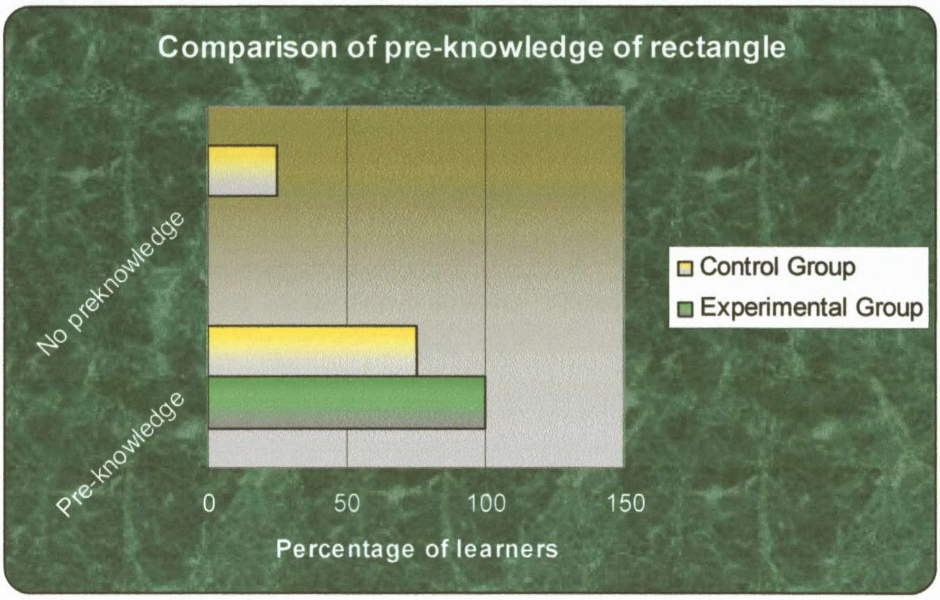
***Graph 11:*** *Comparison of the ability of the learners in the experimental and control groups to describe a square*




**Question 5**: *Did you know what a rectangle was before these lessons?*

75% (15) of the respondents indicated that they had prior knowledge of a rectangle while 25% (5) responded that they did not have prior knowledge. This is in contrast to the experimental group where 100% of respondents had prior knowledge of a rectangle. This contrast is illustrated by graph 12. This response was of significance as one of the theories discussed in the literature review espoused that pre-knowledge frames played an important role in shaping learners' abilities to deal with more abstract problems (Davis, 1984).

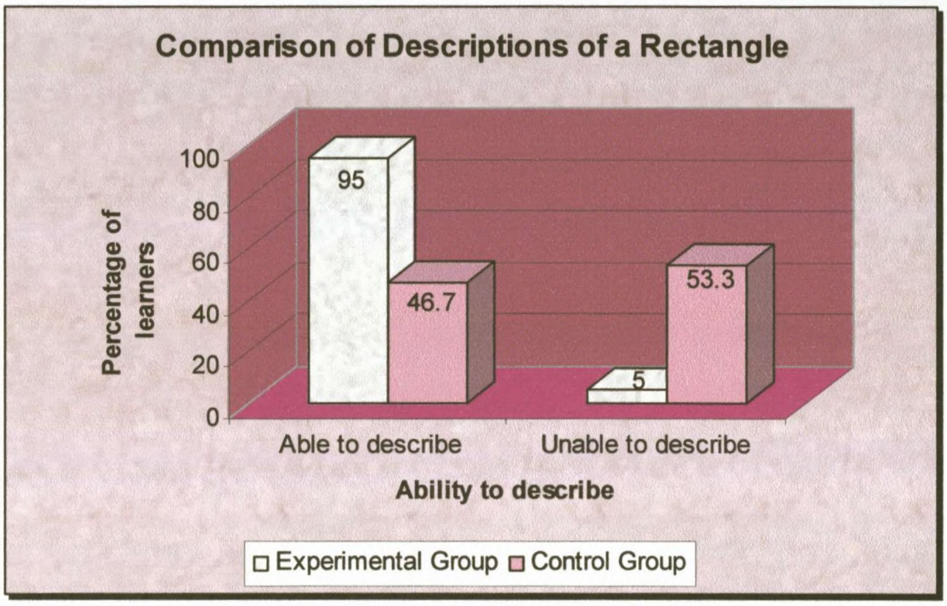
***Graph 12:** Comparison of sample learners' pre-knowledge of rectangles*




**Question 6**: *Provide a brief description of what you understood a rectangle to be.*

Of the 15 learners who answered this question only 7 (46.7%) were able to describe a rectangle according to its properties. The crux of their answers was that a rectangle was a shape with 4 sides, with each pair of opposite sides being equal in length. The remaining 8 (53.3%) learners described a square or triangle. This is in stark contrast to the experimental group where 95% (19) learners were able to provide an appropriate description of a rectangle. These errors may be attributed to flawed pre-mathematical frames (Davis, 1984) which were discussed in detail in question 2, section D of the experimental group questionnaire. This finding is of significance in that it may have been a contributory factor to the control group having greater difficulty in calculating area and perimeter of rectangles. Graph 13 compares the aforementioned findings.

***Graph 13:*** *Comparison of the ability of the learners in the experimental and control groups to describe a rectangle*

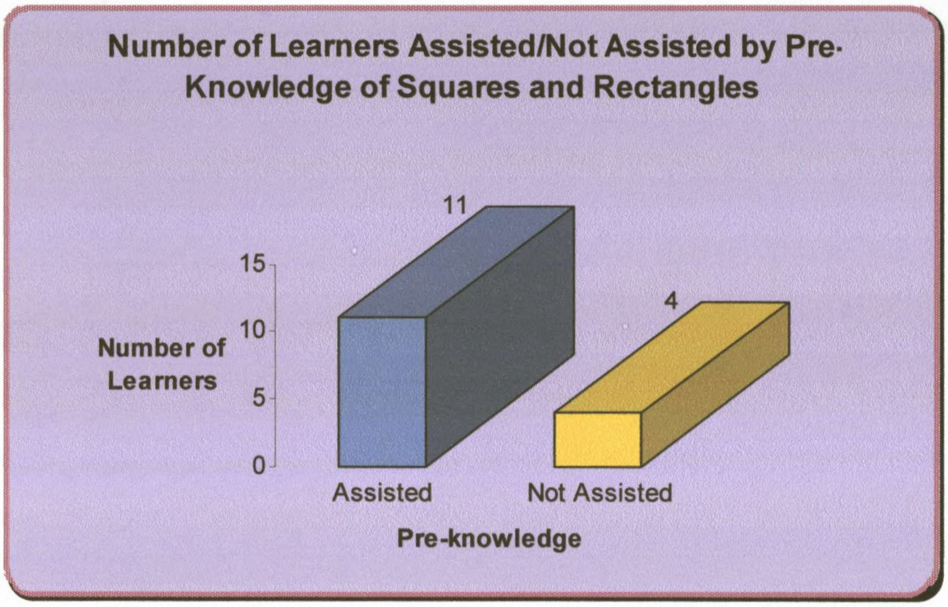



**Question 7:** *Did your knowledge of squares and rectangles assist you in finding a method of calculating the area and perimeter of these shapes?*

15 learners responded to this question. The responses to this question revealed that 73.3% (11) of these learners felt that their pre-knowledge of squares and rectangles enabled them to find a method of calculating the area and perimeter of these shapes. 26.7% (4) indicated that the pre-knowledge did not assist in finding a method to calculate area and perimeter. This finding is vindicated by Davis (1984) who postulates that cognitive pre-

mathematical frames play an integral role in enabling learners to deal with more complex concepts. The data gleaned from this question is presented in the graph below (Graph 14).

***Graph 14:*** *Number of learners assisted/not assisted by pre-knowledge of squares and rectangles*




**Question 8:** *How did your pre-knowledge of squares and rectangles assist you in finding a method of calculating perimeter and area?*

Following from the responses to question 7, this question was answered by 11 learners. 63.6% (7) of the respondents indicated that they used the properties of the square and rectangle to develop formulae which entailed:

- I added all the sides of the square to get perimeter
- I added the 4 sides of the rectangle for its perimeter
- I counted the units for area

36.4% (4) of the respondents were not clear as to how their pre-knowledge assisted them in calculating perimeter and area.

However as can be gleaned from the responses above the learners did not actually develop formulae. Therefore when compared to the experimental group, they were not thinking mathematically (Papert, 1980). Thus traditional teaching methods were found lacking. Furthermore the errors made by these learners in calculating perimeter may be classified as structural errors according to Donaldson's types of errors (Kogan, 1966).

**Question 9:** *If you indicated in question 7 that pre-knowledge of squares and rectangles did not assist you in finding a method to calculate area and perimeter of these shapes, explain what method you used.*

Only 4 learners (20%) answered this question. Their responses also indicated that perimeter was calculated by adding up the sides and area was calculated by counting the number of units. One learner indicated that answers were obtained by guessing. When comparing the respondents' method to those who claimed to have used their prior knowledge, the similarities are obvious. Thus as concluded in the previous question despite learners having pre-knowledge, exposure to traditional teaching methods do not ensure that they have the ability to develop mathematically sound formulae to calculate area of squares and rectangles.

Responses to **Section C** reflect learners' perceptions about using traditional learning methods to learn area and perimeter. Learners had to indicate whether they agreed with a statement by placing a tick next to it. The results are illustrated in table 6.

