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SUPER HIGHWAY OR CUL DE SAC: THE INTERNET AS A TOOL FOR LEARNING SCHOOL MATHEMATICS

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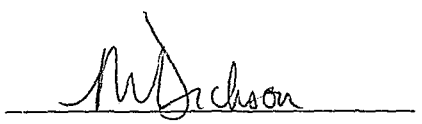
A research report submitted to the School of Science Education in the Faculty of Science, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science.

Johannesburg, 1999

DECLARATION

I declare that this research report is my own, unaided work. It is being submitted for the degree of Master of Science in Education in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.



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19 day of April 1999

ABSTRACT

This research report examines the possible contribution, if any, the Internet can make in enabling mathematics learning at junior secondary school level. In particular it looks at the ways and extent that learners respond to specifically designed mathematics lessons that use the Internet. The research takes the form of a case study and considers learners' actions with, and reflections on their use of, the tool. Within a framework of *communities of practice* I identify the existence of 'local communities of mathematical practice' (LCMPs) in certain mathematics lessons that use the Internet. I suggest that learning within such LCMPs cannot be fully explained without also considering notions of *mediation,* provided by the tool and/or a more able other. Further issues that impact on this study are the 'visibility' of the mathematics within more integrated lessons and the technicalities of time when working with the Internet within a South African context.

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CHAPTER ONE

INTRODUCTION

1.1 THE CONTEXT

> "Computermen have been advised to get their machines out to 'see life' by setting up communications links between them and other computers in disperse locations. Thus, computers will eventually become as close to everyday life as the telephone - a sort of public utility of information."
>
> *Time Magazine April 2, 1965, from a cover story on "The computer in Society".*

This statement made in 1965 must have stretched peoples' imaginations at a time when computers were relatively new and were used by a few interested people in special situations. Few then could have imagined the impact that computers, the Internet and the World Wide Web (WWW) would have on our society as we approach the 21st century. E-mail, Web pages and global communication are encountered every day in advertising, news reports, magazines, etc. Today, even if one does not personally own a computer, through work, school or cyber cafés, these aspects of technology are accessible to almost everyone in urban environments. From individuals to huge global conglomerates, links to up-to-the-minute information and resources are transforming the way we view the world. The number of people who have access to the Internet is growing daily, with the number of web-sites increasing accordingly. Neubarth (1996), editor of Internet World Magazine, wrote that the estimated number of people linked world wide to the Net is between 40 - 50 million, "with a projection of 200 million by the year

2000". There are an estimated 100 000 sites on the Web that house more than a million home pages. Most of the users are in America – estimated at 22 million – but the number in Africa is also growing.

> "Current estimates of the number of African Internet users range from about 700 000 to one million. Of course most of these are in South Africa (about 600 000) leaving only a hundred thousand amongst the remaining 700 million people on the continent. This works out at about one Internet user for every 5 000 people. The world average is about one user for every 40 people. In North America and Europe, the figure for Internet use is about one in every 4-6 people, depending on the country. South Africa by itself is still behind the world average, at about 65 people for every user and this bring the average up for the whole of Africa to one in every 1000 people."
>
> *TELECOM AFRICA '98 'The African Renaissance'*

1.2 THE INTERNET AND EDUCATION

The Internet refers to a world-wide network of computer connections. For most people its features are e-mail and the WWW, but it also includes newsgroups, 'chat' rooms and video conferencing. Much concern is expressed about the freedom of the Internet for accessing undesirable information and pornographic literature. Fetterman (1998) writes, "the WWW, virtually unheard of in 1993, now occupies a prominent place in world popular culture". In this study I look at the WWW and it's applications in education for learning mathematics.

There has been an explosion of educational sites on the Web from America, aimed at research and instruction, estimated at more than 20 000 links under 'educational research' in one of the larger search engines. The magnitude of the Internet as a

data source, whilst providing access to huge amounts of information, is also one of its weaknesses. It is often difficult to know where to start looking for relevant and useful information. It has been suggested that the Internet and the Web will significantly change how we view education. It will have a "true transformational impact on learning both in and out of school" (Global SchoolNet Foundation, 1997), and will "free teaching and leaning from the physical boundaries of the classroom and the time constraints of class schedules" (Owston, 1997: 27). However given the recent history of technological innovations and similar predictions for education which have not been fulfilled, one might be a little sceptical of such promises. If one walks into most classrooms today one will most probably find traditional transmission models of teaching and learning taking place. Rogers (1998) says that schools are stuck in a time warp within an "outdated paradigm more akin to the 19th century than to the 21st."

Bill Clinton's proposal for American children linked to the Internet is encouraging:

> "Every eight-year-old must be able to read, every 12 year old must be able to log onto the Internet, every 18 year old must be able to go to college"
>
> *Bill Clinton, in his nation address in February 1997.*

Similar plans are expressed for South Africa - Jay Naidoo, South Africa's Post and Telecommunications Minister, described a government plan to link every South African school online within the next 5 to 10 years and thereby

"leapfrogging from illiteracy to computer literacy" (Naidoo in Cohen, 1998) as a key to success in the 21st century.

> "The Internet has become a platform for the development of the national information infrastructure. Africa must devote more attention to the Internet as one way of bridging the gap between the information rich and the information poor. Applications such as Internet telephony, distance education, tele-medicine and e-mail provide immense advantages for Africa. The possibilities are endless".
>
> *Jay Naidoo TELECOM AFRICA 98*

1.3 SCHOOL MATHEMATICS IN SOUTH AFRICA

In South Africa school mathematics is often viewed as empowering and as a means of access to further education. However, in the past few years, the level of mathematics education has been of a very low standard - not only do some secondary schools not offer mathematics as a subject, but there is a huge drop-out rate amongst pupils and many teachers are not adequately qualified to teach mathematics.

The June 1997 issue of *Edusource* lists statistics for mathematics and science at schools in 1995. The student drop-out rate in mathematics, over the whole country, show only 54 % of standard 8 students continued through to standard 10. Similar figures show that of the total number of students enrolled in standard 10, only between 17% and 56 % (depending on the province) were enrolled for mathematics; whereas only 50 % of mathematics teachers specialised in mathematics teaching.

In a report entitled "Mathematics and Science Teachers: Utilisation, Supply, demand and Training in South Africa" in *Edusource* 1997, looking at the position of mathematics and science in our schools, found that "pupil access to and enrolment in mathematics and science is often inadequate" (Arnott et al: 1997: 1). It also said that few student teachers coming out of colleges of education "could be regarded as either mathematically or scientifically literate" (page 3).

The latest results in the Third International Maths and Science Study ranked South Africa last of 22 countries in problem-solving skills. One of the overall findings of the study was that mathematics and science literacy among South Africa school pupils was at a very low level. (*The Star*, 25 February 1998)

In the light of these comments something needs to be done about mathematics education in our schools. An alternative approach to mathematics teaching is urgently required. With the vast inequalities in education inherited from the past, it is of immediate concern to attempt to upgrade both the teaching of mathematics in schools and the training of mathematics teachers. With many schools poorly equipped and under resourced, a major rethink is required as to how to, not only redress the imbalances of the past, but to push the teaching and learning of mathematics into the 21st century. Perhaps the Internet could help provide a means of facilitating such change?

1.4 CURRICULUM 2005 AND EDUCATIONAL REFORM IN SOUTH AFRICA

The introduction of Curriculum 2005, with its emphasis on learning outcomes and a more integrated curriculum, is seen as a means of access and redress for an education system that ignored the majority of the population. The new curriculum sees a shift from a content-based, examination-driven approach to learning, towards achieving outcomes in a more affirming environment and places great emphasis on active participation of learners.

Learner centred activities form an integral part of the new curriculum and whether learners work individually or in groups, the emphasis is on encouraging learners to be instruments of their own learning. By sharing their knowledge and experiences through classroom talk and co-operative learning situations learners can extend their horizons and take responsibility for their own decisions and knowledge creation. Perhaps the Internet can provide opportunities to engage learners in meaningful activities to promote learning?

As a teaching tool the Internet can be utilised in all learning areas. In terms of the Critical Cross-field Outcomes the use of the Internet may allow learners opportunities, among others, to 'communicate effectively using visual, mathematical and/or language skills.....'; to 'identify and solve problems by using creative and critical thinking'; to use '. ..technology effectively and critically..' and 'to understand the world is a set of related systems.....'

While historically underprivileged schools are hugely under-resourced in terms of facilities, textbooks and equipment, links to the Internet would be able to provide access to information far exceeding that to be found in large libraries. Enormous though the costs of setting up computers and Internet links in such schools may be, the potentials for learning are huge. With the necessary power and telephone connections these schools would be able to use the Internet as a resource for teachers and learners, who would no longer be isolated from educational opportunities. Students would be able to access information from around the world and teachers would have the facilities to upgrade their knowledge and skills.

1.5 THE INTERNET, MATHEMATICS AND THIS RESEARCH

The purpose of this study is to examine the possible contribution, if any, the Internet can make in enabling learning in schools in South Africa. In particular, some ways in which the Internet can be used as a tool for learning mathematics at a junior secondary level (senior phase in the National Qualification Framework) are explored.

To provide a focus to the study the following question will be addressed:

* In what ways and to what extent do learners respond to specifically designed mathematics lessons that use the Internet?

In particular I will attempt to answer the questions:

* How do the learners act with the tool?
* How do learners reflect on their use of the tool? [1]

This study takes the form of a case study and is conducted in a more privileged school environment in Johannesburg and it cannot be assumed that there will be transfer to less privileged schools. However, it is important to begin to explore the Internet as a tool for learning and these findings might still inform as to the use of the Internet for the learning of mathematics.

The research is based on four mathematics lessons that use the Internet. Two lessons were specifically designed for this research and are included in the appendix. Two other lessons can be found on the Internet site of Cynthia Lanius - http://math.rice.edu/~lanius/Lessons/.

1.5.1 OUTLINE OF THE REPORT

In Chapter Two of this report I give a broad overview of current research into the use of technology, in general, and the Internet, in particular, in enabling learning at school. As there is yet very little research looking at the Internet as a tool for learning, this research opens a small window into a potentially wide and important field of study.

[1] By 'tool' I am referring to the Internet in the context of the specific lessons

In Chapter Three I consider the theoretical background that informs this research. I give an overview of Lave and Wenger's theory of social practice relating to 'communities of practice', in particular looking at notions of transparency. I also consider Vygotsky's ideas of mediation through tool use and intervention by a more able other. In the context of this research I refer to the Internet and the specific mathematics lessons as the 'tool', and the learners' interaction with this tool falls within Vygotskian theory.

In Chapter Four I outline the methodology and methods of data collection in this study. In particular I justify the use of an interpretive, qualitative framework for trying to understand curriculum in use, and the choice of a case study in a particular school in Johannesburg.

Chapter Five is devoted to the description of the learners' actions with the 'tool' and their reflections on their use of the 'tool'. This description arises out of the data collected from field notes and observations, learners' questionnaires, written work and interviews.

In Chapter Six I analyse the descriptions of the actions and reflections in the light of the theoretical framework given in Chapter Two.

In Chapter Seven I provide a summary of the main points of the discussion and analysis and consider any other implications that may arise out of this research.

CHAPTER TWO

LITERATURE REVIEW

It is commonly acknowledged that the Internet is the fastest growing aspect of information technology in the world and the World Wide Web is the 'superhighway' to access the information. This rapid access to up-to-the-minute information impacts on all aspects of social, political and economic life. However, considering the high profile that the Internet is given in business and the everyday lives of so many people, there appears, as yet, to be little literature relating to its impact on education. While doing the reading for this literature review I found that there has been much research into the different uses of computers and diverse software packages as interventions in the classroom learning of mathematics, but there has been limited research into the use of the Internet in schools.

2.1 THE INTERNET AND RESEARCH

The proceedings of the 'Technology in Mathematics Education' conference organised by the Mathematics Education Research Group of Australia in 1996 has discussions on the effects of technology in the mathematics classroom with regard to teachers and learners, particularly relating to the graphic calculator, but nothing on the Internet. Similarly at the recent International Psychology of Mathematics Education conference held in Stellenbosch in July 1998 there were numerous

research reports looking at learning using dynamic geometry packages, but none that looked at the use of the Internet as a tool for learning.

One of the few papers, in an educational research journal, which looks specifically at the Internet and its uses for education, is that of Iseke-Barnes (1996). She talks about educators as the 'drivers' on the 'superhighway' of information that links the different sites in the Internet, yet there appear to me to be few mathematics teachers out there 'driving'! Kaput (1994) suggests that much of mathematics education research is not involved in technology as technology is seen as the preserve of specialists. He says

> "to exploit the real power of technology is to transgress the boundaries of school mathematics" (p. 681)

Curriculum technology specialists are beginning to investigate the Internet as a means of learning. However this technology is seen more as a subject in itself than as a tool for enabling learning in traditional school subjects. At the recent National Educational Computer Conference held in Natal in September 1998 Carol Siwinski (Curriculum Technology Specialist from Germantown Academy in Fort Washington in the United States of America [1]) discussed the importance of providing the pupils with the necessary skills to access and explore the Internet. She talked about 'Internet Integration' and highlighted goals to "integrate technology appropriately to support effective instructional practices across the curriculum". She also discussed software that provides the means to publish on,

[1] http://www.ga.k12.pa.us.curtech/curtech.htm

and navigate the Internet, and stressed the potential of access to vast amounts of information. Whilst much of this information on the World Wide Web is of little or no intrinsic value, there is a great deal that is relevant for classroom use. It is because of the huge volumes of information on the Internet that searching and retrieval becomes a crucial element in the effective use of the Internet for teaching and learning. In this research I do not consider the searching or retrieval of information but instead look at how specifically designed lessons based on the information on the Internet can be used for learning mathematics.

2.2 TECHNOLOGY IN THE MATHEMATICS CLASSROOM

When considering technology and mathematics education one can distinguish between the effects of working with technology and the effects of technology in helping to understand mathematics. (Salomon, 1993)

Initially new technologies such as calculators and computers were used to facilitate the rapid computation of numbers. Later, applications for symbolic manipulations and graphical representations were developed. These are examples of 'working with' the technology. Today the almost limitless possibilities of access to vast levels of information and different levels of interaction when using the Internet, means a dramatic shift in the use of technology. This research begins to look at how such a shift may be achieved. In this research real-life contexts from the Internet are used in lessons for learning mathematics. The Internet therefore becomes another resource within the mathematics classroom. This

research therefore begins to look at one aspect of the effect of 'working with' the technology to help mathematical understanding.

In the introduction to the discussion document on 'Technology Enhanced Learning Investigation in South Africa' (1996) it states that:

> "Technology can be extremely effective in supporting the development of learner-centred and outcomes based education, but only if and when it is skilfully employed"

Similar observations based on research into the effects of computers on learning mathematics, carried out at Princeton in the United States of America, were reported in a recent article in the *ITechnology* section of The Star Newspaper (6 October 1998) - "Computer is a fair maths teacher". The results of this research showed that when used for games, simulations and applications the computer can markedly increase performance. However when used for drill and practice type activities the performance gains are the least effective.

The computer by itself cannot change learning. It is how it is used that makes the difference. Dorfler (1993) says that the 'appropriate usage of tools introduces, or has the potential to bring about structural changes in the system of (cognitive) activities" (page 161). Iseke-Barnes (1996), in talking about the Internet, says:

> "whether it engages meaningful interactions or not, whether it engages users in knowledge-making or information gathering is dependent upon the uses made of it" (p. 2)

This is particularly relevant when considering using the Internet for learning mathematics, as in this research. The types of lessons that may be designed using the Internet are very varied and their consequent success for learning mathematics must depend on numerous factors including their context, structure and the embeddedness of the mathematics. The lessons in this research project have been especially chosen - or specifically designed - to demonstrate the connectivity of the Internet that allows learners to interact with a unique environment while learning mathematics.