***Table 6:*** *Control group perceptions of teaching/learning methods*

| Variable | Percentage |
|---|---|
| a. I was allowed to try my own methods to find answers | 0 |
| b. I felt confident trying my own method after the lesson | 50 |
| c. I did not fear getting answers wrong | 30 |
| d. I felt in control of the lesson | 20 |
| e. I was able to work at my own pace | 50 |
| f. I was able to share ideas with other learners during the lesson | 60 |

The data revealed in table 6 contrasts markedly with those gleaned from the responses provided by the experimental group. The responses to sections a, d and e reflect a rigid and restrictive traditional approach to learning. Learners were denied the opportunity to develop their own tasks (Jolliffe et al, 2001). They were not allowed to try out new ideas or to modify suggestions (Jones, 2005). Furthermore they were not allowed to work at their own pace thus ignoring different skill levels (Horton and Horton, 2003). The traditional approach also failed to address the issue of cultural barriers (Papert, 1980). This is reflected in the fact that 30% of learners feared getting answers wrong. Therefore they may not have attempted to answer questions. This would in turn impact on their self-confidence as well as their confidence in sharing ideas with their peers. Thus their negative attitude to mathematics would prevail.

Responses to **Section D** provide insight into additional mathematical concepts that the control group may have discovered.

**Question 1**: *Did you discover any other mathematical concepts during this activity?*

50% (10) of learners in the control group indicated that they had learned additional mathematical concepts during the course of the activities.

**Question 2**: *List the additional mathematical concepts.*

The responses are listed in the following table (Tab. 7).

***Table 7:*** *List of additional mathematical concepts discovered by the control group*

| **Concepts** | **Number of Learners** |
|---|---|
| Formula | 2 (10%) |
| Addition | 1 (5%) |
| Multiplication | 3 (15%) |
| Shapes | 1 (5%) |
| Measurement | 1 (5%) |

It is evident that the control group, using traditional teaching/learning methods, discovered fewer additional mathematical concepts than the experimental group. This indicates that the traditional method fails to address the issue of cultural barriers. The issue of types of errors and pre-mathematical frames is explained in greater detail in question 2, section D of the experimental group questionnaire analysis.

### 4.4 Analysis of the Focus Group Interviews

The focus group interview was conducted with 8 members of the experimental group for reasons explained in Chapter Three. Discussion of the questions and responses follow.

**Question 1: Please explain how each of the following affected your learning experience.**

**1.1 E-mail:**

The responses were as follows:

- ✓ "I was able to ask for help after school hours."
- ✓ "I contacted my friends for information."
- ✓ "I worked with my group outside school."

These responses clearly show the advantages of web-based learning. E-mail enables learners to communicate with their peers and educators outside normal school hours. Thus it fosters the idea of learning being relevant to everyday experience. In this way it assists in overcoming cultural block (Papert, 1980). Furthermore the fact that learners indicated that they were able to work with their groups via e-mail after school hours illustrates how web-based learning facilitates collaborative learning.

**1.2 Chat:**

The responses were as follows:

- "I felt less afraid to say what I wanted."
- "It was exciting."
- "I was able to talk to my friend without others knowing."

The first and third responses illustrate how web-based learning allows learners to emerge from their shells and actively participate in lessons. It provides the opportunity for learners to provide input without the fear of being ridiculed. In this manner it builds self-confidence and in so doing may instil a positive attitude to learning in children. This would assist in negating adverse cultural barriers to learning (Papert, 1980). Furthermore the fact that learners found the use of chat exciting also shows that technology may be used make learning more child friendly.

**Question 2: What were some of the advantages of web-based learning?**

The responses were as follows:

- "I was able to find out a lot of new things about area and perimeter on the internet."
- "It was quicker to find information."
- "I was able to go back to lessons that I wanted to see again."
- "I worked how fast I wanted to."
- "We were able to do group work with little disturbance."

The first 2 responses vindicate the internet as an effective, infinite and speedy source of information, and highlight the role of web-based learning in constructing and consolidating pre-mathematical frames. Learners may not grasp a concept immediately or they may skip a lesson due to unforeseen circumstances. Therefore it is important for them to retrieve lessons from an archive (Alessi and Trollip, 2001). Web-based learning enables the aforementioned, as illustrated by the third response. The fourth response indicates that web-based learning caters for different ability levels as learners are allowed to work at their own pace (Horton and Horton, 2003). Finally web-based learning provides opportunities for individual as well as team-based learning (French, 1999). Thus as the last response indicates collaborative learning is enabled.

**Question 3: Was the use of the VNC Viewer beneficial to your learning experience? Explain.**

The responses were as follows:

- I was able to follow instructions by watching and listening and knew what had to be done.
- I could give ideas through the computer.
- The teacher and my friends could show me things on my computer.

The first response clearly shows the value of the VNC Viewer as an instructional tool since it incorporates both visual and audio elements. Furthermore it allows for input by clients thus facilitating a collaborative process. This ties in with the other 2 responses which also indicate the value attached to collaboration by the learners. This is vindicated by the view that learners are also responsible for the learning of their peers (Gokhale, 1995). Furthermore the point that learners were allowed the opportunity to share their own ideas with others, including the educator, illustrates the degree to which cultural block and cultural barriers to the learning of mathematics are overcome (Papert, 1980). Finally, from the view of the educator, the VNC Viewer provides an excellent medium to observe learners thought processes as they engage in mathematical activities.

**Question 4: How did the use of Logo assist you to develop formulae to calculate area?**

The responses were as follows:

- ✓ I followed the patterns provided.

- ✓ Building the shapes helped me see which sides were equal and I followed the corrections the computer gave me.

Thus the nature of the Logo program which allows for interaction and constructive feedback assisted learners in their activity. The learners' interaction with Logo via the computer is not a one-way process. The program provides feedback in such a manner as to provide learners with a choice as to how they want to react to it (Papert, 1980). It is also apparent that by actively constructing shapes learners were able to gain a clearer understanding of the properties of these shapes thereby enabling them to develop formulae to calculate area and perimeter.

**Question 5: What were some of the difficulties you experienced?**

The responses were as follows:

- ◊ "I had to get used to Logo."
- ◊ "It was the first time I used the internet."
- ◊ "The teacher could see me doing my work on the computer."

All 3 responses reflect the fact that these learners were computer novices, due their socio-economic circumstances. Therefore the difficulties mentioned would have been expected. Furthermore due to large class sizes learners were not accustomed to being observed during lessons. Usually their completed written work would be marked by the educator. Hence the third response.

**Question 6: What are variables?**

The responses received were:

- ❖ Letters that stand for numbers.
- ❖ One letter can mean many numbers.
- ❖ Many letters may stand for the same number.
- ❖ Example: 4 x a

If a = 4 then the answer is 16.

A body of research suggests that learners have difficulty in understanding that a letter can represent a range of values (Booth, 1984; Collis, 1974; Kuchemann, 1981). Furthermore they do not accept that the different letters can represent the same value. However the use of Logo seems to overcome this obstacle. Studies have indicated that learners perceive a variable in Logo as representing a range of numbers (Noss, 1986; Sutherland, 1989). Within a Logo environment they have little difficulty in accepting that any variable name can be used and that different names could represent the same value. In addition variables reinforce the notion that area is dynamic as the former affect the area of a shape.

**Question 7: Can you link the activities on area to your everyday life? Provide examples.**

The responses were:

- ◊ We see shapes all around us.
- ◊ We use shapes to make things.
- ◊ We have to be able to find short ways to measure to build things like a volleyball court. We must know a rectangle.
- ◊ Our houses are made of different shapes like squares and rectangles.

◊ If we buy a new TV we should know its area to see if it fits in the unit.

It is apparent from the responses that the learners are able to relate their activities to their everyday lives. Further this is evidence that the learners are removing the obstacle of cultural barriers by being able to apply mathematics to their everyday life situations. Thus they are being given meaning and they are giving meaning to mathematics (Papert, 1980).

### 4.5 Analysis of the activities on Perimeter and Area

For the purpose of analysis this section is divided into four categories which follow.

#### 4.5.1 Deep and Surface Learning

Evidence of both deep and surface learning, as espoused by Chomsky (1968), were displayed in the learners' responses to the questions in the activities. All 20 (100%) respondents in the experimental group and control groups respectively displayed surface learning which required basic calculation. Following are exemplars of surface learning (Appendix G):

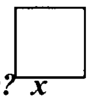
***3. Click on RESET to clear the screen. Now type SQUARE 20. Each side of the square is 20 units long. Therefore, the distance the turtle has to walk around the square is** _80___ **units.***

***(b) Describe the image on your screen.*** *I see a small square.*

***3. Click on RESET to clear the screen. Now type SQUARE 1. Each side of the square is 1 unit long. Therefore, the space contained within the square is** __1___ **square unit.***

All 20 (100%) learners in the experimental group displayed evidence that a degree of deep learning had occurred. Evidence of this is the ability of learners to develop formulae to calculate perimeter and area, calculate the measurement of 1 side of a shape after being provided with the perimeter or area, to draw shapes that have the same area or perimeter and to establish patterns in shapes. However, only 5% of the control group displayed evidence of deep learning. Following are exemplars of the aforementioned (Appendix G).

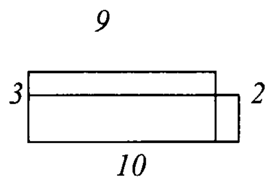
***5. What would you type to draw a square whose perimeter is five times the perimeter of SQUARE 20?*** *SQUARE 100*



***6. If one side of a square =x, what will the perimeter of the square be?*** *x* *4 x X*

***3. (a) Without clearing the screen, draw a second rectangle which has the same perimeter.***

***(b) In the space provided at the right, draw a sketch of both rectangles as they appear on your screen.***




***(c) Label the dimensions on your diagram.***

***(d) What patterns do you notice between the two rectangles?*** *Area is not the same but perimeter is the same.*

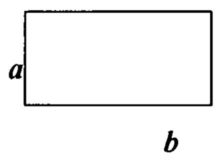
***(e) How many different rectangles can you find which also have the same perimeter as RECT 2 10? Sketch the rectangles you have found and label the dimensions on your diagrams.***

Therefore it is obvious that deep learning is facilitated through the use of Logo and a networked computing environment encompassing the utilisation of the VNC Viewer.