Iseke Barnes (1996) also distinguishes between acquiring information and constructing knowledge and asks whether using the Internet, and searching within it, is about information or knowledge? She suggests that it is through interpretation and analysis that information becomes knowledge. This implies that it is the type of Internet environment and learning experience that a teacher provides for learners, that will enable the construction of knowledge.

In the mathematics classroom the Internet as a vast source of information is of limited value unless this information is used in such a way to facilitate the acquisition of mathematical concepts. While there are numerous sites on the Internet in which pages are published with mathematical data, school tests and drill and practice exercises, it is the interactive nature of the Internet that makes it markedly different from other technological interventions. The immediate accessibility to 'real life' situations beyond the experience of the average school-going child, and the communication possibilities with learners in other countries,

makes it unique. In this research I am particularly interested in such implications for learners working on mathematics lessons that make use of the interactive nature of the Internet. Lessons that allow the learners to 'travel' to different sites on the Web as they meet mathematical problem solving situations within real-life settings provide unique learning environments.

Balacheff and Kaput (1996) mention the expansion of new technologies, including the Internet, and the need for more research into their use. They talk about the 'microworlds' in which mathematical ideas can be expressed. Noss and Hoyles (1996) also discuss the different 'microworlds' that have been developed for learning mathematics. These 'microworlds' are mathematical systems specifically designed for learning mathematics within a "knowledge domain to be investigated by interaction with the software" (p. 65). Such 'microworlds' include the worlds of turtle geometry as found in Logo, and the dynamic geometry of Cabri-geometre. In Logo, drawings are static but can be redrawn and modified. In Cabri-geometre drawings can be manipulated in a dynamic way. These 'microworlds' are therefore substantially different and the learning that takes place is significantly different. Subsequently the way the learners make sense of their activities within the different 'microworlds' shapes their understanding of the mathematics involved in the activities.

In this sense the Internet cannot be considered to be a 'microworld'. It is not a specific mathematical system for learning mathematics. Rather it is another sort of world packed with all sorts of information. I will argue that the ways learners

access this information when engaged in mathematical activities on the Internet are unique and the learners' understandings are specific to these activities. The mathematical understanding acquired when using the Internet will be specific to the specific lessons and not the same as other computer aided technologies.

2.3 TECHNOLOGY AND CULTURE

New technologies, including computers and the Internet, are products of the global culture to which all learners are exposed. Just as hand held calculators have become an accepted part of the mathematics classroom in most countries, so computers are likely to become universally accepted in the future. Despite the enormous financial implications involved in equipping schools in South Africa with such tools, they are seen as a means of access and empowerment.

> "In South Africa, old and new technologies have the potential to help address critical questions of access, redress and flexibility and relevance"
>
> *Technology Enhanced Learning Investigation in South Africa: (1996, p. 16)*

Noss and Hoyles (1996) talk about the "dialectic between how cultures structure technology and how technology can shape the culture" (p. 52). They discuss the computer as an integral part of mathematical learning together with the learner and the teacher. The computer "plays a role in communicating the actions, sharing and re-negotiating mathematical expression and facilitating the (co-) construction of mathematical meaning" (ibid. 228). They talk about the computer 'opening a window' on meaning making in a cultural domain. In their book

Windows on Mathematical Meanings. Learning Cultures and Computers they describe the use of Logo in promoting mathematical meaning, and they say that the computer not only advances technological skills but also helps to pull cultural meanings from outside school into schools and so helps to breakdown the isolation of school mathematics. They distinguish between mathematics as a part of culture and mathematics as a tool, and they stress that children can appropriate mathematical meaning through interaction with the technological tools of the culture. In this context the Internet can be seen as a technological tool within the culture of today's school learners, which has huge potential for being used to facilitate and promote mathematical understanding. The 'window' opened onto such understanding appears much wider when using the Internet. By using it in learning situations teachers can help the learners' mathematical meaning making.

Crawford (1994) talks about technologies that:

> "... occupy a different niche in the system of human activities and discourses and [that] have changed the relationships between culture, science and technologies" (p. 92)

She talks about the fusion of knowledge and action and the transformation of information into mental representations. She says that computers have changed the nature of mathematical knowledge and the way people think mathematically. Computers have made mathematical ideas more accessible and have shifted the focus away from memorisation and drill techniques towards posing problems, interpretations and evaluations. They provide opportunities for interactive learning environments that before were not possible. Logo and dynamic geometry

packages, such as Cabri-geometre or Sketchpad, are examples of software that allow interaction between the learner and the mathematics in the exploration of active, independent learning.

2.4 TECHNOLOGY AND THE CURRICULUM

Just as computers have impacted on mathematical knowledge and the construction of mathematical meaning, the Internet, with its capabilities for interaction and connectivity, and its ability to provide a realistic environment in which to situate mathematical activities, will presumably impact on the understanding of the learner.

New technologies, be it computers or the Internet, must however, result in dramatic new approaches to the content of the curriculum. And such changes to the curriculum have implications for teachers. Balacheff and Kaput (1996) say that the traditional professional knowledge of teachers is "not sufficient to deal with the deep changes in learning, teaching and epistemological phenomena that are emerging" (p. 495) as a result of the introduction of computers into the learning situation. They highlight two different dimensions to this change in approach:

i) symbolic, in which the computer (or in the context of this study, the Internet) causes changes in the representation of the mathematics:

and

ii) interactivity, in which the relationships between learners, teachers and mathematics is changed by introducing a new partner into the learning environment (in this case the computer).

Rogers (1998) talks about teachers who are using technology in the classroom, not just for storing and sorting data, but as an innovative tool. They are "discovering, inventing and sharing the kinds of practices and programs in their own classrooms" that represent a new paradigm of learning. He talks about 'side-by-side' learning in which both teachers and learners use the new technology "to shape, process and manage information, to look for relationships, trends, anomalies and details, which can not only answer questions, but create questions as well."

Owston (1997) discusses how the Internet can make learning more accessible and how it can promote improved learning. With so many schools in South Africa under-resourced and disadvantaged in terms of facilities and skills, perhaps the Internet can help in making mathematics more accessible to the majority of students in South Africa?

2.5 TECHNOLOGY AND THE LEARNER

One of the main attractions to using the Internet in classrooms is that it appeals to the students.



The Star Newspaper

Owston (1997) says, "children relate to the computer in ways that baffle adults" (p. 29). He talks about children as visual learners who thrive on the visual stimuli that the "rich, multisensory, interactive nature of the Web" provides. What may be lost in face-to-face contact with a teacher is made up for in the interaction and learning that takes piace on-line. New environments empower the students to become "part of an Internet community and to take advantage of the wealth of learning opportunities". They can "weigh evidencc, judge the authenticity of data, compare different viewpoints on issues, analyse and synthesise diverse sources of information, and construct their own understanding" (ibid. 31).

When considering the relationship between computer programming at school and college, and possible mathematical activities, Turkle and Papert (1993) talk about the "computer's intellectual personality" (p. 49), and they distinguish between two different types of interaction with the computer – the 'planners' and the 'bricoleurs'. The 'planners' need to work within the rules of the system and need to control and organise their work, while the 'bricoleurs' tend to 'play' with the

elements of the system. The 'bricoleurs' work with contextualised, concrete arguments that provide access and collaborative interaction with the computer. They prefer to work through negotiation and rearrangements rather than control and planning. Turkle and Papert say that the computer makes ideas more concrete and has the capability for making changes, "not only within the computer culture, but within the culture at large" (p. 49).

In the description of learners' actions with and reflections on using the Internet – in Chapter Five - I will show that these distinctions appear to have parallels with learners' actions when working on specific mathematics lessons. It is almost impossible to plan and/or control the Internet, so those learners who prefer a more instrumental approach to learning mathematics - the 'planners' - will encounter difficulties and frustrations. A more relational approach to working with the Internet provides a means for discovery and exploration. Learners who appear to work as 'bricoleurs' have opportunities to link their mathematical meaning making to other concepts in more contextualised situations and to prior learned knowledge.

E-mail communication allows students in different geographical locations to collaborate on projects and learn from each other. In America there are numerous schools who collaborate on Web-learning using Internet sites (Stead, 1998), as well as universities and colleges who offer tuition via the Web. They use the Internet more than just as a huge on-line library, but as part of an interactive

learning environment that enables the students to be actively engaged in their learning.

While these aspects of Internet use have vast potential for learning, in this study I do not consider the possibilities of e-mail communications between learners. In the Cynthia Lanius lessons there is the facility to send geometric designs by e-mail, however the limited time spent with the girls at PGH School restricted this usage.

2.6 DISTANCE LEARNING

Another important aspect of the Internet for education is the expectations for 'distance learning'. Balacheff and Kaput (1996) suggest that changes in intervention between teachers and learners and machines will require new skills. Video-conferencing and asynchronous communication environments can be created that simulate a real classroom. With the use of the Internet and electronic mail the virtual classroom is a reality. Cronje (1996), in discussing a pilot study for a Masters degree in Computer-Assisted Education at the University of Pretoria, talks about the "flexibility of the design, allowing students to do more or less what they wanted to". However he does highlight enormous stumbling blocks in stabilising the technology. Not only did the students have to learn how to use the technology; they had to contend with technical breakdowns and the uncertainty of their links being successful.

However in this study I am not concerned with these aspects of the Internet, though there is vast scope for further research into the use of the Internet in this area of distance learning. Curricula and course contents published on the Web is accessible to vast numbers of learners, were they to have access to computers with Internet connections. In such instances there would be fewer problems and disadvantages for learners in remote and inaccessible locations being denied learning materials.

2.7 FINANCIAL CONSIDERATIONS

One point of uncertainty when talking about education using the Internet seems to be the question of cost effectiveness. Owston (1997) raises this issue with regard to the situation in America. How much more so must this be for the South African situation? Even with offers such as that from Telkom to sponsor free Internet connections to 900 schools through out South Africa (Cohen, 1998) the capital outlay is enormous. Will education through the Internet really provide a solution to our education crisis?

While the financial implications of learning with the Internet are vastly important for the South African situation they fall outside the limited scope of this study and I do not consider them in any depth.

2.8 THIS RESEARCH

This research project looks at the Internet as a possible resource within the mathematics classroom. As already mentioned there are literally hundreds of educational sites on the Web, with numerous sites having something to do with mathematics - many with drill and practice exercises and tests, others with lists of lessons and still more with explanations of mathematical concepts. Most of these sites have been developed in America and those relating to school mathematics are aimed at the American curriculum and so have limited relevance for classrooms in South Africa.

This research uses some of the materials designed for the American curriculum -- in particular the lessons published by Cynthia Lanius[2] - as well as specially designed materials to fit the South African curriculum.

The purpose of this study is to make a small, initial contribution to research into looking at the potential of the Internet for facilitating change in the way mathematics is taught. I intend to look at learners' actions with the Internet as they work on specific mathematics lessons and their reflections as they use the tool. In this way I am opening a small window onto a much larger field of research, which may contribute to new exciting ways of using the Internet for learning mathematics.

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[2] http://math.rice.edu/~lanius/Lessons/

CHAPTER THREE

THEORETICAL FRAMEWORK

This study is informed primarily by Lave and Wenger's (1991) theory of social practice and a sociocultural theory of learning based on the work of Vygotsky in social psychology. Ideas of learning taking place within 'communities of practice', together with notions of 'transparency' while learning in different contexts, form the background against which I consider learners' reflections on using the Internet for learning mathematics. Sociocultural learning theory forms the framework for understanding 'tool' use and mediation while learning mathematics in the social environment of the Internet, teachers and fellow learners. Perspectives of learners constructing their own knowledge and sharing meaning through social interaction and communication contribute towards ideas of learning mathematics using the Internet.

In discussing the implications of these ideas on learning mathematics with the Internet, I first consider social practice theory and 'situated learning' within 'communities of practice', as proposed by Lave and Wenger, and whether learners learning mathematics using the Internet may be considered a 'community of practice'. I also look at Vygotsky's notions of tool-use and mediation, (both with tools and more capable others), and their relevance when considering learning mathematics using the Internet. Other aspects of Vygotskian theory that are relevant to this research are the 'zone of proximal development' and notions of the formation of 'scientific' and 'everyday' concepts.

An alternative framework for this research might have been a Piagetian one. In such a framework notions of learners actively constructing their own knowledge are implicit, and the teacher needs to provide the learner with experiences and environments which will encourage the child's natural inclination to develop and learn. Within such a framework the individual is the meaning maker and the social setting provides possibilities for exploration and discovery and negotiation of meanings. One could consider the Internet as the environment in which a child's natural inclination to learn could be let loose, and specifically designed mathematics lessons as being special elements of the environment suited to the child's specific stage of development. However, this presents a far too simplistic version of what is involved in a teaching-learning situation using the Internet and does not take into account the social interaction between learners or between a learner and the Internet. Neither does it take into consideration the specialised nature of the Internet environment with its capabilities for highly social active interaction.

3.1 SITUATED LEARNING AND COMMUNITIES OF PRACTICE

3.1.1 THEORY OF SOCIAL PRACTICE

Traditionally learning is envisaged as a cerebral activity in which knowledge is 'transmitted' to the learner, who then 'internalises' it. In such a situation the success or otherwise of the learning appears to depend on the ability of the learner

or the skilfulness of the teacher. In reconsidering the way different learning theories account for individuals' construction of knowledge Lave and Wenger (1991) have suggested that learning is 'situated' within 'communities of practice' in a particularly social way – "learning is a facet of the communities of practice of which they are composed" (Lave, 1996: 150). Their theory of social practice includes notions of 'distributed cognition' and 'situated learning' that form the basis of their ideas of learning taking place within 'communities of practice'. In describing their theory of social practice, Lave and Wenger (1991) write:

> "... a theory of social practice emphasises the relational interdependency of agent world, activity, meaning, cognition, learning and knowing. It emphasises the inherently socially negotiated character of meaning and the interested concerned character of thought and actions of persons-in-activity... Cognition and communication in, and with, the social world are situated in the historical development of ongoing activity ".
>
> (p. 50,51)

They talk about 'situated learning' as learning that is an integral and inseparable part of the social 'situation' within which it occurs and 'situated activity' as the activity in which people are engaged as they learn.

3.1.2 THE SITUATION

In a narrow sense the 'situation' could be the place in which learning occurs, i.e. looking at learning that is located in space and time. In childhood this situation is the home and school and, in particular, the classroom. Meaning is shared and

negotiated with other people through language and therefore is social in nature. However ideas of 'situatedness' and 'situation' go beyond the physical location to include social actions and interactions. Meaning is then "situated in interested, intersubjectively negotiated social interaction" (Lave, 1991: 67). Intersubjective mathematical knowledge is constructed within the classroom through negotiation of meanings among learners and teachers and the culture of mathematics. There is a mathematical enculturation that takes place that enables the learners to participate in 'taken-as-shared' knowledge construction. There is also participation within the classroom culture of the school.

Lave and Wenger take this idea of 'situation' even further and in talking about "the relational interdependency of agent and world, activity, meaning, cognition, learning and knowing", link the person, the physical situation, the social situation, the activity and the doing, all together into the learning and knowing. An interpretation of this would be that one learns to be a mathematician by doing mathematics with other mathematicians who are doing mathematics. An important feature of this 'situatedness' is that it is located in and within a social world and the ongoing activity of that world. Lave and Wenger call this social 'situation' a 'community of practice', and learning, therefore, is a 'social practice' within a 'community of practice' in the world. This 'community of practice' embodies certain beliefs and behaviours that are peculiar to that particular community.

3.1.3 COMMUNITIES OF PRACTICE

In recent research Winbourne and Watson (1998) have worked within a theoretical framework of 'situated cognition' and 'communities of practice'. In attempting to define the characteristics of a 'community of practice' they highlight six essential features that are necessary for such a 'community': -

- "participants create/find their identity within the practice;
- there has to be some social structure which allows participants to be positioned on an apprentice/master scale;
- the community has a purpose;
- there are shared ways of behaving, language, habits, values and tool-use;
- the practice is constituted by the participants;
- all participants see themselves as essentially engaged in the same activity." (p. 178)

Lave and Wenger developed their concept of a 'community of practice' by studying apprenticeships whose members formed a shared community in order to learn a skill or trade. The levels of participation in the practice changed as the apprentices progressed from 'newcomers' to 'masters' and learned their trade. In all such examples of 'community of practice' knowledge is acquired through authentic contexts and learning requires social interaction and collaboration. Learning is characterised by increasing participation in the 'practice' and Lave and Wenger talk about the 'legitimate peripheral participation' through which learners progress as they gain mastery in the 'practice' They highlight the power play that is involved as 'newcomers' take over the roles of 'masters' as they enter full participation. For the 'newcomer' the peripheral position is empowering in that there is a move towards fuller participation, but also disempowering as he/she

is kept from this full participation by virtue of being a 'newcomer'. Access is gained through greater participation and involvement in the 'practice' on the way to becoming a 'master'.

While Lave and Wenger extended the idea of such a 'community' to include communities in other contexts, such as school learning, teaching and the communities of different learning disciplines and different schools, there is much debate over whether such concepts apply to schools or classrooms. Dowling (1995) argues that teaching and apprenticeship are not the same -- the "pedagogical relationship is not one of apprenticeship" (p. 184) - and thus implies that one should not consider the possibility of learners becoming masters or of the learning/teaching situation as a 'community of practice'...

In this research it is important to consider how these notions of 'communities of practice' could be applied to learners learning mathematics using the Internet? What is the 'practice'? Is it the learning of school mathematics, the use of the Internet within which learning takes place or the learning of mathematics using the Internet? What is the 'community'? Is it the learners, the learners and the teacher, or the learners and the teacher together with the Internet? Do learners at school begin as 'newcomers' to a 'practice' and progress towards 'mastery'? At school they cannot become masters of mathematics, but perhaps they may become masters of school mathematics! Similarly does this mean they become masters at using their learned school mathematics in out of school situations? This ability to

transfer school knowledge to out of school situations is a major area of concern in teaching mathematics at school.

Perhaps one should consider whether school mathematics is a 'community of practice'? Adler (1998a) talks about school mathematics as a 'distinct practice' with "recontextualisations from the discipline of mathematics" and from 'everyday' mathematics (p. 11). Does this equate to Lave and Wenger's notions of a 'community of practice'? In that learners are engaged in gaining access to the knowledge of school mathematics, perhaps it may be described a 'community of practice', and the learners may in some way form part of the 'community of practice' of school mathematicians. Similarly the learners may be described as 'newcomers' into this 'practice', as they strive for understanding and greater participation in school mathematical activities. Could the teachers be considered 'old-timers' or 'masters' in the 'practice' of school mathematics?

Can the Internet be considered a 'community of practice' in a similar way? The highly social interactive nature of the Internet certainly means it constitutes a 'community' of users, but is this the same sort of 'community of practice' as proposed by Lave and Wenger? There is a certain changing participation as the users engage in interaction with the Internet, but hardly any shared ways of behaving and habits. The uses of the Internet are many and varied from email and communication, information seeking, research and economic functions to more trivial usage such as playing games. Perhaps when used specifically for learning mathematics there is a common purpose and a certain degree of progression from

'newcomer' to 'master', but much depends on the anticipated use. The Internet can certainly provide a specific framework or resource within which to learn mathematics – but is this the same as a 'community of practice'?

Winbourne and Watson (1998), in looking at whether schooling can be considered a 'community of practice', talk about 'local' communities of practice. They say such communities may be 'local' in time and space for specific lessons and yet display the characteristics of larger communities as proposed by Lave, such as a common purpose of learning. When discussing the classroom or particular lessons as 'local communities of practice' Winbourne and Watson suggest that there are essential features that such 'local' communities must display.

- "pupils see themselves as functioning mathematically within the lesson;
- within the lesson there is public recognition of competence;
- learners see themselves as working together towards the achievement of a common understanding;
- there are shared ways of behaving, language, habits, values and tool-use;
- the shape of the lesson is dependent upon the active participation of the students;
- learners and teachers see themselves as engaged in the same activity."

(p. 183)

These features relate specifically to the learning/teaching situation of the classroom and show a slight variation from those defining a more general 'community of practice' – mentioned above.

Many of these features are significantly apparent when using the Internet for specifically designed lessons for learning mathematics and they will be discussed in more detail in Chapter Five. They include learners engaged in a common

purposeful activity – the learning of mathematics – with shared ways of behaving and interacting with the Internet that are unique to the activity. To a certain extent there is a structure of increasing participation as the learners engage in the lessons and as they actively interact with the Internet and come to a common understanding of the mathematics. Winbourne and Watson also talk about the "common direction of learning" (p. 182) that is supported by a 'local community of practice'. This is again demonstrated by notions of learners using the Internet for the construction of mathematical knowledge through specific lessons.

In these considerations of learning 'situated' within a 'practice', are ideas of sharing knowledge socially. Salomon (1993) highlights the social as an integral part of the cognitive process. He talks about cognitions as "situated and distributed rather than decontextualised tools and products of mind" (p. xiv). The social aspect of such learning situations is an important feature of learning with the Internet, where learners share meaning and construct knowledge as they interact with the Internet, with the teacher and with their peers.

3.2 SOCIOCULTURAL THEORY

Notions of social interactions between learners form the basis of interactionist, social constructivist and sociocultural perspectives, that all argue that communication forms a crucial part of the development of mathematical knowledge. Through sharing and negotiation, mathematical meanings and understandings are formulated. Both teachers and learners are active participants

in the process. This is illustrated by Lerman's idea of the intersubjectivity of shared knowledge in the classroom (1996), and Jaworski's notion of 'taken-as-shared' meanings that occur as a result of interaction between teachers and pupils (1994). Similarly, Ernest (1991) argues that the intersubjective mathematical knowledge that is shared by individuals and is made public through discussion and negotiation, becomes the 'objective knowledge' of mathematics.

Vygotsky envisaged that learning took place within cultural contexts and he focussed on the social interactions within such contexts. He stressed the

> "connections between people and the cultural context in which they act and interact in shared communication aimed at intersubjectivity – a shared consciousness of culturally significant phenomena by the use of language and other symbolic tools"
> (Crawford, 1996: 44)

3.2.1 VYGOTSKY AND SOCIOCULTURAL THEORY

Vygotsky's view of meaning making is that of meaning constructed in discursive practices. He stressed the acquisition of meaning through communication, mediation and language. The individual, situated in time and place, is acculturated into discursive practice. From this viewpoint the Internet may be considered to be a cultural artefact within which a learner is engaged in social interaction and through which he/she enters into the discursive practice of learning mathematics.

From a sociocultural perspective, when considering a learner's development, social and cultural processes are given priority over cognitive processes. The central theme of Vygotsky's psychology was that 'action is mediated' and all cognitive development takes place within a sociocultural environment in which learners interact with others (Wertsch, 1985).

Vygotsky was strongly influenced by Marxist theory and for him the social dimension is dominant –

> "every function in the child's cultural development appears twice, first on the social level and later on the individual level; first between people (interpsychological), and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formulation of concepts. All the higher functions originate as actual relations between human individuals."
>
> (Vygotsky, 1978:57)

He distinguished between 'intermental' processes – those that take place with other people – and 'intramental' processes – those that place inside an individual's head – and said that the intrapsychological processes are determined by, and derived from, interpsychological processes through mediation. Wertsch (1985), in considering these notions of Vygotsky, says that this is more than learning being influenced through social interaction, it implies an internalisation of the interpsychological that is mediated by signs and tools, such as language and speech, to become intrapsychological. This internalisation becomes the very process of learning.

In Vygotskian theory there are three ideas that have important implications for mathematics learning and that have further implications for learning mathematics when using the Internet: - the development of scientific concepts, the zone of proximal development (ZPD), and the use of tools as a form of mediation through the ZPD.

3.2.1.1 SCIENTIFIC AND SPONTANEOUS CONCEPTS

Vygotsky distinguished between

i. spontaneous concepts - those that a child acquires in the everyday, and
ii. scientific concepts - those that a child acquires at school through instruction.

In the context of this study the 'scientific' concepts are the concepts learned - the mathematical and technological concepts - through the lessons using the Internet. The 'spontaneous' concepts, in this study, relate particularly to the everyday contexts within which the lessons are situated and from which the mathematical concepts are developed through the questions in the lessons.

Vygotsky said that the direct teaching of concepts is impossible and that concepts are not acquired by rote; rather they are constructed through instruction at school. In a teaching situation a learner is able to make generalisations and to systematise his/her concepts - which start as everyday concepts - and so raise his/her consciousness. There is an interweaving of 'spontaneous' concepts with 'scientific' concepts - the one informs and enriches the other. The mastery of a higher realm of scientific concepts enriches the level of spontaneous concepts:

"scientific concepts grow down through spontaneous concepts; spontaneous concepts grow upward through scientific concepts" (Vygotsky, 1962:109), and the development of scientific concepts influences the development of the child.

3.2.1.2 THE ZONE OF PROXIMAL DEVELOPMENT (ZPD)

Vygotsky defined the ZPD as:

> "the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978:86)

This 'zone' describes a conceptual space in which a learner interacts with another - a teacher or more able other learner. This idea highlights the potential development of the learner; a potential that can only be achieved with the assistance of another. Vygotsky envisaged this assistance to be by way of tools and signs in a social world. He stressed the link between language, action and thought within the ZPD - "language enables children to provide for auxiliary tools in the solution of difficult tasks" (Vygotsky, 1978:28) - and emphasised that learning creates the ZPD and enables development through internalisation and imitation. The ZPD - that space between unaided learning and assisted learning - arises out of Vygotsky's stance that instruction precedes learning. The teacher is in the position to lead the learner ahead of his/her development within the ZPD. It is in the mediation through the ZPD that the mathematics teacher plays a significant role. Through the provision of challenging activities the teacher is able

to extend a learner's ZPD, and through a process of 'scaffolding' is then able to mediate his/her learning to enable him/her to perform tasks without assistance.

Lave and Wenger (1996) mention other interpretations of the ZPD depending on the theoretical stance of researchers. A 'cultural' interpretation defines the ZPD as:

> "the distance between the cultural knowledge provided by the sociohistorical context – usually made through instruction – and the everyday experiences of individuals" (page144).

This has parallels to ideas of scientific and everyday concepts.

On the other hand there is a more 'social' interpretation in which the ZPD is defined as the:

> "distance between everyday actions of individuals and the historically new form of the societal activity that can be collectively generated as a solution to the double bind potentially embedded in ..... everyday actions".
> (Engestrom, 1987: 174 in Lave & Wenger, 1996:144).

This interpretation emphasises a social transformation within the ZPD more in line with Lave and Wenger's ideas of changing participation in a practice.

I will argue that these ideas have particular relevance for this research as the Internet lessons may help create a ZPD of significance for the learners. Mediation through the ZPD can be as a result of teacher intervention, a more able peer, the 'tool' or help from other sites on the Internet that are designed to give assistance

in the formation of concepts. The teacher may 'scaffold' the learner through tasks in mathematics lessons, or may assist in the actions of the learners as they engage in new forms of interactions with a cultural artefact, in increasingly acceptable forms of societal activity.

3.3 TOOLS AND MEDIATION

3.3.1 LANGUAGE

Central to Vygotsky's theory of learning and development is the notion of mediation. The whole idea behind the internalisation of external activities is that of mediation through cultural means. In Vygotskian terms there were two principle agents of mediation; signs or psychological tools, such as language and speech, which are internally organised, and physical tools or artefacts that are externally oriented. Language was the form of mediation that preoccupied Vygotsky most - (Confrey (1995) talks about the 'dialectic of thought and language' in Vygotskian theory) - and he stressed the primary role that language and signs play in the development of thought. Initially language accompanies action in the form of egocentric speech; later it is used to plan actions; later still it forms the 'tool' of mediation when interacting with others and becomes internalised into the processes of thinking. Vygotsky's notion that the structure of thinking is strongly influenced by language, and the fact that language has strong social and cultural links, means that cognitive development can be considered to be a social and cultural process.

3.3.2 PHYSICAL TOOLS

The primary means by which the teacher assists the child through the ZPD is language, although other means of mediation may be considered such as physical tools or the tools of modern technology - computers and the Internet. John-Steiner (1995), quoting from Brown et al (1993) suggests that the

> "... active agents within the ZPD 'can include people, adults and children, with various degrees of expertise, but can also include artefacts such as books, videos, wall displays, scientific equipment and a computer environment intended to support intentional learning'."
> (Brown et al, 1993 in John-Steiner, 1995: 34)

Salomon (1993) in discussing 'distributed cognitions' stresses the importance of the role played by computers as tools of learning, and the consequent collaboration between individuals and computers. He talks about 'solo' cognitions which are located 'inside' individuals' heads, and 'distributed ' cognitions which are socially and culturally developed 'outside'. In a similar way Pea (1993) talking about "distributed intelligence" that supports the achievement of an activity's purpose, distinguishes tools that "carry intelligence in them" (p. 53) and those that have a major influence on distributed intelligence (e.g. physical tools such as a thermometer or speedometer; or symbolic tools such as algebra). He says that these are everyday tools, that with familiarity, are no longer seen as remarkable and they become 'invisible'. Pea (1993) says that such "tool-aided, socially shared cognition" (p. 74) has an important role within classroom learning.

Meira (1995), in considering 'tool mediation' in the mathematics classroom talks about two types of tool - signs or semiotic systems, such as tables and graphs, and technical tools or instrumental artefacts, which he describes as 'concrete materials'. The computer and the Internet fall into this category. He describes tools as "instruments of access to knowledge, activities and practices of a community" (p. 103) rather than "containers or conduits of meaning" (p. 105). The quality of the tool for mediation is found in the process of using the tool in a purposeful activity.

Crawford (1996), in looking at the computer as a cultural artefact for mediating learning, talks about the 'social ontogeny of knowledge" (p. 47), in particular mathematical knowledge, that is constructed within culturally defined social contexts. She sees the computer as a cultural artefact that has "sociocultural ontogeny". She says that new technology allows new ways of looking at mathematical activity and allows for new ideas for constructing ZPDs for learners in new and different sociocultural contexts. She says it is

> "... inappropriate that the zone of proximal development in mathematics classrooms still orientates students towards imitation, memorisation and practising techniques with the intent to reproduce them in obedience to authority figures and without any reference to their personal needs and goals". (p. 60).

3.4 ACTIVITY

In terms of using the Internet for learning mathematics, it is important to consider the 'purposeful activity' in which the learners are engaged. Vygotskian theory

considers the concept of activity as located in particular social and cultural contexts. Tools involved in such activities are socially developed and defined, and by using them in socially structured activities, learners' thinking and understanding are mediated. Lave and Wenger's notion of activity resides within the purposes of a specific 'community of practice'. Any activity is situated within the 'community of practice' and relates to the learning of the practice.

Leont'ev extended Vygotsky's idea about activity into an Activity Theory which considers the "interaction of personal development and social context and goals" (Ernest, 1991: 245). It is beyond the scope of this study to consider in any depth the implications of such a theory, however the notion of learners' knowledge and meaning being constructed through social interactions as they engage in purposeful activities is pertinent.

Rogoff et al (1991) in looking at the cultural contexts of learning and development say "thinking as well as acting are intricately interwoven with the context of the activity" (p. 300). They stress the meaningful purpose of activities and say the use of such cultural tools involves certain conventions and genres that are peculiar to the cultural contexts in which they are enacted. The development of thought depends on the "social interaction of children with people who are proficient with the skills and tools of society" (p. 321) as they are mediated through their ZPDs.

Within the theory of social practice the purposeful activity in which learners are engaged depends on the 'community of practice'. Learners' participation in

activities is a function of the 'practice'. Mathematical problem-solving activities embedded in the Internet constitute such activities within a unique cultural milieu.