### 4.5.2 Stages of Cognitive Development

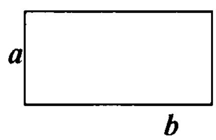
All (100%) learners in the experimental group showed evidence of being able to use logical thinking and apply symbols to abstract concepts (Berk, 2000). They were able to develop formulae, as illustrated in 4.5.1, and use variables (Appendix G).Thus they are operating at Piaget's formal operational stage. This is contrary to Piaget's theory in that he places 7-11 year old learners in the concrete operational stage (Berk, 2000). Only 5% of learners in the control group were able to operate at formal operational stage. Therefore Piaget's theory may be more applicable to traditional teaching methods. Following are exemplars of learners operating at the formal operational stage (Appendix G).

***4. If one side of a rectangle = a and another side = b, what will the perimeter of the rectangle be?***



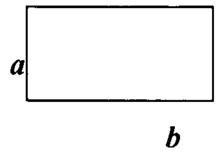

*2a + 2b*

***4.. If one side of a rectangle = a and another side = b, what will the area of the rectangle be?***




*a x b*

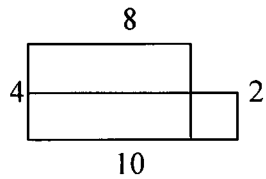
*4. If one side of a rectangle = a and another side = b, what will the perimeter of the rectangle be?*




*2(a+b)*

***3. (a) Without clearing the screen, draw a second rectangle which has the same perimeter.***

***(b) In the space provided at the right, draw a sketch of both rectangles as they appear on your screen.***




***(c) Label the dimensions on your diagram.***

***(d) What patterns do you notice between the two rectangles?*** *When the perimeter is the same the area can change.*

This finding may imply that the hybrid web-based model accelerates development of learners or that Piaget's stages of cognitive development are too rigidly structured (Kuhn et al, 1977).

### 4.5.3 Types of Errors

While the learners have showed evidence of deep learning and operating at Piaget's formal operational stage there were different types of errors in some of the responses in the experimental group. These errors have been classified according to Donaldson's types of errors (Kogan, 1966).

#### 4.5.3.1 Arbitrary Errors

Only 5% (1) of the learners made arbitrary errors. The learner breached a constraint of the problem in that perimeter could not be calculated by adding all 4 sides. Furthermore the learner attempted to calculate area of a square by multiplying all 4 sides which also breached a constraint of the problem (Donaldson, 1964 as cited by Kogan, 1966). Following are the exemplars of these errors (Appendix G).

***6. If one side of a square =x, what will the perimeter of the square be?*** *x*

x+x+x+x

***6. If one side of a square =x, what will the area of the square be?*** *X*

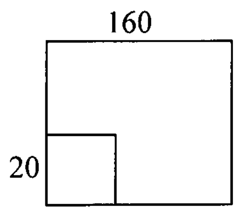
X x X x X x X

#### 4.5.3.2 Structural Errors

Of the 20 participants 25% (5) made structural errors. They did not grasp the principle that the length of the side of a square or rectangle would affect it area or perimeter. Furthermore they failed to conceptualise the link between the perimeter or area of a square and rectangle to the length of its sides. This is illustrated in the following exemplars (Appendix G).

***4. (a) Without clearing the screen, draw a second square which has a perimeter of 160 units.***

***(b) In the space provided at the right, draw a sketch of both squares as they appear on your screen.***



*(c) Label the lengths on your diagram.*

*5. What would you type to draw a square whose perimeter is five times the perimeter of SQUARE 20?* 25

*5. What would you type to draw a square whose area is 25 times the area of SQUARE 1?* 25

However it is interesting to note that after all the activities were completed these learners were able to develop formulae for area and perimeter.

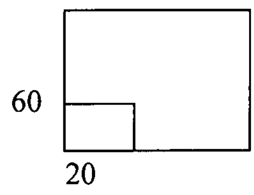
#### 4.5.3.3 Executive Errors

Executive errors were made by 15% (3) of the learners in that they made basic errors in calculation (Donaldson, 1964 as cited by Kogan, 1966). These are illustrated by the following exemplars (Appendix G).

*(a) Without clearing the screen, draw a second square which has a perimeter of 160 units.*

*(b) In the space provided at the right, draw a sketch of both squares as they appear on your screen.*

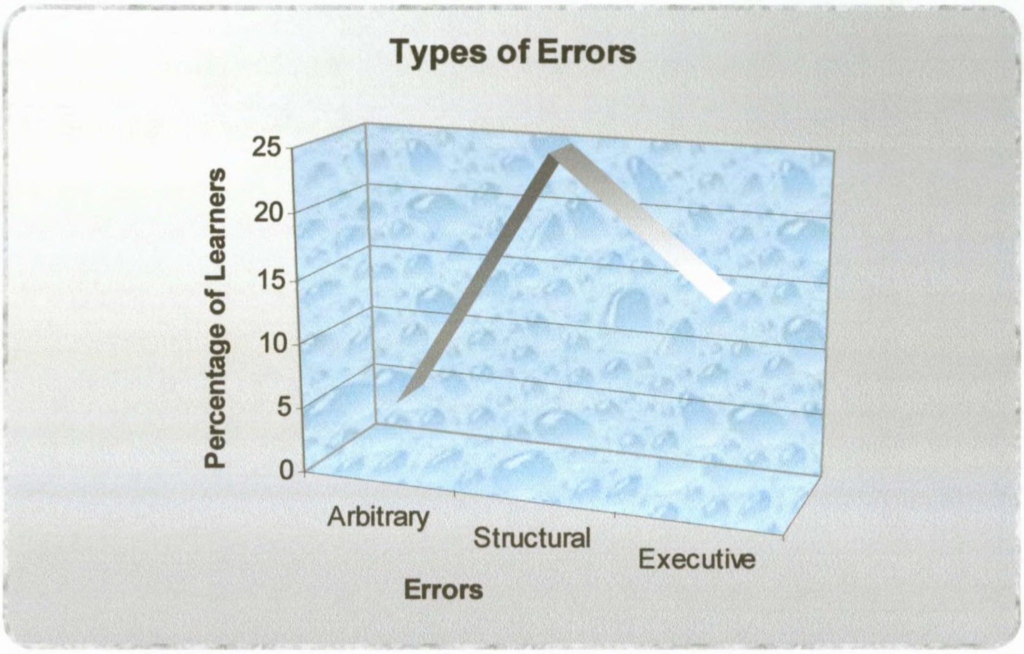
*(c) Label the lengths on your diagram.*




*5. What would you type to draw a square whose perimeter is five times the perimeter of SQUARE 20?* 5

The following graph (Graph 15) illustrates the data regarding the types of errors made by learners during their activities on perimeter and area.

***Graph 15:*** *Types of errors made by learners*




Through the use of web-based learning, in this instance specifically the medium of the VNC Viewer, the different types of errors were identified. However there was no facility in the software to review these errors and correct them.

#### 4.5.4 Pre-mathematical Frames

Central to this study is the idea that pre-mathematical frames play an integral role in determining learners' ability to solve more complex and abstract mathematical problems

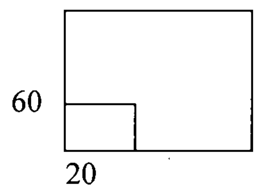
(Davis, 1984). Analysis of the activities on perimeter and area further illuminates this view.

The executive errors made by 15% of the learners concerned division (Appendix G). These errors may be traced back to pre-mathematical frames. Upon closer examination it is noticeable that the learners associate a digit in the question with their answer. The following exemplars illustrate this point (Appendix G).

***(a) Without clearing the screen, draw a second square which has a perimeter of 160 units.***

***(b) In the space provided at the right, draw a sketch of both squares as they appear on your screen.***

***(c) Label the lengths on your diagram.***




The learner may have answered 60 because of the association with the 60 in 160.

The next exemplar reinforces this notion.

***5. What would you type to draw a square whose perimeter is five times the perimeter of SQUARE 20?*** 5

The learner may have answered 5 because of the association with the five in the question. Therefore these learners may have a pre-mathematical sub-frame with this notion which becomes activated whenever they encounter such a calculation (Davis, 1984).

Similarly such pre-mathematical frames with flawed sub-frames may exist for the arbitrary and structural errors made by learners. The following exemplar of a structural error made by 25% of the learners is explained in figure 9.