3.5 TRANSPARENCY

Ideas of the 'transparency' of subject matter and resources are derived from Lave and Wenger's notions of social practice. Access to participation within a 'community of practice' is through a variety of activities and resources of the community, which may include different forms of technology and other artefacts. Their transparency is an importance function of their use and to access to the 'community.' Lave and Wenger (1991), in talking about transparency, highlight notions of 'visibility' and 'invisibility' and say that "transparency refers to the way in which using artefacts and understanding their significance interact to become one learning process" (p. 102). This duality of visibility and invisibility can be applied to many features of learning mathematics at school level - textbooks, chalkboard, context of lessons and computer.

> "If the resource is to enhance and enable mathematical learning, then at some point it will need to become invisible - no longer the object of attention itself, but the means to mathematics".
>
> (Adler, 1998a: 10)

Whilst mathematical concepts can be embedded in different contexts in specific lessons, it is important that the contexts do not make the mathematics become invisible. Similarly, when using the Internet for learning mathematics it is

important that neither the technology nor the context is too visible, and that neither make the mathematics become invisible.

3.5.1 VISIBILITY IN CONTEXTS

The 'context' of learning can be understood to be the setting in which the learning takes place. Not a physical setting, but more an abstract setting, that locates the learning in an environment that attempts to make it more meaningful. Often the focus is on everyday situations where the context provides a bridge between the abstract mathematics of mathematicians and a real-life problem. In such instances the mathematics can be said to be embedded in the 'real-life' context.

One of the reasons for looking at the different contexts and situations in learning mathematics is to try to facilitate and enhance the transfer of school learning to everyday situations outside school. It is assumed that if mathematics is learned in an everyday context it will be easier to transfer this understanding and apply learned concepts to problems encountered outside school. Learning in different contexts is said to encourage students to explore, negotiate, discuss, understand and use mathematics more readily. The learning of different mathematical concepts is more meaningful and relevant to the learners if it relates to everyday situations that they may encounter.

Boaler (1993) argues that contexts can "motivate students, engage their interests and combat underachievement" (p. 15). She says that contexts can enhance

transfer to the extent that if the contexts are meaningful for individuals, not just arbitrary and random, and occur in more open ended and interpretive perspectives, the students will engage more fully and be more aware of the usefulness of mathematics. She says that "using real world, local community and even individualised examples which students may analyse and interpret, is thought to present mathematics as a means with which to understand reality" (p. 13). Within a South African perspective and looking at the implementation of the new curriculum, 'real life' contexts provide mathematics that is more relevant to learners.

Arguments against learning in different contexts include those that say that theories of transfer are based on unsubstantiated evidence and false assumptions, so learning mathematics in such a way will have no effect on transfer anyway. It has also been argued that contexts tend to obscure the mathematics. It is argued that by inserting real life situations into the learning of mathematics additional conflict for the students is created, in that they have to negotiate the setting or the task as well as the mathematics (Christiansen, 1997). The 'virtual reality' of the context can confuse the students and lead to further misunderstandings.

Lave (1991) argues against ideas of transfer and suggests that the notion of life as a series of unconnected situations is incorrect. She argues for the "interrelations of communities of practice" (p. 91) and learning as legitimate participation within such 'communities'. From the perspective of social practice, the 'learning of mathematics in a real life context' may be the 'community of practice'. So there

is no need for any transfer to out-of-school situations as that is the context within which mathematics is learned.

Whatever the viewpoint, it is important that for learning to be effective, the context in which the mathematics is embedded should not cause the mathematical concepts to become invisible to the learner.

3.5.2 VISIBILITY IN TOOL USE

As discussed above, an important feature of Vygotskian theory is that of tool mediation. In order for tools to help mediate mathematical thinking they need to be both visible and invisible. Adler (1998a), in discussing Lave and Wenger's idea of the transparency of artefacts, says that transparency is a feature of the "use in practice" (p. 8) of the artefact as it mediates learning and enables meaning making. Elsewhere she says "mediating technologies need to be invisible so that they can support the visibility of the subject matter." (Adler, 1998b: 165). To be an effective tool the Internet needs to enable students to engage fully in the learning and consolidation of mathematical concepts, provide a resource to mathematical information, and at the same time provide access to other information. The "transparency is not a property of the resource, but a function of how the resource is used and understood within the practice in context" (Adler, 1998a: 11).

3.6 THE INTERNET

Vygotsky's notions of 'mediated activity' through the use of signs and tools, and the social relationships involved in learning, including the sociocultural context, have important implications for the learner of mathematics when working on Internet lessons. In Piagetian terms the Internet can be considered as a special environment in which learners interact and construct knowledge. From the standpoint of social practice the Internet may be considered a unique 'community' in which learning takes place. In Vygotskian terms the Internet can be conceived of as a different type of tool that allows for a different construction of knowledge thereby enhancing the learners' enculturation into mathematics. Confrey (1995) talks about the "shifts in conceptual knowledge accompanying different tool use" (p. 41) and Cobb (1997) says that "tool use is viewed as central to the process by which students mathematise their activity" (p. 170).

Within the parameters of this research issues of transparency are of prime importance – both within the context of the lessons and the embeddedness of the mathematics and in the use of the Internet. The real life contexts of sites in the Internet, within which some of the lessons were designed, have the potential for being too visible and so causing the mathematical concepts to be too invisible. This could result in the learners being unaware of the mathematics and becoming too involved in the context. Similarly the technology could become too visible thus not letting the learners see through it to the mathematics.

3.7 THE THEORY AND THIS RESEARCH

In this research the above notions of '*local communities of practice*' (LCPs) and *tool mediation* form the framework within which I describe and analyse the learners' actions and reflections. Issues of the *visibility of the mathematics* in the different contexts within the lessons have implications for the successful learning of mathematics, and the very *interactive nature of the Internet* also impacts on the learning in the lessons.

In analysing the learners' actions I look particularly for instances confirming the existence of LCPs in the different lessons. Such instances are reflected in the learners' participation, interaction and engagement with the Internet and mathematics in the lessons. LCPs, while helping to explain how mathematical learning takes place, cannot fully explain it. It is for this reason that I also consider the mediation that the tool or a more able other has in helping the learners negotiate ZPDs within the activities in the lessons. At times the learners' partner takes on the role of a more able other; at other times it is the teacher or a 'help' site on the Internet. I argue that the learning of mathematics when using the Internet can only be fully explained when mediation is considered to be an integral part of a 'local community of mathematical practice'.

CHAPTER FOUR

METHODOLOGY

4.1 METHODOLOGICAL FRAMEWORK

This research falls within an interpretive, qualitative framework as I attempt to understand curriculum in use, and consider learners' actions and reflections as they work through specific mathematics lessons using the Internet. The research is a case study using one particular girls' school in Johannesburg. The results may not necessarily transfer to differently resourced environments in other schools, but they may have implications on how the Internet can be used for learning mathematics.

4.1.1 QUALITATIVE RESEARCH

The interpretive methods of qualitative research are often criticised for being unscientific, unreliable and trivial and therefore not leading to "objective scientific knowledge" (Kvale, 1993: 167). However, if the basic premise behind any research is to produce 'new knowledge' that is worth knowing, then interpretive methods can provide different perspectives, theories and methodologies that can contribute to the creation of such new knowledge. In recent years interpretive methods have made important contributions to research in teaching, specifically in issues of content, and ethnographic approaches to research in education have

provided alternative viewpoints that have given fresh insights. (Wolcott (1988); Erickson(1986)).

Interpretive methods can include a whole range of different approaches, namely "ethnographic, qualitative, participant observational, case study, symbolic interactionist, phenomenological [and] constructivist" (Erickson; 1986: 119). The overarching characteristic in these approaches is a concern for "specifics of meaning and action in social life that take place in concrete scenes of face-to-face interaction" (p. 156).

Instances when interpretive methods are most suitable can be when one needs to know specific occurrences rather than general characteristics or distributions; when "meaning-perspectives of particular actors" (Erickson, 1986: 121) are of importance and when events are organised into particular social locations. The answering of research questions in these instances raises important issues for interpretive methods, in particular:

- The need for specific detailed understanding of events in practice
- The need for understandings in specific settings which might have 'local meanings'
- The need for comparisons of different local social settings
- The need for comparative understandings beyond the local settings.

In looking at social phenomena and the constructions of actions and actors, a particular perspective is required. These social interactions cannot always be observed using empirical scientific methods and interpretive methods provide a useful means of describing them. Erickson (1986) talks about the "specifics of actions and meaning-perspectives of actors" (p. 124) which cannot be adequately described by other approaches.

As stated in Chapter One the intention of this research is to consider the actions and reflections of learners as they use the Internet for specific mathematics lessons. I am particularly interested in the "specifics of actions and meaning-perspectives" of learners at a specific school. In this instance it is the actions and meaning perspectives of the girls at PGH School as they use the Internet for work on mathematics lessons. I am concerned with the specific understanding of events in a particular setting. However, within the scope of this research I am not concerned with comparisons with other different social settings. Rather I look at diverse activities in the four different lessons that use the Internet.

4.1.2 FIELDWORK IN QUALITATIVE RESEARCH.

Fieldwork in interpretive research involves an intensive study of social settings with careful recording of events and significant actions - either through field notes, video and tape recordings, observations, interviews or surveys - and subsequent analytical reflection and analysis.

In this research I used structured observations and field notes, questionnaires and taped interviews with learners, and written answers as major sources of data. The data collected through these methods is described in more detail later in this chapter.

4.1.3 THE CASE STUDY

Within an interpretative framework an important method of research is the case study. Cohen & Manion (1994) state that one of the purposes of a case study is to "probe deeply and to analyse intensively" (p. 106) the phenomena and characteristics that form part of an individual unit or system - like a school or community within a wider social setting. Stake (1988) discusses the characteristics of a case study and says such a study may portray "an educational problem in all its personal and social complexity" (p. 254). He talks about a 'case' as being a "bounded system" that is bounded by the experiences of the system and is "worthy" of being studied (p. 258). Research using the methods of a case study is aimed at finding an understanding of a particular system (the case) in all its complexity.

Arguments against such an approach say that it tends to be subjective and biased; that the findings of case studies, which may be based on personal experiences, are untrustworthy and do not display the aspects of external validity that are found in more rigorous, systematic and generalizable research. Opponents of such research say that as the findings are based on a personal account they may therefore be

open to many different interpretations. Those in favour of such methods stress that the perspective of the researcher and the purpose of the study form part of the boundaries of the case and that there is a strong internal validity arising out of the rich descriptive narrative of the actions and actors in the social setting of the study. Proponents also argue that the unique case may help in the understanding of more typical cases. In helping to understand what's happening inside one 'bounded system' it may contribute to a "naturalistic generalization [rather] than to scientific generalization" (Stake, 1988: 260).

I chose the method of a case study for this research as it provides a way to begin to look at the use of the Internet in the classroom for learning mathematics. In attempting to answer the research question of the possible contribution, if any, the Internet can make in enabling the learning of mathematics in schools in South Africa this case study opens a small window onto a much wider field of research. With so little research into the use the Internet in classrooms, a case study is an ideal approach to use to begin to look at how learners act with the 'tool' and their reflections on their tool-use.

Within the limited scope of this research it was necessary to find a school that had access to the Internet and where the computers were networked, so allowing a number of learners to work simultaneously. The school also needed to be willing and open to having outsiders coming into it and conducting research with the learners. PGH School is such a school in Johannesburg and this case study involves a group of 20 girls from the Grade 8 mathematics class.

PGH School is an ex Model C all-girls school, with a fairly diverse population of girls, drawing from predominantly affluent white urban areas, but also including middle class black families from Soweto and Alexandra, girls of Asian descent and girls of mixed race. By South African standards the school therefore has a diverse racial mix and learners come from both urban and township situations. The fact that the school is an all-girls school is interesting, though gender issues do not form a focus for this research. PGH School is typical of the South African schools that have the necessary access to the Internet and where most of the learners in Grade 8 are familiar with using computers. The school is also very supportive of having any sort of research into education being conducted with the girls.

In order not to interrupt the normal classroom teaching it was arranged to have the 'Internet Maths' lessons for several sessions of forty minutes on Thursday afternoons, at the end of the school day. As the sessions would therefore be an 'extra' the girls were asked to volunteer if they wished to participate. As mentioned, we had room for only twenty girls and more than that volunteered, so the Grade 8 mathematics teachers selected a cross-section of girls from those mathematically more able to those who find mathematics more difficult.

The context of the study depended on school circumstances over which I had little control. As the lessons took place after school they had the possibility of being viewed as a 'fun' option for which no serious work was required. In addition no Grade 8 mathematics teacher was able to be involved in the project so the lessons

had little or no continuity with normal mathematics lessons. As a consequence the lessons were not integrated into the regular curriculum but formed an add-on extra. These issues have implications for the findings of the research and are taken into account in the description and analysis of the learners' actions and reflections that follows in Chapter Five and Six.

As already mentioned, the results of the research may not necessarily transfer to differently resourced environments, however, they are still valid in their own right as they provide some understanding into how the Internet may be used in schools for learning mathematics. The results provide a starting point from which to look further into the use of the Internet in schools.

4.1.4 GENERALIZABILITY

One of the major concerns for research is the generalizability of the findings. This is particularly true of empirical, quantitative research. However Kvale (1993) mentions that in modern social research there is a shift away from "generalization to contextualisation" (p. 185). Similarly, Erickson (1986) says, "a primary concern of interpretive research is particularizability rather than generalizability" (p. 130) because sometimes the universal aspects of events can be recognized in specific instances rather then general ones.

In analysing the data from the fieldwork and writing descriptive accounts the researcher generates and tests assertions based on meaningful explanations, and

understandings can be made about observed actions and actors. In looking for connections between settings and the surrounding environment the researcher can look for links of instances within particular settings that form a pattern.

As already mentioned, this research is a case study of a particular school. While there may not be instances that have a more general understanding and that are valid across other settings, the descriptive accounts of the learners' actions and reflections may provide insights into understanding the particular setting of this specific case.

4.1.5 VALIDITY

Another major criticism of interpretive research is that it is too subjective and depends too much on the perceptions and interpretations of the researcher or observer. From this viewpoint the research may lack the same type of validity that more quantitative methods have. Erickson (1986) talks about the aims of the researcher being "not [for] proof, in a causal sense, but the demonstration of plausibility" (p. 149). Maxwell (1992) says "qualitative research has its own procedures for attaining validity that are simply different from those of quantitative approaches" (p. 280) and that understanding is a more important concept than validity. In a positivist or instrumental approach validity is expressed in terms of the procedures used and lies within the truth of objective reality, while in an interpretive approach validity lies more in the descriptive account and in terms of integrity, credibility and legitimacy.

Maxwell (1992) talks about validity in interpretive methods as:

- Descriptive validity which refers to the 'factual accuracy' of the records and the account of the events observed;
- Interpretive validity which pertains to aspects of meaning, intentions, beliefs and interpretations of actions and actors;
- Theoretical validity which is linked to notions of explanation and causality;
- External validity - or generalizability to other situations within the same setting or other settings (as discussed above); and
- Evaluative validity which involves the application of an evaluative framework to the study.

He stresses that by adopting an alternative approach to validity - one based on understanding - interpretive methods can be considered reliable and legitimate.

In this research into the use of the Internet for learning mathematics validity falls within the factual reality of events and the integrity of the descriptive accounts. I describe the learners' actions with the tool and their reflections as they use the tool for learning mathematics in Chapter Five. In looking at the learners' actions I focus on their participation, interaction and engagement with the tool. The categories for the description of actions are:

* Task demands
* Time, and
* Mathematics.

In considering the learners' reflections, the categories of description include:

* Enjoyment, and
* Mathematics

Further validity is provided through attempts to understand the meanings of learners' actions and intentions and the interpretations of their actions and reflections against the theoretical background of communities of practice and tool-use. This analysis is found in Chapter Six.

4.2 THE RESEARCH PROJECT

In conducting this research into the use of the Internet in schools I wanted to examine the possible contribution, if any, the Internet can make towards the learning of mathematics at junior secondary level. In particular I wanted to try to answers questions relating to how learners act with the 'tool'[1] and their reflections on their use of the 'tool'.

I used several different means to collect data:

1. Observation and field notes
2. Interviews
3. Questionnaires
4. Short written responses

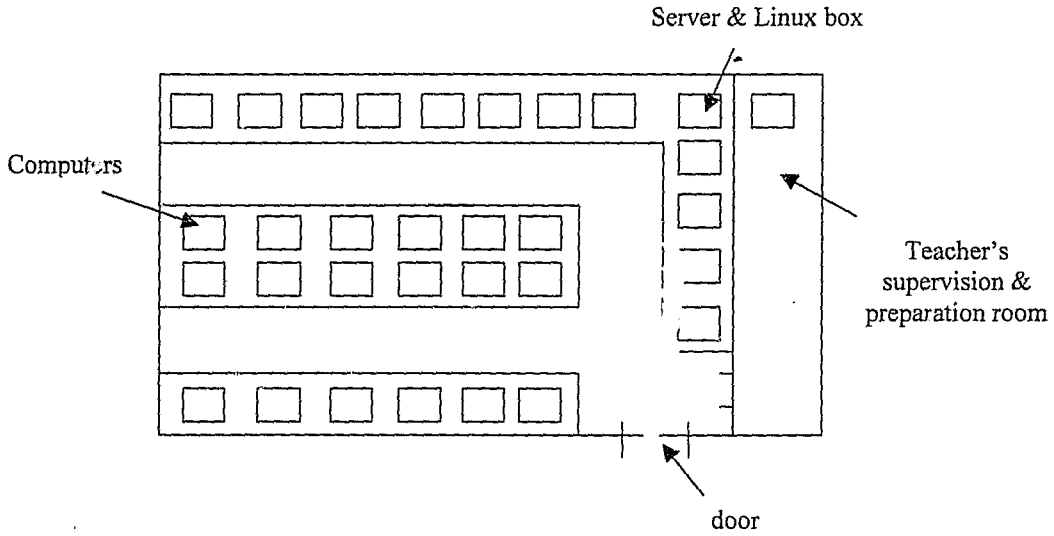
[1] By 'tool' I am referring to the Internet in the context of the specific lessons.

5. Written work for tasks in lessons.

A description of the data collection follows the short description of the school setting and the lessons that the learners were required to work on while using the Internet.

4.2.1 THE SCHOOL AND THE INTERNET

The Internet connection at PGH School is through a Linux box with one telephone line to the service provider - they have access to the WWW and email. The school has about thirty 486 computers set up in a classroom as shown below:



The computer teacher suggested that we use only ten computers so as to minimise the load on the school network and keep the time delays in accessing the Internet

as low as possible. We decided that it would be feasible to have two girls working at each machine, so allowing twenty girls to take part in the study.

4.2.2 THE LESSONS

While participating in the research the girls of PGH School worked on four different Internet lessons for a total of nine sessions. Two lessons were designed specifically for the study using different sites on the Internet - see Appendix for copies of these lessons; two were selected from a set of mathematics lessons published on the Internet by Cynthia Lanius[2] in America - see Appendix for examples of Web pages from these lessons. The four different lessons were spread across ten sessions. There was one introductory session at the very beginning as a way of familiarising the girls with the purposes of the study and the use of the Internet. There were six sessions in term three - the last six weeks of term - and three in term four, before the end of year examinations.

The lessons that I designed use 'real world' sites on the Internet around which mathematical activities have been developed. They did not necessarily teach new concepts - the mathematics teacher might have already done this during regular class lessons. The lessons use different sites on the Internet depending on their anticipated outcomes, and include some problem-solving tasks and activities as well as consolidation activities. By embedding different mathematical procedures and concepts within different contexts I hoped to be able to help towards enabling

[2] http://math.rice.edu/~lanius/Lessons/

the mathematical learning of the learners. In accordance with current ideas on relevance I did not merely want to 'lift' mathematics lessons from the Internet, but wished to construct lessons that would be relevant and meaningful to learners in South African schools, and that would extend their horizons beyond their immediate vicinity.

However, as the girls worked through the lessons I had designed, I realised that they were not always 'finding' the mathematics. Whether this was because of the use of the Internet or as a result of the embeddedness of the mathematics in the contexts of the lesson, is a question that needed to be considered. Because of the 'invisibility' of the mathematics in the more contextualised lessons I decided to also use mathematics lessons already on the Internet – the lessons designed by Cynthia Lanius in which the mathematics is far more visible.

The mathematical activities in the four lessons are very different and I have included a short description of the lessons here, although the two I designed myself are included in the appendix. The lessons are aimed at Grade 8 level and I originally envisaged them taking perhaps 2 to 3 half-hour lessons each. As it turned out I badly miscalculated the time the lessons would take to complete and I will look in more detail at the implications of time and the use of the Internet in the analysis.

4.2.2.1 'WHALES AND DOLPHINS'

In this lesson the students start by visiting the Internet site for the 'Whale Route' off the Southern Cape Coast, in order to find out about the different species of whales and dolphins that visit South African shores. The first few questions help to focus the students in finding out information about the different animals, and to position them in a lesson that requires some sort of investigation into facts provided on a web page. I designed this lesson with the idea of using it within a more integrated framework, as suggested by an outcomes based educational approach, which might involve ideas relating to other subjects, such as Science, Biology, Geography and History, as well as Mathematics. The mathematics is therefore contextualised within a 'real world' situation found on the Internet.

Questions involving mathematical activities require the learners to convert units, to make simple calculations relating to rates, to draw a simple graph to compare the lengths of different whales, to compare the length of a whale with a tennis court and to introduce a concept of volume

Additional information about whales and dolphins can be found in other sites, e.g. the Sea World in Florida, USA; and the learners are expected to go to these sites. Other links include the site for the conversion of units and a site giving information about the game of tennis.

Examples of the questions in this lesson are given below:

- Use the table below to compare the length and weight/mass of 3 different whale species and one dolphin species found on the whale route.

Whale/dolphin	Meters	Feet	Centimeters

- If there were 500 Southern Right whales off the Cape coast this year, assuming they return next year with their calves, how many would there be?

- Find out how long a tennis court is and compare this with the length of a whale. Are you surprised?
- If one wanted to find the volume of a whale think of a way that one could make an approximation of the volume of the whales you chose in question 4.

Answers to the first three questions above can be found in the information about the animals given in the different Web pages. The last question above assumes that the learners may have an idea about volume but might not have actually studied it in regular mathematics lessons.

4.2.2.2 'THE PIZZA PARTY'

In this lesson the students plan a fantasy pizza party with some friends. They have to decide how many friends to invite, and then they visit the Internet Pizza site and have to decide the 'best buy' of the pizzas available for their party. They can choose a variety of different toppings for their pizzas as well as several different sizes. They work with fractions, percentages - for VAT and a tip for the delivery person - and areas of circles. Examples of the questions in the task are given below:

- Go to the Internet Pizza Server. Order a small, medium, large and family sized pizza with two toppings so that you can compare prices. Work out

the price per slice of each. Is this a good way to compare the price of the pizzas?

- If the measurements of the different pizzas are:

Small:	10 cm radius
Medium:	25 cm diameter
Large:	30 cm diameter
Family sized:	22 cm radius

Calculate the area of each pizza.
What size pizza with 2 toppings would be the best buy?

There are several links within the Internet Pizza site which learners need to access in order to find out how to 'order' a pizza. Also included in the lesson is an address for a 'help' site - the 'Pi' site - for information to do with circles – properties of circles, areas, etc.

The assumptions in the questions in this lesson are that the learners would be able to use their own knowledge to answer questions on the 'best buy'; they may need to access the 'help' site to answer questions to do with calculations about circles, or to ask the teacher for help.

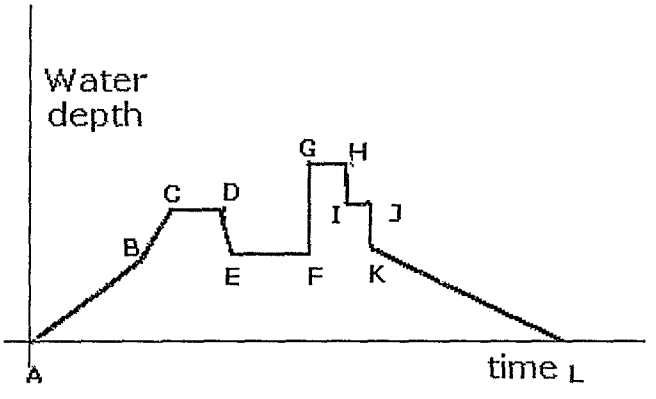
While this lesson is much more decontextualised than the 'whales' lesson the entertainment value is much greater as the list of different toppings is quite unusual and the chosen pizza is constructed on screen when it is 'ordered'.

4.2.2.3 'THE HOT TUB'

(This is the first of Cynthia Lanius' lessons)

This lesson is about the interpretation of a graph. The graph (over the page) shows the relationship between the time taken to fill a bathtub and the depth of

water in the tub. The students have to tell the 'story' of the graph and then look at the mathematics involved when the slope of the graph is positive or negative.



This lesson is one of several published on the Internet by Cynthia Lanius. There are no other links with this lesson, so it is very much like a hardcopy page in a textbook. Although couched within the context of a bath being filled with water the mathematics is clearly more 'visible'.

There are only two questions on the web page; the first question combines the very every-day task of 'story telling' with mathematical concepts and so represents a new and different type of activity. The second question requires the learners to construct new mathematical knowledge about the slope of the graph.

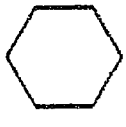
4.2.2.4 'FRACTIONS'

(This is the second of Cynthia Lanius' lessons)

This lesson is one of Cynthia Lanius' and has to do with the recognition of 'wholes' and 'fractions' when working with different geometric shapes made up of triangles - diamond, parallelogram, hexagon, etc – to assist algebra. At the beginning of the lesson the mathematics is fairly simple but as the lesson progresses the mathematical thinking required becomes more complex. There are numerous different links integrated into this site - sites to check answers, sites that give hints, sites that give further explanation of symmetry and an e-mail address so that students can send their own pattern designs to Cynthia Lanius. As in the 'Hot Tub' the mathematics in this lesson is very 'visible' - the visual content is very clear, as is the work with fractions.

To illustrate these aspects of the lesson I have included some questions from the lesson below:

How many  are there in  ?

If  +  = 1, what is  ?

If  +  = 2/3, what is 1?

These show the highly visual nature of the questions in the task and the sort of thinking that is required by the learners.

This lesson demonstrates many of the more interesting features of the Internet that may be considered to be of importance when considering its use for educational purposes. In particular the interaction between the student and the working environment, the high levels of connectivity within the Internet, the high visual content of the lessons and the many links to other sites. There are also links to sites that provide answers, thus enabling the learners to receive immediate feedback to their work that is not teacher dependent. This sort of facility on the Internet has possible consequences for distance education.

As can be seen from these descriptions of the different lessons, the embeddedness of the mathematics decreases significantly, from the 'whales' lesson (where the mathematics is highly embedded within the 'real world' context of the Internet site), to the 'hot tub' and the 'fractions' (where the mathematics is decontextualised and the Internet site is the lesson). In the 'pizza' lesson the mathematics is less embedded in a 'real world' situation, however the context of a party appeals strongly to students and the entertainment value of the site could make the mathematics seem to be 'invisible'.

As a consequence of this embeddedness the 'transparency' of the mathematics in the lessons was an issue that that I was particularly interested in. This will be dealt with in more depth after the analysis of the girls' actions with, and reflections of their use of, the 'tool'.

4.3 METHODS OF DATA COLLECTION

As mentioned above there are five sources of data that I have employed for analysing the girls' actions with, and reflections on their use of, the 'tool'.

4.3.1 OBSERVATIONS AND FIELD NOTES

After the initial period of informal observation in the introductory session, I used a structured observation schedule for the eight sessions that the girls worked on the lessons (see Appendix for copy of schedule). I observed the whole group, looking at each pair's activities at ten-minute intervals during the forty minutes that they were in the computer laboratory. In addition I took field notes focussing on the actions of three specific pairs of girls for the third term – MA & C, B & TL and Z & S. In the fourth term the participation and attendance of girls in the lessons was slightly more erratic and as a consequence my observations were more generally spread over the whole group. I looked particularly at their actions with the 'tool'; i.e. their involvement in the lessons, their engagement in the mathematics and their use of the technology. The dates of sessions and particular lessons are as follows:

Term three:

Observation & field notes 1

'Whales' 13 Aug. (Obs. 1 & FN 1)

Observation & field notes 2

'Whales'	20 August	(Obs. 2 & FN 2)
Observation & field notes 3		
'Whales'	3 September	(Obs. 3 & FN 3)
Observation & field notes 4		
'Pizza'	10 September	(Obs. 4 & FN 4)
Observation & field notes 5		
'Pizza'	17 September	(Obs. 5 & FN 5)

Term four:

Observation & field notes 6		
'Hot Tub'	22 October	(Obs. 6 & FN 6)
Observation & field notes 7		
'Fractions'	29 October	(Obs. 7 & FN 7)
Observation & field notes 8		
'Fractions'	5 November	(Obs. 8 & FN 8)

4.3.2 INTERVIEWS

At the end of the third term I interviewed two pairs of girls that I had observed more closely during the sessions. The interviews were semi-structured and I asked questions relating to their reflections on their use of the 'tool'. Towards the end of the three sessions in term four I conducted three further interviews. One of these interviews was with the third pair that I had observed more closely in term three. Generally the girls' attendance in the fourth term was erratic and not all of

them returned for the last three sessions. Unfortunately neither of the pairs, that I had interviewed before, was available for another interview. So for the other two interviews I tried to select girls who had participated throughout the sessions but whom I had not observed that closely in term three. The dates of interviews are as follows:

Interview 1	21 September	C and MA	(Int. 1 – C & MA)
Interview 2	21 September	B and TL	(Int. 2 – B & TL)
Interview 3	28 October	K and T	(Int. 3 – K & T)
Interview 4	2 November	Z and S	(Int. 4 – Z & S)
Interview 5	10 November	A	(Int. 5 - A)

4.3.3 QUESTIONNAIRES

At the conclusion of the 'whales' and the 'pizza' lessons I asked the girls to complete questionnaires. In addition the girls completed a third questionnaire at the end of all the sessions. Copies of the questionnaires are included in the appendix. These questionnaires were concerned with the girls' engagement in the lessons and their reflections on their use of the 'tool'. In the questionnaires I wanted to find out more generally how the girls responded to using the 'tool' - whether it had helped them with their mathematics and what they thought of the use of the 'tool' in relation to their regular mathematics lessons. The initial questionnaires informed my interviews with C and MA, and B and TL and I used

their responses as a starting point for the interviews. The questionnaires are as follows:

Questionnaire 1	after the 'Whales' lesson	3 Sept. - (Quest 1)
Questionnaire 2	after the 'Pizza' lesson	17 Sept. - (Quest 2)
Questionnaire 3	at the end of all sessions	5 Nov. - (Quest 3)

4.3.4 WRITTEN RESPONSES

At the end of the second session on 'whales' I asked the girls to write down one paragraph on what they thought about the 'tool' up to that point and to hand it to me at the next session. I stressed that it did not have to be long, but I wanted a spontaneous reaction from them on their thoughts about the 'tool'. Unfortunately only three girls handed this written response to me at the next session, but I have included them in my data as they highlight the initial enjoyment the girls experienced in using the 'tool'. These responses are as follows:

Written response 1	K	(WR 1 K)
Written response 2	D	(WR 2 D)
Written response 3	L	(WR 3 L)

4.3.5 WRITTEN WORK FOR TASKS

Each lesson - both the ones that I designed and the ones from Cynthia Lanius' set - required the girls to answer different questions relating to the Internet sites and

to mathematics. These answers were written down on paper and handed in at the end of the lessons and included more general descriptions as well as calculations and estimations. It is this written work that forms the last source of data for this study. Although a lot of it is incomplete and some is fairly sketchy it does highlights some aspects of how the girls responded to the 'tool' and their use of it and so it informs parts of the analysis.