***(a) Without clearing the screen, draw a second square which has a perimeter of 160 units.***

***(b) In the space provided at the right, draw a sketch of both squares as they appear on your screen.***

***(c) Label the lengths on your diagram.***

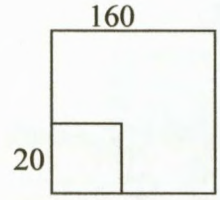
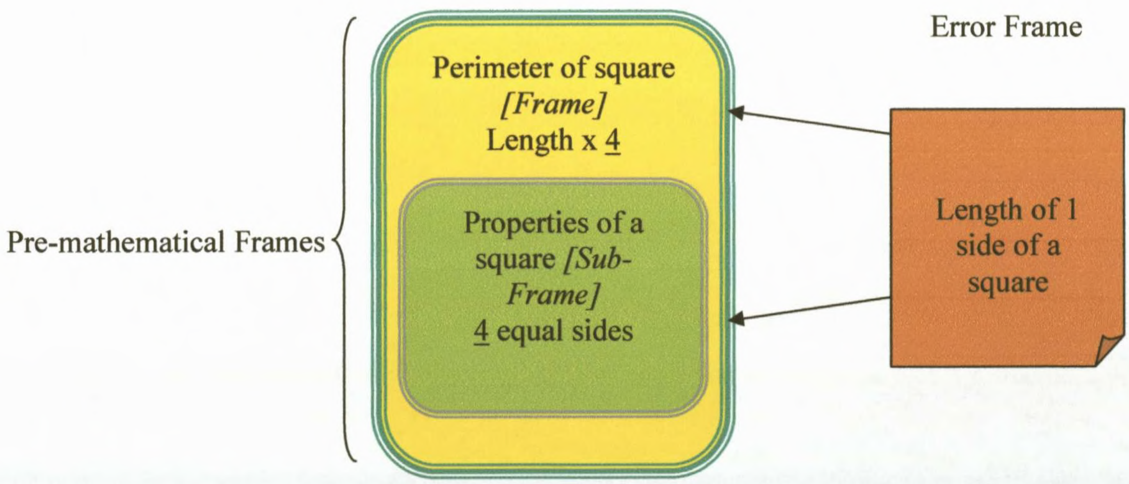



***Figure 9:*** *Pre-mathematical frame of a structural error*




A shortcoming of this study was that while pre-mathematical frames were established for the errors there did not exist a facility in the software to attempt to review and modify these frames. However it was established, through analysis of the questionnaires, that pre-mathematical frames play a significant role in determining learners' ability to solve more complex and abstract mathematical problems (Davis, 1984).

### 4.6 Conclusion

The aim of this study was to enhance the learning experience of primary school learners through the utilisation of a hybrid web-based learning model. The research design was structured using questionnaires, activities on perimeter and area and a focus group interview to illicit responses related to the topic. Thus this chapter presented and discussed the findings derived from the questionnaires, activities on perimeter and area and the focus group interviews. The findings reveal that learners using the hybrid web-based learning model displayed were better equipped to handle abstract mathematical problems involving area and perimeter than the learners who were exposed to traditional teaching methods only. The next chapter will summarise the main findings and the information gathered in this chapter will be used to develop recommendations for future research.

# CHAPTER FIVE

# SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Introduction

This chapter provides a summary of the study (5.2), presents the main findings of the questionnaires and the focus group interview (5.3), outlines the main conclusions emanating from the findings (5.4), and puts forward recommendations with regard to related issues for future research (5.5).

## 5.2 Summary of the study

As already mentioned, the focus of this study was to enhance the learning experience of primary school learners through the utilisation of a hybrid web-based learning model with a special focus on mathematics (perimeter and areas). With regard to the literature review, a conceptual framework for this study was highlighted and selected relevant theories were discussed. This study centred around a qualitative research design with quantitative elements, in which a case study methodology was employed. Through a process of purposive sampling, one school in Isipingo was selected, and forty grade five learners who were deployed in an experimental group and a control group in equal proportion respectively were also selected. The experimental group did a series of activities on area and perimeter using a web-based approach while the control group did a series of activities on perimeter and area using traditional learning methods. The research instruments included questionnaires and a focus group interview. The focus group interview was conducted with learners in the experimental group. Data analysis included frequency counts and content analysis.

### 5.3 Main findings of the study

Emanating from the study are the main findings which are summarised according to the research questions.

**Research question (1):** *What are the shortcomings of existing internet technologies used by South African government primary schools?*

These shortcomings may be listed as follows:

- ◊ Lack of interactive web pages
- ◊ Lack of the use of databases
- ◊ Little evidence of interaction or avenues for communication through the design of web-based learning environments

**Research question (2):** *What is the alternative to the current technologies being utilized?*

This study proposes the use of a hybrid web-based learning model which comprises the following features:

- ➢ E-mail which was revealed as being of benefit to learners, during the focus group interview.
- ➢ Chat which learners put forth as being of assistance to them in their activities, during the focus group interview.
- ➢ Access to internet search engines which enabled learners to access more information at a greater speed. This was gleaned from the focus group interview.

- ➢ Logo mathematics which was revealed to have played an integral role in enhancing learners' understanding of mathematical concepts like area and perimeter.
- ➢ A networked computing environment to facilitate the use of interactive, collaborative software like the VNC Viewer.

**Research question (3):** *How can learners' mathematical skills (with regard to perimeter and areas) be improved through the use of web-based learning?*

- Learners using the hybrid web-based learning model displayed a better understanding of the concepts of area and perimeter than the learners using the traditional learning methods. In the experimental group 75% of learners were able to explain the concept of perimeter accurately and 85% were able to explain area while in the control group only 5% of learners were able to explain perimeter and area. Therefore the experimental group's skills in handling perimeter and area have been improved.
- The learners using the web-based model were better able to develop formulae to calculate area and perimeter than their counterparts using the traditional methods. 89.5% of respondents in the experimental group were able to develop formulae to calculate area and perimeter. This was facilitated by the use of Logo. On the other hand learners in the control group failed to formulate mathematically sound methods to calculate area and perimeter. Therefore the hybrid web-based learning model enhances learners' skills in developing formulae.
- The learners using the hybrid web-based model displayed an understanding of the concept of variables. 45% of learners indicated that they discovered the concept of variables during their activities on perimeter and area using the web-based model.

Furthermore 100% of learners interviewed during the focus group interview were able to explain what variables were. Therefore the hybrid web-based model improves learners' abilities to handle abstract mathematical concepts.

### 5.4 Conclusions emanating from the findings

The conclusions are derived from the findings of this study and will be discussed according to themes.

#### 5.4.1 Stages of Cognitive Development

The findings in this study regarding the learners using the hybrid web-based model are in contrast to Piaget's stages of cognitive development which places 10 – 11 year old learners in the concrete operational stage (Berk, 2000). Since these learners are capable of developing formulae to calculate area and perimeter and are able to utilise the idea of variables, they are operating at Piaget's formal operational stage. Therefore this may imply that the hybrid web-based model accelerates development of learners or that Piaget's stages of cognitive development are too rigidly structured (Kuhn et al, 1977).

#### 5.4.2 Cultural Barriers

The findings in this study vindicate the idea that web-based learning through the use of Logo contributes to learners hurdling the obstacle of adverse cultural attitudes to the learning of mathematics (Papert, 1980). The data from the questionnaire reveal that learners maximised the opportunity to try out their own methods and ideas. Furthermore they were allowed to change plans and modify suggestions (Jones, 2005). Learners were allowed to work at their own pace and were encouraged to share their ideas with others.

In so doing their self-confidence was boosted and collaborative learning, which was enabled through the use of the VNC Viewer, was made possible. Thus learners were able to develop a more positive attitude towards the learning of mathematics dispelling the negative cultural influences that may have been exposed to.

### 5.4.3 Pre-mathematical Frames

The findings in this study indicate that pre-mathematical frames play an integral role in determining learners' ability to solve more complex and abstract mathematical problems as stated in Davis (1984). Of the experimental group, in which 100% of learners were able to formulate formulae to calculate perimeter and area during their activities, 100% of learners had pre-knowledge of squares and 95% had pre-knowledge of rectangles. This may be attributed to the benefits of web-based learning which enabled learners to access the internet to research area and perimeter thus developing pre-mathematical frames. These learners were then able to grasp an understanding of variables which a body of research suggests that learners have difficulty in understanding that a letter can represent a range of values (Booth, 1984; Collis, 1974; Kuchemann, 1981). Furthermore they do not accept that the different letters can represent the same value. However the use of Logo seems to overcome this obstacle. Studies have indicated that learners perceive a variable in Logo as representing a range of numbers (Noss, 1986; Sutherland, 1989). Within a Logo environment they have little difficulty in accepting that any variable name can be used and that different names could represent the same value. Furthermore pre-mathematical frames were used to determine the cause of some of the errors made by learners (Refer to figure 6).

### 5.4.4 Deep and Surface Learning

All twenty (100%) respondents in the experimental group indicated that they had they had begun to understand associated additional mathematical concepts during the course of the activities. According to Papert (1980), using Logo mathematics through computers can change the way learners learn everything else. Furthermore this may imply that the use of Logo through the medium of computers enables learners to think on a deeper level by relating other concepts to their activities. Therefore Logo is affecting the way learners think and what they think about. This in turn can be linked to the theory of Chomsky (1968) because web-based learning is thus facilitating the learning of new concepts which affect the understanding of deep structures. Chomsky (1968) 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.

### 5.4.5 Errors

According to Donaldson (1964) as cited by Kogan (1966), in arbitrary errors the learner often applies concepts from his/her real life experiences which breach the constraints of the problem. Structural errors occur when the learner fails to grasp a basic principle of the problem. Executive errors arise when there is a failure in performing the manipulations required. Through the use of web-based learning, in this instance specifically the medium of the VNC Viewer, such types of errors were identified. However there was no facility to review these errors and correct them.

### 5.5 Recommendations for future research

On the basis of the literature review and the main findings made earlier in this chapter, this section will refer to recommendations for future research.

The findings reveal that while the utilisation of the hybrid web-based learning model enhanced the learning experience of learners, there is room for improvement as far as the networking software is concerned. The VNC Viewer was successful in fostering collaborative learning and facilitating the identification of mathematical errors. However a shortcoming of the study was the inability to address and correct the types of errors made by learners (Kogan, 1966) and to modify learners' pre-mathematical frames through the medium of the VNC Viewer. Therefore further research could be undertaken to develop software that would address these issues.