CHAPTER FIVE

DESCRIPTION OF LEARNERS' ACTIONS AND REFLECTIONS

As already stated, in the description and analysis of the data in this study I will look particularly at how the girls at PGH School acted with the 'tool' and their reflections on their use of the 'tool'. In this chapter I use the structured observations and the field notes to describe some typical and some atypical actions of the girls with the 'tool'. I analyse the transcripts of the interviews and the questionnaires in order to answer the question of how the girls reflected on their use of the 'tool'. The written data also informs the study with regard to the learners' interaction with the Internet environment. In the next chapter I analyse the learners actions and reflections from the perspective of 'communities of practice' and 'tool' mediation through the ZPD.

5.1 THE LESSONS

The different levels of embeddedness of the mathematics in the four lessons that the learners worked on when using the Internet resulted in different types of learner participation, interaction and engagement in the lessons. In the 'whales' lesson the mathematics was highly embedded in the real world web sites of the 'Cape Whale Route' and 'Sea World' and others, and there were numerous different links to be made to access information. The 'pizza' lesson, while

involving many mathematical tasks like calculating the areas of circles, included a highly novel, interactive web site and the planning of a party. In comparison the 'hot tub' lesson incorporated a fairly static web page, but the notion of 'telling a mathematical story' created an unusual context for school mathematics. In the 'fraction' lesson the mathematics was far more mathematically explicit, though presented in a highly visual way.

5.1.1 CATEGORIES OF DESCRIPTION

In order to interpret the learners' actions with the 'tool' and their subsequent reflections on their tool use, I have focussed on the following:

* the level of the learners' *participation* in the sessions - were they interested or bored; were they working with the 'tool' or with their partner or on their own?
* the nature of the learners' *interaction* with the 'tool' - were they reading web pages, scrolling through pages or waiting for connections?
* the level of the learners' *engagement* with the Internet environment - were they working interactively with the Internet, discussing what they had read or had they lost interest?
* the level of the learners' *engagement* with the tasks in each lesson - were they discussing the tasks with their partners or seeking help about the task?

* the learners' *participation* and *engagement* in mathematical activities - were they calculating, discussing mathematics or seeking help about the mathematics?

While accessing the Internet and reading and scrolling through web pages were common features of all the lessons, the level of interaction between the Internet and the learners and the resulting learners' actions were different in the different lessons. Similarly the learners' reflections on their use of the 'tool' were different depending on the lessons they were engaged in. In the light of these differences I will consider the lessons separately as I look at the learners' actions and reflections.

The main categories for the descriptions of the learners' actions in the lessons relate to:

* Task demands
* Time, and
* Mathematics.

The main categories for the descriptions of the learners' reflections in each lesson are based on their notions of:

* Enjoyment, and
* Mathematics

Within these main categories there are sub-categories in the different lessons which are different depending on the predominant actions within the lessons and the related issues arising out of their actions. Similarly the main categories may be slightly different depending on the lesson. The descriptions of actions and reflections in the different lessons are as follows:

'WHALES' LESSON:

◊ ACTIONS

* Task Demands

  Reading and looking for information

  Discussing the task

* Time

  Reading slowly

  Sitting and waiting for connections

* Mathematics

  Calculations and writing answers

  Asking questions

  Making connections

◊ REFLECTIONS

* Enjoyment

* Mathematics

'PIZZA' LESSON:

- ◊ ACTIONS
  - * Participation
    - Motivated engagement
  - * Time
    - Sitting and waiting
  - * Mathematics / Task demands
    - Discussing the mathematics
    - Calculating and writing answers
    - Accessing mathematical 'help' sites
    - Asking questions
- ◊ REFLECTIONS
  - * Enjoyment
  - * Mathematics

'HOT TUB' LESSON:

- ◊ ACTIONS
  - * Task demands
    - Negotiating the task
  - * Mathematics
    - Working with slope
    - Seeking assistance
- ◊ REFLECTIONS
  - * Mathematics

'FRACTION' LESSON:

- ◊ ACTIONS
  - * Mathematics / Task demands
    - Talking about the mathematics
    - Working with the visual
  - * Time
- ◊ REFLECTIONS
  - * Mathematics

In all the lessons the learners worked from handouts on which were printed the addresses for accessing the different sites on the Internet, as well as tasks involving questions that they had to answer.

5.2 THE INTRODUCTORY SESSION

The introductory session was aimed at familiarising the girls with the intentions of the research and with the use of the computers and accessing the Internet. The purpose of the research was explained and their permission to use them and their work for the study was obtained. I explained that I would observe them and take field notes as they worked and that I might wish to interview some of them after they had worked through the different lessons. In addition I would ask them to complete questionnaires and they would be expected to hand-in written work after they had answered the questions in the tasks.

At this initial session I wanted to ensure that all the girls could access the Internet, scroll through the pages, move confidently through the links to other pages, and generally felt comfortable about using the Internet. As an introduction to the Internet the girls accessed the Cynthia Lanius lesson page and looked at the first lesson on Fractions [1]. At this stage I was not interested in how they handled the mathematics but in how they managed the technology. For many of the girls it was the first time they had used the Internet so it was quite an exciting experience. They did not find it difficult to make the links on the pages and quickly learned how to scroll through the pages and find the relevant answers to questions.

5.2.1 TIME

Issues of 'time' were a significant technical aspect of this study that have repercussions for any future work with the Internet in classrooms. There were *delays* in making connections to the service provider and in making subsequent connections to link pages on the Web. This gave rise to *frustration* on the part of the learners and much *time wasted* as they sat and waited for links.

In order to minimise the delay in accessing the Internet the first site was cached onto the network. Caching the sites allowed a more rapid initial downloading from the Internet onto the individual machines. This worked well in this first introductory session, however, at the time I was a little concerned how this might work for later sessions. It is almost impossible to cache all the different sites that

[1] http://math.rice.edu/~lanius/Patterns/

may be visited through different links on a web page and one of the more interesting aspects of the Internet is the spontaneous interactive nature of it's environment.

Delays in accessing different sites on the Internet were an aspect of the school sessions that I had not fully taken into consideration. The time taken to make the initial connection to the Internet and the subsequent links to different sites became an issue of some importance in the lessons. In working at home, on one stand-alone Pentium machine with a large memory I had been able to log into different sites reasonably quickly. Whereas ten machines networked together through one ordinary telephone line to the service provider was a different matter. Such technological considerations are definitely something that need to be taken into consideration when thinking about a whole class accessing the Internet for lessons. As I discovered in the sessions the frustration that results when connections cannot be made with minimal fuss, and the time wasted waiting for links, does definitely impact on the success or otherwise of a lesson.

5.3. THE 'WHALES' LESSON

(See Appendix for a copy of this lesson)

In this lesson the mathematics is embedded in the real world context of the whales and dolphins. The girls were required to read through information on different web pages to find answers, make links to other sites to find answers, discuss

possible ways to work out strategies of finding information and to calculate answers to mathematical questions in the task and to write their answers on paper.

Generally, looking at the observation schedules for these three sessions on the 'whales' lesson, (Obs. 1, 2, & 3) it is evident that most of the girls spent most of their time in the sessions reading the web pages, searching for information and discussing the task. There was little direct mathematical activity taking place during the sessions. Another significant aspect is the amount of time the girls spent sitting and waiting for, either an initial connection to the service provider, or connections to different sites in the Internet.

5.3.1 ACTIONS

5.3.1.1 TASK DEMANDS

* Reading and looking for information

The most notable feature of the girls' actions during the 3 sessions on this lesson was the time spent reading the web pages, looking for information and for the relevant data to answer questions in the task. (Obs. 1, 2 & 3). There was a little discussion about the questions in the task but mostly it was about finding the information. There was a lot of information in the different sites and the girls had to read through it all to find answers to the questions.

In my field notes of the first session (FN 1) I noted that MA & C were not at the introductory session, so their first session was the 'whales' lesson. I quickly

showed them how to log onto the Internet and how to move through the web pages and then left them to work on their own. They very quickly were able to access the initial site in the lesson and they started to read through the task handout and then the site for information relating to the task. They were very involved in the lesson and spent most of the time scrolling through the site looking for information and discussing the questions in the task and then writing down their answers. Towards the end of the session they experienced some difficulty in accessing a new site and they asked for help. They had made a typing error in the address for the new site. All the girls quickly learnt that they needed to be precise and careful in their typing to minimise errors.

* Discussing the task

In the first session B & TL were involved in the task, but they seemed to be working very slowly (FN 1). They appeared to spend a long time reading the web pages and scrolling through looking for information. They were troubled about how much information to include in the question that asked for a 'small sketch map'. The 'real world' context of the site appeared to confuse them and they seemed unsure of what to do and how to do it.

In the second session B & TL appeared to experience further problems finding the relevant information to answer the questions in the task. (FN 2). They took a long time to type in the different addresses for the sites, making frequent errors in their typing and then starting over again. They appeared not to know about the 'back' and 'forward' buttons that help one to navigate the Web. They also appeared to

spend a long time talking about how to find the information on the whales and dolphins, but not quite knowing what to do with it once they had found it.

Throughout the three sessions Z and S were quietly involved in reading the web pages, looking for information relating to the questions in the task, discussing the task and the information, and writing their answers. (FN 1, 2, 3). They encountered a few minor problems with using the Internet. They commented that sometimes making successive visits to a site took a long time. I suggested they used the 'back' button and then try again. (FN 2). I noticed in the second session that Z seemed to have got 'lost' in the Web while reading in the 'Sea World' site and ended up on another web page not immediately related to the task or the questions. S was just sitting watch' .g! (FN 2). This is one of the dangers of the ease of navigation within the Internet – it is possible to become so engrossed in following different links that the learner can quickly find herself at a site far from where the task intended!

5.3.1.2 TIME

Throughout the sessions on the 'whales' lesson the issue of time became more and more apparent. Not only were there unexpected technical problems with the Internet connections but the girls appeared to work through the tasks very slowly.

* Reading slowly

Many of the girls seemed to work very slowly through this lesson. Not only were the Internet connections slow, but the girls also seemed to read the information on

the Web pages slowly. (FN 1). This was particularly true of B and TL, as mentioned above, who read slowly and their negotiation of the task was slow.

My initial response after the first session on this lesson was twofold - I wrote the following in my field notes (FN 1):

- Some girls appear to be very slow in actually doing the work required in the task. They are not involved in off-task chatter, but the actual process of reading the information and answering the questions seems to be taking much longer than I had anticipated.

- As a consequence of this they have not progressed very far with the questions and some of them have not got to those questions that required more mathematical thinking. Are they were even aware that this is about mathematics? Are they 'finding' the mathematics, or are they side-tracked by all the information about the whales and dolphins?

* Sitting and waiting for connections

At the start of the second session on this lesson there was a general problem with accessing the Internet (Obs. 2). A 'FATAL ERROR' message kept appearing on the screens as link to the service provider could not be established. Initially this was quite alarming for the girls, however when they realised that it was a technical error and not something they had done they were a little reassured. The first five to seven minutes of the session were spent with girls just sitting and waiting for the connections to be made.

In this session, although B and TL appearing to be working, they spent a great deal of the time just sitting and waiting for connections to the Internet and then to other sites for more information. When other girls sometimes busied themselves

with rereading the task or discussing and writing answers, B and TL would just sit and do nothing, or engage in off-task chatter.

At the beginning of the third session the connections to the service provider were also very slow – in my field notes (FN 3) I noted that after ten minutes some girls had still not been able to access the Internet. The site for the conversion of units appeared to be 'hanging' which meant that the girls could not use it. These delays in accessing the Internet sites were frustrating for the girls as much time was spent waiting for links. The time taken waiting for either initial connections or links to other Web pages meant that many girls did not finish the task in this lesson. They handed in incomplete answers at the end of the three sessions.

5.3.1.3 THE MATHEMATICS

* Calculations and writing answers

Only two pairs of girls handed in a completed set of answers for the task for the 'whales' lesson. MA & C's work was clearly written and all the questions were answered concisely. However they showed no calculations and only gave the numbers as answers to some questions. They drew a good graph to show the different sizes of whales and their explanation (described below) for working out the volume of the whale was interesting. Most of the girls did not get beyond the question requiring the conversion of units.

* Asking questions

MA & C asked me about the last question on the task and whether they had to find the exact volume of the whale or could they find an approximate volume? (FN 3). I asked them if they had enough information to find the exact volume and they said no and they then decided it would be quite difficult to find an exact volume. I asked them if they had done anything about volume in regular Mathematics or Science lessons. They decided that they knew what to do and discussed their ideas together.

* Making connections

Later in the interview we talked about how they had found the volume. MA was able to make a connection between what was required in this lesson, and what she had learnt in her Science lessons:

129 **MA** Well – to work out volume, you know you have to have length, breadth and height – so - (indistinct) – so when I saw volume I pictured a cube – that's where we went wrong in trying to work out the volume of a whale. Because we don't have length, breadth and height (laughs) of a whale. So then I thought back to our - a previous science lessons that we'd done. I knew that if you filled a container with water – and took the measurements – and then you dropped a stone in – and then you took the measurements again – the difference between these two would give you the volume of a stone. Because, you know – (indistinct) - . If you tried to do something like that with a whale it would possibly work. (laughs)

(Int. 1 MA & C)

MA appeared to work with the Internet like a 'bricoleur' as defined by Turkle and Papert (1993) - mentioned in Chapter Two. She seemed to work as one who can

work within the contextualised framework of the setting and gain access to the collaborative nature of the Internet, preferring to work through negotiation and rearrangement rather than through control and planning.

5.3.2 REFLECTIONS

Almost all of the girls at this initial stage of the study said that they enjoyed working with the Internet and found the mathematics lessons fun, enjoyable and exciting (Quest 1). However, it is interesting to note from their interviews and questionnaires after the first two lessons how they responded in different ways to the different lessons. The initial excitement of using the Internet in the 'whales' lesson was replaced by the enjoyment of the novel Internet site in the 'pizza' lesson. It is therefore difficult to distinguish between the enjoyment of the task and its mathematical potential and the initial enjoyment of using the Internet.

5.3.2.1 ENJOYMENT

Overall, the initial response from the girls working on this lesson was one of enthusiasm and interest. However, even at this early stage of the sessions the frustration with some aspects of the technology and slow connections to sites in the Internet, was evident. In a short written response after the first two sessions one girl wrote:

> "The maths is fun but sometimes irritating because sometimes I can't find the info' I need. But it's also fun to look at different whales and dolphins. I find this fun because I don't have the Internet and I like going to the different sites. This is also tiring typing in those long addresses and then waiting a long time to get a reply" (WR 3 L)

I asked the girls to complete a questionnaire at the end of the third session relating to their work in the 'whales' lesson (Quest 1). The majority of them said they thought using the Internet made the mathematics interesting and fun. They also said the mathematics seemed more exciting. Most of them said that they thought doing the 'whales' lesson showed them a use for mathematics. Most of them also said they did not think the Internet had helped their learning of mathematics, and many of them said they had not learned any mathematics in the lesson! One girl, in answer to the question 'What do you feel you learned about maths during this lesson?" wrote:

> "Nothing – it was all general knowledge or things we had learnt before"
> (Quest. 1 – An.)

Others mentioned "solving maths problems" or "converting units" as things they had learnt. This might have been because so few of them got beyond the first few questions that had minimal mathematical content; or because the 'real world' context of the 'whales' lesson made the mathematics 'invisible'.

5.3.2.2 MATHEMATICS

I wrote in my field notes at the end of the first session (FN 1) that I was concerned about whether the girls were 'finding' the mathematics in the task. This continued to concern me throughout the time of working with the 'whales' lesson. This 'invisibility' of the mathematics might have been because of the structure and type of the questions within the lesson, or as a consequence of the embeddedness of the mathematics. The first few questions in the task required the learners to

find out statistics about the whales and dolphins and facts about the whale population off the Cape Coast at different times of year.

27 **Me** At the beginning there were questions that were more about the whales …
A Yes. I wasn't quite sure of - is that to do with maths.
30 Because it was more like the information.
Me OK.
A I found that a bit confusing.
(Int. 5 – A)

The 'information seeking' activity that the girls had to do in order to find answers appeared to divert their attention away from the mathematics.

13 **A** Um - we started with whales I think. And I found it a bit of a problem, looking through all the pages and stuff. It was quite interesting … um …
Me OK. I know there was quite a lot to read in the whales-
A Yes
Me - wasn't there? Did you find that difficult - or was it easy to read or - ?
20 **A** Um. I found it quite hard to - like - find the answers to the questions, because it was - all a bit - muddled up, I think. You forget where certain stuff was – and things like that.
(Int. 5 - A)

Although the girls also experienced problems with the technology which diverted attention away from the mathematics, it seemed as though the context of the whales and dolphins was too 'visible' and the mathematics too 'invisible' for them to be really engaging in mathematical thinking. I will discuss this transparency of the mathematics in more detail in the next chapter.

In order to find the relevant answers to some of the initial questions in the task the girls had to read through a lot of information. Some of the girls talked about the 'whales' lesson being like a comprehension:

28 **S** Well - like - the whales one was more - sort of like a comprehension.

(Int. 4 - Z & S)

Added to this was the fact that the information about the whales and dolphins was to be found in sites that required a quite lot of reading. The reading was not difficult but the girls either skimmed through the pages trying to find appropriate numbers, missed relevant answers, or spent a long time reading all the information looking for answers. In interviews I asked the girls about the reading and about finding the information in the 'whales' Web pages. I asked K and T if they found the reading difficult.

29 **T** Not difficult – um – sometimes I just – I focus on the words (laughs) it's all mixed!
I didn't find it hard – it just put me off.

(Int.3 - K & T)

In the same way the amount of reading definitely detracted from the enjoyment of lesson for A.

205 **Me** OK. I noticed in your answers to the questionnaires – in the whales you started off and you weren't too sure if you enjoyed it?

A No. I'm not a reader. I don't like reading so much.

Me Oh!

210 **A** I do read. But I don't read for pleasure.

(Int.5 - A)

Considering the initial enjoyment of this lesson, other comments about it showed that some of the girls experienced difficulties in coming to grips with the learning - it was, as TL said, "boring" and "too educational"! (see below).

100 **B** Ya the whales – was like going nowhere. -

and

204 **TL** Whales were boring – like – pizzas are more to our age.

Me In what way?

TL Like – people – like – they don't exactly like hearing all the time – if you know what I mean …

B They like making – (indistinct)

TL Ya (laughter) – Like – the whales was like too educational
210 - too boring. It didn't have fun things – like bright coloured picture – and – it wasn't witty or anything – like "this pizza will self-destruct in 5 minutes".

(Int. 2 - B & TL)

The consequences of designing such mathematical activities in context embedded tasks will be considered in more detail in the next chapter where I analyse the learners' actions and reflections. Whether such activities are enabling or constraining have important implications for the learning of mathematics in more integrated curricula.

5.4 THE 'PIZZA' LESSON

(See Appendix for a copy of this lesson)

In this lesson the mathematical activity is embedded in a fantasy context of planning a 'pizza party'. The girls were required to access the 'Internet Pizza' site where they can 'order' pizzas with different toppings and of different sizes. They were required to decide on the 'best buy' of pizza for their party, as well as work with percentages to calculate the VAT and a tip for the delivery person. In addition they were required to calculate the areas of the pizzas they ordered to help work out the 'best buy'.

The 'Internet Pizza' site, around which this lesson is designed, has enormous entertainment value for learners. They can choose different toppings for pizzas – some fairly normal items like bacon bits and cheese, or some more outlandish ones such as 'eyeballs'! As a consequence there was an immediate 'buzz' as the girls read through the task, accessed the site, scrolled through the pages and started to discuss decisions. Again they were given a handout with addresses and with a task with questions. Generally they seemed to skim through the instructions and questions on the handout before accessing the Internet. The idea of a 'pizza party' appealed to the girls. When I asked them in interviews to distinguish between the 'whales' and the 'pizza' lessons TL described it as "more our age" (Int.2 - B & TL) while the food aspect appealed to A:

242 A Um - I think I enjoyed it because it was fun working with - like food - and - because I love food (giggles). I preferred it

a bit more than the others.

(Int.5 - A)

5.4.1 ACTIONS

5.4.1.1 PARTICIPATION

* Motivated engagement

Initially this lesson provided much entertainment for the girls - there was much giggling and laughter as the girls accessed the site, read the choice of toppings and ordered their pizzas. (Obs. 4 & FN 4). The 'Internet Pizza' site is very interactive with links to several other sites - there is a page to choose different toppings for pizzas, a page for the different prices of pizzas and the on-line construction of the pizzas that are 'ordered'.

In my field notes (FN 4) I noted that Z & S appeared to enjoy the amusing features of the site and were very involved, during the session, in discussing the task and reading the web pages as they made choices for different pizza toppings.

B & TL were also very involved in the discussions around the site and the task, although more of their discussion seemed to revolve around whom to invite to the party. Towards the end of the fourth session I noted that, whilst waiting for the very slow connections to be made, B was trying to log into another computer beside her - it appeared as though she had lost interest in the lesson! The technical problems were again causing a block to significant learning.

In the fifth session (FN 5) I noted that although B and TL appeared to enjoy the visual and amusing aspects of the Internet Pizza site, and the idea of a 'party', they appeared to have a very negative attitude towards actually doing any work. They seemed to be very easily distracted by the context of the party, the amusing aspects of the Web site and the technological problems. In my field notes on this session I wrote:

> 'B and TL spend a long time on the task and don't get through to the mathematics – they enjoy ordering the pizza and seeing its picture. TL says, "If only they didn't have so many choices". B says, "Check how many slices here!" (FN 5)

Although the mathematics is far more evident in this lesson, it seemed as though the context of the party and the choice of toppings were too 'visible' for B & TL. At the end of the session they were still choosing different toppings for their pizzas - a question from the very beginning of the task - while MA & C had completed the whole lesson.

5.4.1.2 TIME

* Sitting and waiting

The network system at PGH School definitely appeared to be getting more over-loaded in the sessions on the 'pizza' lesson and this resulted in all the machines working very slowly. I noted in my field notes (FN 4) that towards the end of one session, six of the nine pairs of girls were just sitting waiting for connections and links. MA & C, who worked more quickly than some of the other girls, appeared to be particularly frustrated at the delays in making connections (FN 4).

In the second session working on the 'pizza' lesson the computer monitor who usually dialled up the connection to the service provider was away, so for at least the first ten minutes, until a replacement could be found, there was no connection to the server at all. Seven of the pairs of girls had 'FATAL ERROR' messages on their machines (Obs. 5). As in the 'whales' lessons these delays were most frustrating. They caused the girls to lose interest in the sessions - as B did (mentioned above) - and the impetus of the lesson was lost.

This overloading was of some concern to the computer teacher at PGH School and during the October holidays the machines in the computer laboratory were overhauled – the hard drives and memory of the individual machines were upgraded. This was done in order to ease the overloading of the network, which had been one of the main causes of the technical problems that were encountered in the 'whales' and 'pizza' lessons. As a consequence there were far fewer problems for the later sessions in term four and the girls experienced fewer frustrations at being unable to make connections with the Internet.

5.4.1.3 MATHEMATICS / TASK DEMANDS

When considering the girls' actions with the 'tool' during the two lessons - the 'whales' and the 'pizza' lessons - the most significant difference is that during the 'whales' they were mostly reading web pages and seeking information, while in the 'pizza' lesson, although reading the web page was still necessary, there was much more activity around mathematics. There was discussion and writing related to mathematics and much questioning of each other's ideas. (Obs.4 & 5

and FN 4 & 5). As they worked out the 'best buy' for the pizzas, used percentages for tips and tax and calculated areas of circles they talked with their partners about mathematics more than they had in the 'whales' lessons. The task demands and the mathematics in this lesson are interwoven and cannot easily be separated.

* Discussing mathematics

As I observed the girls during the sessions they worked on the 'pizza' lesson (Obs. 4 &5 and FN 4 & 5) I was very aware that there was a great deal more discussion about the mathematics in the tasks than in the 'whales' lesson. The girls talked about the different sizes of pizzas and how to share them, the different prices of the pizzas and how to work out prices of single slices, and how to work with circles. I noted that Z & S were involved in mathematical discussion when they talked about whether to compare the different sizes of pizzas with two toppings or more than two. (FN 4).

* Calculating and writing answers

Other groups talked about the calculations needed for the tax and a tip. A question towards the end of the task required the girls to calculate the VAT at 14%, as well as a tip of 10% for the deliveryman. These calculations also elicited a lot of discussion. MA & C wrote their answers on paper to be handed in at the end of the session. They used a calculator to help them with the working out of percentages and the area of a circle.

* Accessing mathematical 'help' sites

Many of the girls visited the 'Pi'[2] site for information on areas of circles etc. MA & C were very involved during the sessions of this lesson and they spent much time discussing the mathematics in the different calculations. They talked about how to calculate the tip, using percentages, and, after accessing the 'Pi' site, they discussed at length how to work out the area of the circle. I heard them talking about whether to use 3,14 or 22/7 as a value for pi. I heard MA say "remember it's half the diameter" (FN 5).

* Asking questions

My field notes show examples of the discussions between the girls and the type of questions they asked, highlighting the 'visibility' of the mathematics:

> "Guys, I don't know how to get 14%. Oh yes I do."

This was followed by one of the girls asking me for help: -

> "Is it 14 divided by 100 times 7,60?"

On the other hand, this was not true for all groups. One group decided that large pizzas were the best and when I ask why they said:

> "Because we like big pizzas!"

[2] The 'Pi' site explains clearly how to calculate the circumference and the area of a circle.

I wondered if they had actually worked out which was the best buy or whether the 'everyday' context of the pizza party was making the mathematics 'invisible'?

5.4.2 REFLECTIONS

5.4.2.1 ENJOYMENT

The main features of the 'pizza' lesson that the girls mentioned in the interviews were that it was fun and that there was more mathematics in it than the 'whales' lesson. (Int. 4; 5). They thoroughly enjoyed the lesson - it was enjoyable, was relevant to their interests and the dynamic interaction with the on-line construction of the pizzas appealed to them. TL's comments about the 'Pizza' site being colourful and witty illustrate this.

> **TL** Ya (laughter) - Like - the whales was like too educational – too boring. It didn't have fun things - like bright coloured picture - and - it wasn't witty or anything - like "this pizza will self-destruct in 5 minutes".
> (Int. 2 - B & TL)

This highlights the appropriacy of the contexts in which mathematical activities can be embedded. The choice of context raises questions of relevance - relevance for whom?

5.4.2.2 MATHEMATICS

There was a lot of discussion about the mathematics in the 'pizza' lesson and in the interviews the girls talked about the 'pizza' lesson being more about

mathematics than the 'whales'. When I asked one pair of girls which lesson had more mathematics in it, their response was:

81	**S**	'Pizzas' – I think?
	Z	Ya
	Me	Why do you think that?
	S	I don't know. It just had more - like - working out.
85	**Me**	OK, what sort of things did you work out?
	S	Like fractions …
	Z	Division and multiplication …

(Int. 4 - Z & S)

and:

47	**Me**	And now that you're doing the pizza one?
	B	Yes there's maths in there …

(Int. 2 - B & TL)

All the girls also completed a questionnaire after the 'pizza' lesson. Many thought they had learnt more mathematics in the 'pizza' than in the 'whales' lesson. The main thing they said they had learnt about was circles. In answer to the question 'what do you feel you learned about maths during this lesson?' responses included:

> "Lots – area of circles"
>
> (Quest 2 - An)

> "How to do circumference and diameter, because I forgot and didn't know how to do it anymore"
>
> (Quest. 2 - C)

and

"Nothing really because we never finished"
(Quest. 2 - L)

Although they nearly all said they had learnt some mathematics, one or two said they had only learned about 'dividing'! This seems rather trivial for Grade 8 level.

Most of the girls also said they thought the Internet had helped them with the mathematics. The 'Pi' site is very clear and concise in the way it explains the properties of circles and the mathematics in it very 'visible'. The use of it illustrates the mediating nature of a 'tool' as it assisted many of the girls negotiate the ZPDs created by the 'pizza' lesson.

5.5 THE 'HOT TUB' LESSON

(See Appendix for copy of the Web page.)

The first session in the fourth term required the girls to access the Cynthia Lanius lesson site and go to the lesson on the 'Hot Tub'[3]. This is a single web page lesson with no links to other sites – similar to a page out of a hard copy book – and the graph takes up most of the page so there is very little reading required. There are only two questions in the task but they are quite unusual:

1. To tell the 'mathematical story' of the graph – what happens in the segments of the graph, and
2. To articulate an understanding of the slope of the graph – looking at the mathematics of the slope.

[3] http://math.rice.edu/~lanius/Lessons/

The first question combines the very every-day task of 'story telling' with mathematical concepts and so represents a new and different type of activity . The second question requires the learners to construct new mathematical knowledge about the slope of the graph.

5.5.1 ACTIONS

5.5.1.1 TASK DEMANDS

* Negotiating the task

The most noticeable feature of this lesson was the girls' unfamiliarity with 'telling a story' about a graph. They were unsure of what they were supposed to do with the graph, although they could see the mathematics in it. The every-day knowledge of the learners - the story telling - was brought into the task in a very different way compared to the other lessons in this study and this seemed to confuse them.

	T	It was difficult.
	Me	Was it? Why did you find it difficult??
115	**T**	First we couldn't find out what was going on. (laughter)

(Int. 3 - K & T)

and

97	**S**	It was complicated.
	Me	In what way was it complicated?
	S	I just didn't really understand

(Int. 4 - Z & S)

It seemed as though the girls either found the instructions not very clear, or they were unfamiliar with the less structured way of thinking and/or talking mathematically. (FN 6). They therefore had to negotiate the task demands before they could answer the questions.

5.5.1.2 MATHEMATICS

With the very visible mathematical content in this lesson there was immediately a great deal of discussion about the graph and the varying slopes as the water filled the tub. (Obs & FN 6).

* Working with the slope

There was generally a lot of talk about mathematics of the slope of the graph. (FN6). The girls talked about the slope changing and whether it sloped 'up' or 'down'. They also talked about the mathematical implications of the different slopes.

The girls easily grasped that water flowing in or out of the tub changes the direction of slope and that the rate of flow determined the angle of the slope. However most of their discussions and their written answers were of a descriptive nature rather than a justification of why the graph is like it is shown. AM & P wrote:

> "Between A and B the water level rises slowly.
> Between B and C the water level rises quickly."

Similarly SC wrote:

"BC: Water was added.
CD: Water stayed the same.
DE: Water level goes down."

One pair of girls was being videoed for this session and they entered into much more discussion amongst themselves and with me. It was almost as though they were conscious of being 'on show' and so wanted to make a good impression with their discussion on the video and in their written work. Alternatively because I knew they were on video perhaps I interacted more with them than with the other girls. They wrote:

"DE: Tub a bit full so we let out some water – open the drain slowly.
EF: Relaxing in the bath – constant water level
FG: The water has gone cold so we add hot water. Pour it in with a bucket so that it is faster than opening the tap"

This written work illustrates their greater involvement in the lesson as they attempted to explain the different slopes on the graph.