### 5.6 Conclusion

Analysis of the data collected through the questionnaires, activities on perimeter and area and focus group interview show a significant disparity in the learning experiences of the control group, which attempted activities on perimeter and area using traditional classroom teaching and learning methods, and the experimental group which conducted their activities on perimeter and area using a hybrid web-based learning model. The results show that pre-mathematical frames played a significant role in determining the manner in which learners were able to develop formulae to calculate perimeter and area based on their pre-knowledge of the properties of squares and rectangles. Furthermore the learners in the experimental group had to a large extent overcome the cultural barriers towards mathematics that had been inculcated in them by their immediate community, by displaying an enthusiasm to share ideas and to allow others to have access to their thought processes via the local area network. Finally the data shows that the experimental group grasped a better understanding of the concept of perimeter and area and were able to explain and utilise the idea of variables. This may be attributed to a combination of the use of pre-mathematical frames, collaborative learning in a networked computing environment and the use of Logo mathematics under the auspices of a hybrid web-based learning model.

# BIBLIOGRAPHY


Alao, S. and Guthrie, J.T. (1999) Predicting Conceptual Understanding with Cognitive and Motivational Variables. *The Journal of Educational Research*, 92(4), 243-253.

Alessi, S. M. and Trollip, S. R. (2001). *Multimedia for Learning: Methods and Development.* Massachusetts: Allyn and Bacon.

Asgarkhani, M. (2004) The Need for a Strategic Foundation for Digital Learning and Knowledge Management Solutions. *Electronic Journal on e-Learning*, 2(1), 31-42. Retrieved October 11, 2005 from http://www.ejel.org

Babbie, E. (1989) *The Practice of Social Research. 5th* Edition. California: Wadsworth, Inc.

Babbie, E. (1990) *Survey Research Methods.* 2nd Edition. California: Wadsworth, Inc.

Berk, L.E. (2000) *Child Development.* 5th Edition. Needham Heights, MA: Allyn and Bacon. Babbie, E. (1990) *Survey Research Methods.* 2nd Edition. California: Wadsworth, Inc.

Best, J. W. and Kahn, J. V. (1989) *Research in Education.* 6th Edition. New Jersey: Prentice Hall.

Booth, L. (1984) *Algebra: Children's Strategies and Errors.* Winsdor: NFER-Nelson.

Chen, N.S., Ko, H.C., Kinshuk and Lin, T. (2005) "A Model for Synchronous Learning Using the Internet", *Innovations in Education and Teaching International,* Vol. 42, No. 2, pp181-194.

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.

Cohen, L. and Manion, L. (1995) *Research Methods in Education.* 4th Edition. New York: Routledge.

Cohen, L., Manion, L. and Morrison, K. (2000) *Research Methods in Education.* 5th Edition. London: Routledge Falmer.

Collis, K.F. (1974) Cognitive development and mathematics learning. In *Proceedings of the Psychology of Mathematics Education Workshop.* London: Chelsea College Centre for Science Education.

Creswell, J. W. (2003) *Research Design: Qualitative, Quantitative and Mixed Method Approaches.* California: Sage Publications, Inc.

Davis, R.B. (1984) *Learning Mathematics: The Cognitive Science Approach to Mathematics Education.* Kent: Croom Helm Ltd.

Ernest, P. (1989) What's the Use of LOGO? In Ernest, P. (Ed.) *Mathematics Teaching: The State of the Art.* East Sussex: The Falmer Press: p. 33-44.

Fouche, C.B. and Delport, C.S.L. (2002) "Introduction to the Research Process" in *Research at Grassroots,* 2nd Edition, De Vos, A.S., Strydom, H., Fouche, C.B. and Delport, C.S.L. (Eds), Van Schaik Publishers, Pretoria, p. 79.

French, D. (1999). Preparing for Internet-based Learning. In: French, D., Hale, C., Johnson, C. and Farr, G. (editors). *Internet Based Learning: An Introduction and Framework for Higher Education and Business.* London: Kogan Page Limited: p. 9-24.

Gay, L.R. (1992) *Educational Research: Competencies for analysis and application.* 4th Edition. New York: MacMillan Publishing Company.

Gibbs, A. (1997) Focus Groups. Retrieved April 14, 2005 from http://www.soc.surrey.ac.uk/sru/index.html.

Gokhale, A.A. (1995) Collaborative Learning Enhances Critical Thinking. *JTE.* Retrieved February 24, 2006 from http://scholar.lib.vt.edu/ejournals/JTE/v7n1/gokhale.jte-v7n1.html.

Greeff, M. (2002) Information Collection: interviewing. In de Vos, A. S., Strydom, H., Fouche, C. B. and Delport, C. S. L. (Eds.) *Research at Grass Roots,* 2nd Edition. Pretoria: Van Schaik: p. 311-319.

Hardwick, C.S. (1971) *Language Learning in Wittgenstein's Later Philosophy.* The Hague: Mouton.

Horton, W. and Horton, C. (2003). *E-Learning Tools and Technologies.* Indianapolis: Wiley Publishing Inc.

Hoyles, C. (1985) Developing a context for Logo in school mathematics. *Journal of Mathematical Behaviour,* 4(3), 237-256.

Huitt, W. and Hummel, J. (2003) Piaget's theory of cognitive development. *Psychology Interactive.* Retrieved August 28, 2006 from http://chiron.valdosta.edu/whuitt/col/cogsys/piaget.html

Information and communication technology in primary schools. (2005) *The Annual Report of Her Majesty's Chief Inspector of Schools 2004/05.* [Online] Available url: http://live.ofsted.gov.uk/publications/annualreport0405/4.1.6.html.

Jolliffe, A., Ritter, J. and Stevens, D. (2001). *The Online Learning Handbook: Developing and Using Web-Based Learning.* London: Kogan Page Limited.

Jones, K. (2005) Using Logo in the Teaching and Learning of Mathematics: a research bibliography. *MicroMath,* 21(3), 34-36.

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

Kintsch, W. (1988) The role of knowledge in diverse comprehension: A construction-integration model. *Psychological Review,* 95, 163-182.

Kogan, N. (1966) A Study of Children's Thinking. *The American Journal of Psychology,* 79(2), 342-344. Retrieved December 19, 2006 from http://links.jstor.org/

Kuchemann, D.E. (1981) Algebra. In Hart, K. (Ed.) *Children's Understanding of Mathematics.* London: Murray. pp. 11-16

Kuhn, D., Langer, J., Kohlberg, L. and Haan, N.S. (1977) The development of formal operations in logical and moral judgement. *Genetic Psychology Monographs,* 95, 97-188.

Kurkland, D.M. and Pea, R.D. (1985) Children's Mental Models of Recursive LOGO Programs. *Journal of Educational Computing Research.* Retrieved December 19, 2006 from http://scil.stanford.edu/about/staff/bios/pea.html.

Le Compte, M.D. and Preissle, J. (1993) *Ethnography and Qualitative Design in Educational Research.* 2nd Edition. California: Academic Press.

Leung, A. (2001) Mathematics lesson on perimeter and area. *Learning Study 5.* Retrieved November 29, 2006 from www.iediis4.ied.edu.hk/cidv/webdata/

Martin, B. (1988) Mathematics and Social Interests. *Search,*19. Retrieved February 24, 2007 from http://www.uow.edu.au/arts/sts/bmartin/pubs/88search.html.

Mathematics in primary schools. (2005) *The Annual Report of Her Majesty's Chief Inspector of Schools 2004/05.* [Online] Available url: http://live.ofsted.gov.uk/publications/annualreport0405/4.1.6.html.

McMillan, J. and Schumacher, S. (1997) *Research in Education: A Conceptual Introduction.* 4th Edition. New York: Longman.

Merriam, S.B. (1998) *Qualitative Research and Case Study Applications in Education.* California: Jossey-Bass Inc. Publishers.

Mertens, D. M. (1998) *Research Methods in Education and Psychology. Integrating Diversity with Quantitative and Qualitative Approaches.* Thousand Oaks: Sage Publications, Inc.

Moursund (2006) Developmental Theory. Retrieved September 6, 2006 from www.uoregan.edu/~moursund/Math/developmental_theory.htm.

Naidoo, N. and Naidoo R. (2006a) Enhancing the learning experience of primary school learners through the utlisation 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.

Naidoo, N. and Naidoo R. (2006b) Improving Visual and Verbal Skills of Primary School Learners Through Effective Web-Based Learning. In *Proceedings of the International Conference on e-Learning,* p. 347.

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, p4-288.

New Zealand Maths. Newsletter No. 34, June 2005. [Online] Available url: http://www.nzmaths.co.nz/HelpCentre/Newsletter%2034.pdf.

Noss, R. (1986) Constructing a conceptual framework for elementary algebra through Logo programming. *Educational Studies In Mathematics,* 17(4), 335-357.

Noss, R. (1988) The Computer as a Cultural Influence in Mathematical Learning. *Educational Studies in Mathematics,* 19, 251-268.

Oblinger, D. G. and Hawkins, B. L. (2005). The Myth about E-Learning "We Don't Need to Worry about E-Learning Anymore." *Educause Review*, 40(4), 14-15.

Papert, S. (1980) *Mindstorms: Children, Computers and Powerful Ideas.* Sussex: The Harvester Press Limited.

Papert, S. (1985) Computer Criticism vs technocentric thinking. *Proceedings of Logo 85, Plenary Lectures,* Cambridge, MA, p. 53-67.

Renner, J., Stafford, D., Lawson, A., McKinnon, J., Friot, E. and Kellog, D. (1976) *Research, teaching, and learning with the Piaget model.* Norman, OK: University of Oklahoma Press.

Saler, G. and Edgington, C.G. (2006) Piaget WebQuest. Retrieved September 6, 2006 from www.pt3.nl.edu/saleredgingtonwebquest.pdf.

Sutherland, R. (1989) Providing a computer based framework for algebraic thinking. *Educational Studies in Mathematics,* 20(3), 317-344.

Terre Blanche. M. and Kelly, K. (1999) Interpretive Methods. In Terre Blanche, M. and Durrheim, K. *Research in Practice. Applied Methods for the Social Sciences.* Cape Town: University of Cape Town Press (Pty) Ltd. p. 388.

Tuckman, B.W. (1998) *Conducting Educational Research.* 3rd Edition. Florida: Harcourt Brace Jovanovich Publishers.

White, C.J. (2003) *Research Methods and Techniques.* Pierre van Ryneveld: CJ White.

Wiersma, W. (1991) *Research Methods in Education.* 5th Edition. Boston: Simon and Schuster Inc.

**Appendix A** QUESTIONNAIRE

## SECTION A
## BIOGRAPHICAL INFORMATION

*Place a tick in the appropriate block.*

1. Gender

| Male | | | Female | |
|---|---|---|---|---|

2. Age

| 9 | | | 10 | | | 11 | | | 12 | | | 13 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

## SECTION B

*This section comprises questions about perimeter that require you to place a tick in the appropriate block. Some questions may require explanations.*

1. What do you understand by the concept 'perimeter'?

______________________________________________

______________________________________________

______________________________________________

2. What do you understand by the concept 'area'?

______________________________________________

______________________________________________

______________________________________________

3. Did you know what a square was before these lessons?

Yes □ No □

4. If yes, please provide a brief explanation of what you understood a square to be.

______________________________________________

______________________________________________

______________________________________________

5. Did you know what a rectangle was before these lessons?

Yes □ No □

6. If yes, please provide a brief explanation of what you understood a rectangle to be.

______________________________________________
______________________________________________
______________________________________________

7. If you answered YES to questions 3 and 5, did this knowledge assist you in finding a method of calculating the perimeter and/or area of these shapes?

Yes ☐ No ☐

8. If you answered Yes to question 7, please explain how.

______________________________________________
______________________________________________
______________________________________________
______________________________________________

9. If you answered NO to question 7, please explain how you calculated the perimeter and area.

______________________________________________
______________________________________________
______________________________________________
______________________________________________

## SECTION C

*Tick the statements that you agree with.*

1. I was allowed to try my own methods to find answers. ☐
2. I felt comfortable trying my own method. ☐
3. I did not fear getting answers wrong because the feedback from the computer made me feel at ease. ☐
4. Giving the computer instructions made me feel in control. ☐
5. I was able to work at my own pace. ☐
6. Being able to work with other learners by sharing ideas on their/my screen improved my understanding of the lessons. ☐
7. Being able to share my ideas with the entire class on the LAN made me feel that my ideas were important. ☐

## SECTION D

1. Did you learn or gain a better understanding of any other mathematical concepts from this activity?

Yes ☐ No ☐

2. If YES, list these concepts and explain how.

______________________________________________

______________________________________________

______________________________________________

______________________________________________

**Appendix B** QUESTIONNAIRE

## SECTION A
## BIOGRAPHICAL INFORMATION

*Place a tick in the appropriate block.*

1. Gender

| | | | | |
|---|---|---|---|---|
| Male | | | Female | |

2. Age

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | | | 10 | | | 11 | | | 12 | | | 13 | |

## SECTION B

*This section comprises questions about perimeter and area that require you to place a tick in the appropriate block. Some questions may require explanations.*

1. What do you understand by the concept 'perimeter'?

______________________________________________

______________________________________________

______________________________________________

2. What do you understand by the concept 'area'?

______________________________________________

______________________________________________

______________________________________________

3. Did you know what a square was before these lessons?

Yes □ No □

4. If yes, please provide a brief explanation of what you understood a square to be.

______________________________________________

______________________________________________

______________________________________________

5. Did you know what a rectangle was before these lessons?

Yes □ No □

6. If yes, please provide a brief explanation of what you understood a rectangle to be.

______________________________________________
______________________________________________
______________________________________________

7. If you answered YES to questions 3 and 5, did this knowledge assist you in finding a method of calculating the perimeter and/or area of these shapes?

Yes ☐ No ☐

8. If you answered Yes to question 7, please explain how.

______________________________________________
______________________________________________
______________________________________________
______________________________________________

9. If you answered NO to question 7, please explain how you calculated the perimeter and area.

______________________________________________
______________________________________________
______________________________________________
______________________________________________

## SECTION C

*Tick the statements that you agree with.*

1. I was allowed to try my own methods to find answers. ☐
2. I felt confident trying my own method after the lesson. ☐
3. I did not fear getting answers wrong. ☐
4. I felt in control of the lesson. ☐
5. I was able to work at my own pace. ☐
6. I was able to share ideas with other learners during the lesson. ☐

## SECTION D

1. Did you learn or gain a better understanding of any other mathematical concepts from this activity?

Yes ☐ No ☐

2. If YES, list these concepts and explain how.

____________________________________________

____________________________________________

____________________________________________

____________________________________________

Appendix C

Orissa Primary School
Citrus Drive
Orient Hill
Tel: 031 9023102
E-mail: orissa@telkomsa.net

Dear Parent

**Re: Informed Consent**

I am currently pursuing a Master of Technology degree at the Durban University of Technology under the supervision of Dr R. Naidoo (Tel: 2042371). My research is on *Enhancing the learning experience of primary school learners through the utilisation of a hybrid web-based learning model.* The primary aim of this study is to improve the quality of your child's learning experience through the use of the resources available in the school's computer centre in conjunction with the web-based facilities made available by the Durban University of Technology. Permission has been obtained from the KwaZulu-Natal Education Department to conduct this study as part of the normal school program.

All lessons will be conducted in school during normal school hours. Furthermore the content of the lessons form part of the Grade 5 syllabus. In addition to being involved in the lessons your child will be required to answer a short questionnaire and participate in a brief interview based on his/her perceptions of the learning model.

Please note that participation in this study is voluntary. If you decide to grant permission for your child to participate you are free to withdraw your consent and discontinue participation at any time.

Further information regarding this study can be obtained from Niren Naidoo (0845166980).

Thanking You

N. Naidoo

---

**DECLARATION BY PARENT**

I, ................................................................. (full names of parent), hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to my child, ........................................................................., participating in the research project.

I understand that I am at liberty to withdraw my child from the project at any time, should I so desire.

.................................................. ..................
SIGNATURE OF PARENT DATE

Appendix D

114 Braeside Avenue
Bellair
4094

Tel/fax: 4654663

11 January 2006

Mr S. Alwar

Sir

**Academic Research: Request for permission to conduct a study on web-based learning in primary school education**

At present I am pursuing my Master of Technology Degree at the Durban Institute of Technology. A prerequisite of this degree is a paper involving research which I am currently initiating. The focus of my study is web-based learning. The primary aim of this proposed research is to enhance the learning experience of primary school educators through the utilisation of a hybrid web-based learning model. My supervisor is Dr Ramu Naidoo, a lecturer at the Durban Institute of Technology. It is my intention that the information obtained be made available to the Department of Education.

I hereby request permission to conduct the aforementioned research study at Orissa Primary School, Isipingo, Phumelela Circuit, EThekwini Region. Permission will also be obtained from the school principal. The invaluable assistance of the principal and Grade 5 learners is required in completing the study.

The learners who participate in this study will do so voluntarily. In conducting this study I will ensure that normal learning and teaching will not be disrupted, and that all participants will remain anonymous. Confidentiality and privacy will be maintained at all times.

Your kind assistance in this matter will be appreciated.

Yours faithfully

N. Naidoo

Appendix E

PROVINCE OF KWAZULU-NATAL
ISIFUNDAZWE SAKWAZULU-NATALI
PROVINSIE KWAZULU-NATAL

DEPARTMENT OF EDUCATION
UMNYANGO WEMFUNDO
DEPARTEMENT VAN ONDERWYS

Tel: 033 341 8610
Fax:033 341 8612

Private Bag X9137
Pietermaritzburg
3200

228 Pietermaritz Street
Pietermaritzburg, 3201

INHLOKOHHOVISI PIETERMARITZBURG HEAD OFFICE

Enquiries:
Imibuzo: Sibusiso Alwar
Navrae:

Reference:
Inkomba: 0096/06
Verwysing:

Date:
Usuku: 27 February 2006
Datum:

To: Mr. N. Naidoo
114 Braeside Avenue
BELLAIR
4049

RE: APPROVAL TO CONDUCT RESEARCH

Please be informed that your application to conduct research has been approved with the following terms and conditions:

That as a researcher, you must present a copy of the written permission from the Department to the Head of the Institution concerned before any research may be undertaken at a departmental institution bearing in mind that the institution **is not obliged to participate** if the research is not a departmental project.

Research should not be conducted during official contact time, as **education programmes should not be interrupted**, except in exceptional cases with special approval of the KZNDoE.

**The research is not to be conducted during the fourth school term, except in cases where the KZNDoE deem it necessary to undertake research at schools during that period.**

**Should you wish to extend the period of research after approval has been granted, an application for extension must be directed to the Director: Research, Strategy Development and EMIS.**

**The research will be limited to the schools or institutions for which approval has been granted.**

A copy of the completed report, dissertation or thesis must be provided to the RSPDE Directorate.

**Lastly, you must sign the attached declaration that, you are aware of the procedures and will abide by the same.**

**for SUPERINTENDENT GENERAL**
KwaZulu Natal Department of Education

UHULUMENI WAKWAZULU NATAL
UMNYANGO WEMFUNDO
DEPARTMENT OF EDUCATION
DEPARTEMENT VAN ONDERWYS
2006 -02- 27
ISIKHWAMA SEPOSI
PRIVATE BAG / PRIVAAT SAK X04
ULUNDI 3838
RESEARCH, STRATEGY AND POLICY DEVELOPMENT

Appendix E

PROVINCE OF KWAZULU-NATAL
ISIFUNDAZWE SAKWAZULU-NATALI
PROVINSIE KWAZULU-NATAL

DEPARTMENT OF EDUCATION
UMNYANGO WEMFUNDO
DEPARTEMENT VAN ONDERWYS

Tel: 033 341 8610
Fax:033 341 8612

Private Bag X9137
Pietermaritzburg
3200

228 Pietermaritz Street
Pietermaritzburg, 3201

INHLOKOHHOVISI PIETERMARITZBURG HEAD OFFICE

Enquiries:
Imibuzo: Sibusiso Alwar
Navrae:

Reference:
Inkomba: 0096/06
Verwysing:

Date:
Usuku: 27 February 2006
Datum:

RE: **PERMISSION TO CONDUCT RESEARCH**

**TO WHOM IT MAY CONCERN**

This is to serve as a notice that **Mr. N. Naidoo** has been granted permission to conduct research with the following terms and conditions:

- That as a researcher, he/she must present a copy of the written permission from the Department to the Head of the Institution concerned before any research may be undertaken at a departmental institution.

- Attached is the list of schools she/he has been granted permission to conduct research in. however, it must be noted that the schools are not obligated to participate in the research if it is not a KZNDoE project.

- **Mr. N. Naidoo** has been granted special permission to conduct his/her research during official contact times, as it is believed that their presence would not interrupt education programmes. Should education programmes be interrupted, he/she must, therefore, conduct his/her research during nonofficial contact times.

- No school is expected to participate in the research during the fourth school term, as this is the critical period for schools to focus on their exams.

for SUPERINTENDENT GENERAL
KwaZulu Natal Department of Education

UHULUMENI WAKWAZULU NATAL
UMNYANGO WEMFUNDO
DEPARTMENT OF EDUCATION
DEPARTEMENT VAN ONDERWYS
2006 -02- 27
ISIKHWAMA SEPOSI
PRIVATE BAG / PRIVAAT SAK X04
ULUNDI 3838
RESEARCH, STRATEGY AND POLICY DEVELOPMENT

**Appendix F**

**Focus Group Interview**

**Questions**

1. Please explain how each of the following affected your learning experience:
1.1 e-mail
1.2 chat

2. What were some of the advantages of using web based learning?

3. Was the use of VNC viewer as a means of introducing lessons beneficial?
If yes please explain how.

4. Were you able to develop formulae to calculate perimeter and area?
How did the use of LOGO assist you?

5. What were some of the difficulties you experienced?

6.1 Explain what variables are.
6.2 Provide an example.

7. Explain how the activities that you have done are important to your everyday life?

**Appendix G**

## ACTIVITY 1: PERIMETER

1. Enter the following Logo procedure. Leave spaces exactly as shown.

```
TO SQUARE :X
REPEAT 4 [FD :X RT 90]
END
```

2. (a) Run the procedure by typing SQUARE 20

(b) Describe the image on your screen.

(c) Run the procedure again, this time by typing SQUARE 50

(d) Describe the image on your screen.

3. Click on RESET to clear the screen. Now type SQUARE 20. Each side of the square is 20 units long. Therefore, the distance the turtle has to walk around the square is ____ units. This is known as the *perimeter* of the square.

4. (a) Without clearing the screen, draw a second

square which has a perimeter of 160 units.

(b) In the space provided at the right, draw a

sketch of both squares as they appear on

your screen.

(c) Label the lengths on your diagram.

(d) What patterns do you notice between the

two squares?

5. What would you type to draw a square whose perimeter is five times the perimeter of SQUARE 20?

6. If one side of a square =x, what will the perimeter of the square be? x $\boxed{\phantom{x}}$

---

# ACTIVITY 2: AREA

1. Enter the following Logo procedure. Leave spaces exactly as shown.

```
TO SQUARE :X
REPEAT 4 [FD :X RT 90]
END
```

2. (a) Run the procedure by typing SQUARE 20

(b) Describe the image on your screen.

(c) Run the procedure again, this time by typing SQUARE 50

(d) Describe the image on your screen.

3. Click on RESET to clear the screen. Now type SQUARE 1. Each side of the square is 1 unit long. Therefore, the space contained within the square is _____ square unit. The *area* of an object is determined by the number of these *unit squares* that can fit inside it.

4. (a) Without clearing the screen, draw a second

square that is four times as big.

(b) In the space provided at the right, draw a

sketch of both squares as they appear on

your screen.

(c) Label the lengths on your diagram.

(d) What patterns do you notice between the

two squares?

5. What would you type to draw a square whose area is 25 times the area of SQUARE 1?

6. If one side of a square =x, what will the area of the square be? X $\boxed{\phantom{xx}}$

ACTIVITY 3: PATTERNS WITH PERIMETER AND AREA (PART 1)

1. Enter the following Logo procedure. Leave spaces exactly as shown.

```
TO RECT :L :W
REPEAT 2 [FD :L RT 90 FD :W RT 90]
END
```

2. Clear the screen and type RECT 2 10 . What can you say about this rectangle?

3. (a) Without clearing the screen, draw a second rectangle which has the same perimeter.

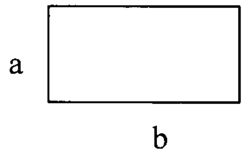
(b) In the space provided at the right, draw a sketch of both rectangles as they appear on your screen.

(c) Label the dimensions on your diagram.

(d) What patterns do you notice between the two rectangles?

(e) How many different rectangles can you find which also have the same perimeter as RECT 2 10? Sketch the rectangles you have found and label the dimensions on your diagrams.

4. If one side of a rectangle = a and another side = b, what will the perimeter of the rectangle be?




---

## ACTIVITY 4: PATTERNS WITH PERIMETER AND AREA (PART 2)

1. Enter the following Logo procedure. Leave spaces exactly as shown.

```
TO RECT :L :W
REPEAT 2 [FD :L RT 90 FD :W RT 90]
END
```

2. Clear the screen and type RECT 2 18 . What can you say about this rectangle?

3. (a) Without clearing the screen, draw a second rectangle which has the same area.

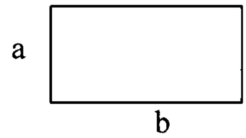
(b) In the space provided at the right, draw a sketch of both rectangles as they appear on your screen.

(c) Label the dimensions on your diagram.

(d) What patterns do you notice between the two rectangles?

(e) How many different rectangles can you find which also have the same area as RECT 2 18? Sketch the rectangles you have found and label the dimensions on your diagrams.

4. . If one side of a rectangle = a and another side = b, what will the perimeter of the rectangle be?



**Appendix G: Student 1**

## ACTIVITY 1: PERIMETER

1. Enter the following Logo procedure. Leave spaces exactly as shown.

```
TO SQUARE :X
REPEAT 4 [FD :X RT 90]
END
```

2. (a) Run the procedure by typing SQUARE 20

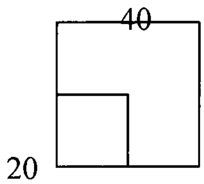
(b) Describe the image on your screen.  I see a small square.

(c) Run the procedure again, this time by typing SQUARE 50.

(d) Describe the image on your screen. There is a small square in a big square.

3. Click on RESET to clear the screen. Now type SQUARE 20. Each side of the square is 20 units long. Therefore, the distance the turtle has to walk around the square is _80___ units. This is known as the *perimeter* of the square.

4. (a) Without clearing the screen, draw a second square which has a perimeter of 160 units.

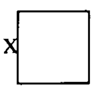



(b) In the space provided at the right, draw a sketch of both squares as they appear on your screen.

(c) Label the lengths on your diagram.

(d) What patterns do you notice between the two squares? The small one is half the big one.  If the small one is changed thebig one will also changeby 2 times the size.

5. What would you type to draw a square whose perimeter is five times the perimeter of SQUARE 20?  100

6. If one side of a square =x, what will the perimeter of the square be?   x  4 x x

## ACTIVITY 2: AREA

1. Enter the following Logo procedure. Leave spaces exactly as shown.

```
TO SQUARE :X
REPEAT 4 [FD :X RT 90]
END
```

2. (a) Run the procedure by typing SQUARE 20

(b) Describe the image on your screen. A smaal square

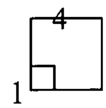
(c) Run the procedure again, this time by typing SQUARE 50

(d) Describe the image on your screen. A small sqare in a big one.

3. Click on RESET to clear the screen. Now type SQUARE 1. Each side of the square is 1 unit long. Therefore, the space contained within the square is __1___ square unit. The *area* of an object is determined by the number of these *unit squares* that can fit inside it.

4. (a) Without clearing the screen, draw a second

square that is four times as big.




(b) In the space provided at the right, draw a

sketch of both squares as they appear on

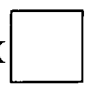
your screen.

(c) Label the lengths on your diagram.

(d) What patterns do you notice between the

two squares? One is 4 times bigger than the other

5. What would you type to draw a square whose area is 25 times the area of SQUARE 1? 5

6. If one side of a square =x, what will the area of the square be? X  x X x

ACTIVITY 3: PATTERNS WITH PERIMETER AND AREA (PART 1)

1. Enter the following Logo procedure. Leave spaces exactly as shown.

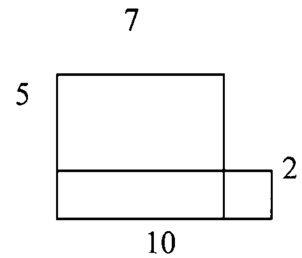
```
TO RECT :L :W
REPEAT 2 [FD :L RT 90 FD :W RT 90]
END
```

2. Clear the screen and type RECT 2 10 . What can you say about this rectangle?

It is normal

3. (a) Without clearing the screen, draw a second rectangle which has the same perimeter.

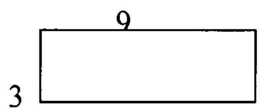
(b) In the space provided at the right, draw a sketch of both rectangles as they appear on your screen.

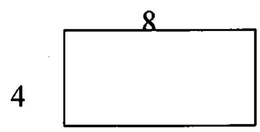



(c) Label the dimensions on your diagram.

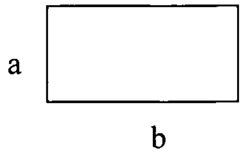
(d) What patterns do you notice between the two rectangles? They are different. Perimetris same but area is not.

(e) How many different rectangles can you find which also have the same perimeter as RECT 2 10? Sketch the rectangles you have found and label the dimensions on your diagrams.



4. If one side of a rectangle = a and another side = b, what will the perimeter of the rectangle be?




2(a+b)

---

ACTIVITY 4: PATTERNS WITH PERIMETER AND AREA (PART 2)

1. Enter the following Logo procedure. Leave spaces exactly as shown.

```
TO RECT :L :W
REPEAT 2 [FD :L RT 90 FD :W RT 90]
END
```

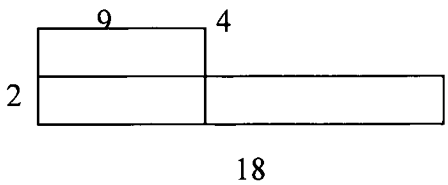
2. Clear the screen and type RECT 2 18 . What can you say about this rectangle?

The lengtn is much longer than breath

3. (a) Without clearing the screen, draw a second rectangle which has the same area.

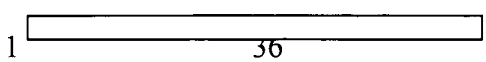
(b) In the space provided at the right, draw a sketch of both rectangles as they appear

(c) Label the dimensions on your diagram.

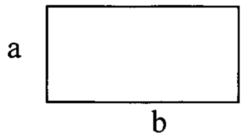



(d) What patterns do you notice between the two rectangles? The perimeter are different but area same.

(e) How many different rectangles can you find which also have the same area as RECT 2 18? Sketch the rectangles you have found and label the dimensions on your diagrams.




4. . If one side of a rectangle = a and another side = b, what will the area of the rectangle be?




a x b

**Appendix G: Student 2**

ACTIVITY 1: PERIMETER

1. Enter the following Logo procedure. Leave spaces exactly as shown.

```
TO SQUARE :X
REPEAT 4 [FD :X RT 90]
END
```

2. (a) Run the procedure by typing SQUARE 20

(b) Describe the image on your screen. 1 square

(c) Run the procedure again, this time by typing SQUARE 50.

(d) Describe the image on your screen.

2 squares

3. Click on RESET to clear the screen. Now type SQUARE 20. Each side of the square is 20 units long. Therefore, the distance the turtle has to walk around the square is _80___ units. This is known as the *perimeter* of the square.

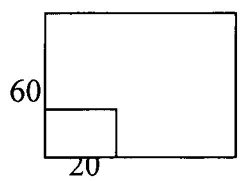
4. (a) Without clearing the screen, draw a second

square which has a perimeter of 160 units.

(b) In the space provided at the right, draw a

sketch of both squares as they appear on

your screen.




(c) Label the lengths on your diagram.

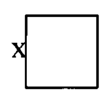
(d) What patterns do you notice between the

two squares?

There is 1 big square and 1 small square

5. What would you type to draw a square whose perimeter is five times the perimeter of SQUARE 20? 5

6. If one side of a square =x, what will the perimeter of the square be?




x+x+x+x

<u>ACTIVITY 2: AREA</u>

1. Enter the following Logo procedure. Leave spaces exactly as shown.

```
TO SQUARE :X
REPEAT 4 [FD :X RT 90]
END
```

2. (a) Run the procedure by typing SQUARE 20

(b) Describe the image on your screen.   1 square

(c) Run the procedure again, this time by typing SQUARE 50

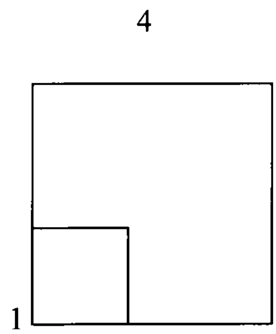
(d) Describe the image on your screen.

2 squares

3. Click on RESET to clear the screen. Now type SQUARE 1. Each side of the square is 1 unit long. Therefore, the space contained within the square is __1___ square unit. The *area* of an object is determined by the number of these *unit squares* that can fit inside it.

4. (a) Without clearing the screen, draw a second square that is four times as big.

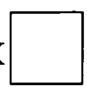
(b) In the space provided at the right, draw a sketch of both squares as they appear on your screen.




(c) Label the lengths on your diagram.

(d) What patterns do you notice between the two squares? 1 big and 1 small

5. What would you type to draw a square whose area is 25 times the area of SQUARE 1? 25

6. If one side of a square =x, what will the area of the square be?   X 

X x X x X x X

## ACTIVITY 3: PATTERNS WITH PERIMETER AND AREA (PART 1)

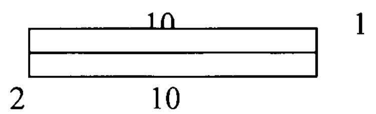
1. Enter the following Logo procedure. Leave spaces exactly as shown.

```
TO RECT :L :W
REPEAT 2 [FD :L RT 90 FD :W RT 90]
END
```

2. Clear the screen and type RECT 2 10 . What can you say about this rectangle?

3. (a) Without clearing the screen, draw a second rectangle which has the same perimeter.

(b) In the space provided at the right, draw a sketch of both rectangles as they appear on your screen.

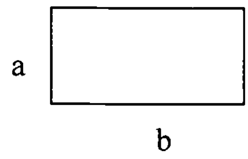



(c) Label the dimensions on your diagram.

(d) What patterns do you notice between the two rectangles? They are the same

(e) How many different rectangles can you find which also have the same perimeter as RECT 2 10? Sketch the rectangles you have found and label the dimensions on your diagrams.

4. If one side of a rectangle = a and another side = b, what will the perimeter of the rectangle be?




a + a + b +b

---

## ACTIVITY 4: PATTERNS WITH PERIMETER AND AREA (PART 2)

1. Enter the following Logo procedure. Leave spaces exactly as shown.

```
TO RECT :L :W
REPEAT 2 [FD :L RT 90 FD :W RT 90]
END
```

2. Clear the screen and type RECT 2 18 . What can you say about this rectangle?

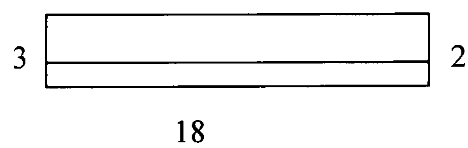
3. (a) Without clearing the screen, draw a second

rectangle which has the same area.

(b) In the space provided at the right, draw a

sketch of both rectangles as they appear

(c) Label the dimensions on your diagram.

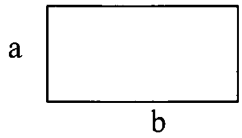



(d) What patterns do you notice between the

two rectangles? Area is same but perimeter is not

(e) How many different rectangles can you find which also have the same area as RECT 2 18? Sketch the rectangles you have found and label the dimensions on your diagrams.

4. . If one side of a rectangle = a and another side = b, what will the area of the rectangle be?




a x b

**Appendix H**

## ACTIVITY 1: PERIMETER

1. Draw a square with sides measuring 20 mm.

2. Describe the picture you have drawn.

3. Each side of the square is 20 mm long. Therefore, the distance around the square is ____ mm. This is known as the *perimeter* of the square.

4. Draw a second square which has a perimeter of 160 mm over the first square.

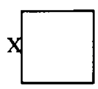
5. Label the lengths on your diagram.

6. What patterns do you notice between the

two squares?

7. What would the side of a square whose perimeter is five times the perimeter of SQUARE 20 be?

8. If one side of a square =x, what will the perimeter of the square be?

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## ACTIVITY 2: AREA

1. Draw a square with sides measuring 20 mm.

2. Describe the picture you have drawn.

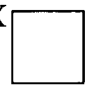
3. Draw a square with sides of 1cm. Therefore, the space contained within the square is _____ square cm. The *area* of an object is determined by the number of these *unit (cm) squares* that can fit inside it.

4. Now draw a second square that is four times as big over the first square.

5. Label the lengths on your diagram.

6. What patterns do you notice between the two squares?

7. What would the side of square whose area is 25 times the area of SQUARE 1 be?

6. If one side of a square =x, what will the area of the square be? X 

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## ACTIVITY 3: PATTERNS WITH PERIMETER AND AREA (PART 1)

1. Draw a rectangle with sides of 2mm and 10mm.

2. What can you say about this rectangle?

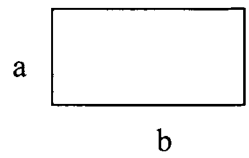
3. Draw a second rectangle which has the same perimeter over the first rectangle.

4. Label the dimensions on your diagram.

5. What patterns do you notice between the two rectangles?

6. How many different rectangles can you find which also have the same perimeter as RECT 2 10? Sketch the rectangles you have found and label the dimensions on your diagrams.

7. If one side of a rectangle = a and another side = b, what will the perimeter of the rectangle be?

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## ACTIVITY 4: PATTERNS WITH PERIMETER AND AREA (PART 2)

1. Draw a rectangle with sides of 2mm and 18mm.

2. What can you say about this rectangle?

3. Draw a second rectangle which has the same area over the first rectangle.

4. Label the dimensions on your diagram.

5. What patterns do you notice between the two rectangles?

6. How many different rectangles can you find which also have the same area as RECT 2 18? Sketch the rectangles you have found and label the dimensions on your diagrams.

4. . If one side of a rectangle = a and another side = b, what will the area of the rectangle be?