The second question of this lesson was much more mathematical and asked about the positive and negative aspects of the slope of the graph and the girls seemed to be able to cope with this question far more easily than the first:

124 **K** ... because at first we didn't know what the first question meant, and so we went to the next one and then came back to that one

(Int. 3 - K & T)

* Seeking assistance

The girls asked me a lot of questions about the graph and seemed more prepared to ask me questions in this lesson than in the previous lessons.

Some of the girls were a little unsure of what they were supposed to be writing down for their answers and they asked me questions about this. I noted in my field notes (FN 6):

> They all appear to need a little help with what they are supposed to be doing.

5.5.2 REFLECTIONS

Many of the girls found the 'hot tub' lesson quite challenging: perhaps the instructions were not as clear as in previous lessons or perhaps the context of the 'story telling' was something quite new to them or perhaps the mathematics was a little more demanding.

5.5.2.1 MATHEMATICS

Despite the very 'visible' mathematics in this lesson - the graph - the more everyday task of writing a 'story' about the graph made the mathematics too 'invisible' for many of the girls. As mentioned in the discussion on the girls' actions, many more girls asked questions about this lesson than they had in previous lessons.

97	**S**	It was complicated.
	Me	In what way was it complicated?
	S	I just didn't really understand
100	**Z**	... no ...
	S	... how to find like a negative and ... a positive and -...
	Me	Oh! (indistinct) I remember you asked me about it didn't you?
	Z	Ya! We did
105	**S**	Ya! Then we like - understood it.

(Int. 4 - Z & S)

5.6 THE 'FRACTION' LESSON

(See Appendix for a sample of a web page from this site.)

The 'fraction' lesson extended over two sessions - the last two of the series - and there was a very mixed group of girls in the sessions. A couple of girls appeared for the very first time during these sessions.! Some of the girls came for just one of the two sessions and others for both, while a few had different partners for each session. As a consequence it was difficult to observe any specific pairs as they worked through both sessions.

Of all the lessons that the girls had to do, this lesson is the most explicitly mathematical. On Cynthia Lanius' web page it is called 'Pattern Blocks/Fractions'[4] so it is immediately clear what the purpose of the lesson is. The learners are required to look at different geometrical shapes - triangles, parallelograms, hexagons, etc. - and answer questions related to fractions and

[4] http://mathe.rice.edu/~lanius/Patterns/

whole parts of the shapes. The site is very colourful and the learners are required to work visually as well as with number. There are links to 'help' sites on fractions and symmetry and a link to answers.

5.6.1 ACTIONS

The girls really seemed to enjoy this lesson and there was a lot of discussion relating to the mathematics (FN 7 &8 and Obs.7 & 8). There was much talking amongst between partners and they asked me more questions than in the other sessions. Even those girls who had worked very quietly together on earlier lessons, such as K & T, were engrossed in mathematical discussion. Perhaps the work was extending them a little more - extending their ZPDs and thus requiring more negotiation or assistance? Perhaps they felt more comfortable with the very explicit mathematical content of the lesson? Perhaps they were more involved participants in the 'local community of practice' of learning mathematics on the Internet.

5.6.1.1 MATHEMATICS / TASK DEMANDS

* Talking about the mathematics

Generally in looking at the observation schedules for these two sessions (Obs. 7 & 8) it is clear that much more time was spent involved in mathematical activity - discussing and/or writing mathematics or asking the teacher for help with mathematics. There was some reading of the web page and the task for instructions or questions but no searching for information as in the 'whales'

lesson. The very 'visible' mathematical content of the lessons meant that the girls were 'doing' mathematics most of the time and they were not side-tracked by real-world or everyday contexts.

Initially it seemed as though the questions in the lesson were very easy, but as they worked through them the girls realised that more thought was required in order to come to meaningful conclusions about the questions. The work in the 'fractions' lesson is linked to shapes drawn on diamond paper and the girls had to make simple deductions about fraction parts and whole parts of different shapes. There are further links to pages with other patterns designs and lines of symmetry. The girls enjoyed the visual mathematics in this lesson and there was a lot of discussion relating to it. They talked amongst themselves more and ask me more questions relating to the mathematics. Listening to them talk during the sessions I realised that they could not always verbalise or explain the reasoning behind their thinking and their answers.(FN 7 & 8) When I asked them to explain to me why they had got a particular answer I did not always understand their thinking, though their partners seemed to. Perhaps they were not used to verbalising their mathematical explanations?

As this site includes links to answers, the girls were able to check their thinking and reasoning as they worked. This facility gave them immediate feedback and illustrates an important feature of the interactive nature of the Internet. However, not all the girls used this link. I noticed in the last session (FN 8), two girls (D & P), who had attended all the sessions but not worked together on other lessons.

They seemed to be less interested in the work than usual. They appeared to want to rush through and finish rather than be involved in any mathematical thinking. When they said they had finished I asked them if they had checked all their answers or gone to the site on symmetry. They had not! The initial thrill of working with the Internet seemed to have palled for them. Or perhaps it was working with another partner that was so different?

* Working with the visual.

The lesson also includes a lot more visual work than the other lessons. I noticed that B, who had shown so little interest in earlier lessons, particularly the 'whales' lesson, was very involved in her own design of a pattern and seemed more interested in the mathematics because of this (FN 8). Perhaps this resulted from working with the more visual aspects of the lesson, or working with someone other than TL, or perhaps she enjoyed the more creative features of this site more? Unfortunately I was not able to interview her again to find out her thoughts.

5.6.1.2 TIME

After the upgrading of the computers in the holidays there were far fewer problems with the technology in these sessions in term four than in the first two lessons in term three. As a consequence the girls did not experience the frustrations and interruptions that they had in the 'whales' and 'pizza' lessons. They did not sit and wait as they had in the first two lessons. There were almost no delays in accessing the Internet or in making connections within sites. This appeared to have a positive effect on most of the girls' participation in the lesson.

5.6.2 REFLECTIONS

As mentioned in the description of the different lessons in Chapter Two, this lesson by Cynthia Lanius is very obviously about mathematics. Its context is coloured shapes and it requires learners to use visual skills as well as problem solving skills to answer questions.

5.6.2.1 MATHEMATICS

The girls were very aware of the mathematics in this lesson – it was very 'visible'. When I asked in interviews about the mathematics in the different lessons they responded:

135	**S**	Um - the 'fraction' one was more maths ...
	Z	More maths in it. (indistinct)
	Me	More maths?
	Z	More to work out - than the 'whales'.

(Int. 4 - Z & S)

B and TL when talking about the 'fraction' lesson said it was "more mathsy", (Int. 2 - B & TL) and A described the 'fraction' lesson as "every sum had some maths" and "everything was about maths" (Int. 5 - A).

In the final questionnaire (Quest 3) nearly all the girls said they though the 'fraction' lesson had the "most maths in it" and that they learned the most mathematics in this lesson. This compares with the 'whales' lesson that they

thought had the "least maths in it". Some of them found this lesson relatively easy and the 'help' site on symmetry "very simple and understandable" (Int. 5 - A)

186	**Me**	And the last one that you did was this one you did with An? About the fractions?
	A	Yes
	Me	Tell me about that one.
190	**A**	I enjoyed that, because it wasn't so difficult. We understood everything and we knew how to do it.

(Int. 5 - A)

When I asked Z and S about this lesson they admitted to having to talk more about the mathematics in it:

143	**Z**	No, we had to work them out a little bit more -
	S	Ya. We talked a bit more - (indistinct)

(Int. 4 - Z & S)

The greater participation of the girls in this lesson and heightened interaction between the girls and the 'tool' might have been because this was the fourth lesson and they knew what to expect in the 'Internet Maths' lessons. It might have been that they were more comfortable with working with the Internet and were more familiar with the situation than they had been at the beginning of the research. The structure of the lesson also might have allowed them to feel more secure in their positions within the 'community of practice' of learning mathematics using the Internet. These and other issues will be dealt with in more

detail in the next chapter when I consider the learners' actions and reflections against the theoretical framework laid out in Chapter Three.

CHAPTER SIX

ANALYSIS OF ACTIONS AND REFLECTIONS

Using the Internet for learning mathematics was novel for the girls at PGH School and they enjoyed being part of the project, but the question: 'Is this a worthwhile way of learning mathematics?', remains fundamental to this study.

The highly interactive nature of the Internet environment is very different to learning with a textbook and also different to the interactive learning environments of computer software, such as Logo and dynamic geometry packages, that allow interaction between the learner and the mathematics in the exploration of active, independent learning. With the Internet the learners are entering an environment that is unique in its character. There is a high level of involvement between the learner accessing the Internet and the navigation through different web pages and different hyper links that is not available in any other medium. It is a special interactive environment that enables the learners to be actively engaged in their learning in a very unique way.

As mentioned in Chapter One, the purpose of this study is to examine the possible contribution, if any, the Internet can make in enabling the learning of mathematics. In particular I focus on how the learners act with the 'tool' and how they reflect on their use of the 'tool'. In the previous chapter I described the learners actions, as they worked on the four specific lessons chosen for the project, and their reflections on their use of the Internet for learning mathematics

in the four lessons. In this chapter I will argue that, on the basis of the evidence gathered in this study, the Internet is a specific resource that can enable mathematical learning. This enabling is through two interacting, but separate, phenomena - a *'local community of practice'* (LCP), as defined by Winbourne and Watson (1998) - and *mediation* as described in Vygotskian theory. This mediation through a ZPD may be by means of the 'tool', the teacher or a more able peer. In addition I will discuss more technical aspects of working with the Internet for learning mathematics that were significant in this study.

6.1 LEARNING MATHEMATICS USING THE INTERNET: - A 'LOCAL COMMUNITY OF PRACTICE'?

As already discussed in Chapter Three there are different explanations for mathematical learning in school classrooms. The concept of a LCP, grounded in social learning theory, explains mathematical learning as taking place within a specific practice and a certain community of learners. When applied to a teaching/learning situation there are, however, tensions within such a concept with regard mediation and the role of the teacher.

In this section I analyse how the mathematically more successful lessons in this study - in terms of learners' actions and reflections - can be linked to the concept of LCPs. Winbourne and Watson (1998) discuss how some classroom mathematics lessons can be described as LCPs - based on certain features of the lessons and the active participation of those involved in the lessons - while other

lessons do not display such characteristics. In a similar way I will argue that some of the lessons using the Internet for learning mathematics in this study can be considered to be '*local communities of mathematical practice*' while others can not. The features, necessary for the existence of a LCP, have already been discussed in Chapter Three, but are repeated here for clarity:

- "pupils see themselves as functioning mathematically within the lesson;
- within the lesson there is public recognition of competence;
- learners see themselves as working together towards the achievement of a common understanding;
- there are shared ways of behaving, language, habits, values and tool-use;
- the shape of the lesson is dependent upon the active participation of the students;
- learners and teachers see themselves as engaged in the same activity."

(Winbourne and Watson, 1998:183)

The four different lessons in this study, with their different structures, questions and levels of embeddedness of the mathematics, each demonstrate some of the characteristic features of a LCP listed above. It is against these features that I will show that two of the lessons clearly demonstrate the existence of a 'local' community, one is more vague in definition and one lesson can not be considered to be a LCP. Looking at each feature separately it is possible to find confirming instances within the different lessons suggesting the existence of a LCP.

The Internet therefore offers possibilities for the creation of a LCP for learning mathematics. The practice, in this instance, is the learning of school mathematics and the community the learners in Grade 8 at PGH School.

6.1.1 PUPILS SEE THEMSELVES AS FUNCTIONING MATHEMATICALLY WITHIN THE LESSON

In order to be a successful practice the community must be aware of the learning they are engaged in. In this research the practice was the learning of school mathematics and I argue for the existence of a 'local community of mathematical practice' in some of the lessons.

In the Introductory Session I gave the girls a written handout describing the work they were going to be involved in as the 'Mathematics Internet Project'. Despite this explicit title the girls were not always aware they were involved in learning mathematics. This was particularly true in the 'whales' lesson where the very embedded nature of the mathematics appeared to make the mathematics 'invisible' and lead to confusion for some of the girls:

27	**Me**	At the beginning there were questions that were more about the whales ...
	A	Yes. I wasn't quite sure of ... is that to do with maths.
30		Because it was more like the information.
	Me	OK.
	A	I found that a bit confusing.

(Int. 5 - A)

I also noted my concern whether the girls were 'finding the maths' in my field notes (FN 1) after the first session of the 'whales' lesson. Further issues of transparency of the mathematics will de dealt with in more detail later in this chapter.

In the final questionnaire (Quest. 3) all the girls said that the 'pizza' and 'fraction' lessons had the most mathematics in them, while the 'whales' lesson had the least. In interviews they also said that the 'pizza and the 'fraction' lesson had the most mathematics. This is illustrated by the comments:

135	**S**	Um – the 'fraction' one was more maths -
	Z	More maths in it. (indistinct)
	Me	More maths?
	Z	More to work out – than the 'whales'.

(Int. 4 - Z & S)

and

47	**Me**	And now that you're doing the pizza one?
	B	Yes there's maths in there …

(Int. 2 - B & TL)

The very visible mathematics in the graph in the 'hot tub' lesson also meant the girls were aware of the mathematical purpose of the lesson. They talked a lot about the implications of a positive or negative slope of the graph. (Obs. 6). However even in this lesson the 'story- telling' that was required in the first question tended to obscure the mathematics and some girls found this a little confusing.

The mathematical visibility of the lessons was therefore an important consideration as it situated the learners clearly in terms of functioning mathematically. The more embedded context of the lessons, while having

importance in terms of relevance for learners raises difficulties when considering the possible existence of LCPs.

6.1.2 WITHIN THE LESSON THERE IS PUBLIC RECOGNITION OF COMPETENCE

This feature relates to the position of the learners in a newcomer/master relationship within a community of practice as proposed by Lave and Wenger (1991). Within an apprenticeship model, competence is clearly established in the position of the master. However, competence in the Internet lessons for learning mathematics is more subtle. It can be found in the teacher, the 'help' sites on the Internet or in the other learners and is therefore distributed through different aspects of the community. Greater participation in the lessons is also linked to accessing and acquiring competence.

The learners at PGH School entered the project as newcomers in using the Internet, and as newcomers in the learning of school mathematics. As they worked on the different lessons there was definitely a growing familiarity and participation within the sessions as the girls became more used to the setting and the work involved. This was particularly evident after the holiday break. Their greater willingness to ask questions in the 'hot tub' lessons was an example of this.

Within the limited scope of this research, further public recognition of competence was evident in the acknowledgement of the position of the teacher/researcher as more knowledgeable. Also with some pairs of girls there was an awareness of competence in the other partner.

> 330 **MA** There're some questions where C knows more where we're going and in some I know and in some we just ... I say something and then she says something - then we've said the same thing in different ways. In some we know - C knows exactly what to do, and in some I know
>
> (Int. 1 - MA & C)

Many expressed their appreciation of working with a partner and helping each other in interviews and I will discuss this later in the chapter.

Within the lessons there was also an awareness of assistance that the 'help' sites from the Internet can give. As the girls linked to the different 'help' web pages for assistance and discussed the mathematics of the different tasks in the lessons with their partners they were able to construct new concepts. The Pi site in the 'pizza' lesson and the 'symmetry' site in the 'fraction' lesson particularly illustrate this.

The distributed competence within the different lessons was therefore an important aspect in the enabling of mathematical learning. It was more evident as the girls' experience in using the Internet increased and as their familiarity with the expectations of the project increased. The greater visibility of the mathematics

in the 'help' sites in the different lessons also raised the level of awareness of competence.

6.1.3 LEARNERS SEE THEMSELVES AS WORKING TOWARDS THE ACHIEVEMENT OF A COMMON UNDERSTANDING

In the different lesson in this study there were different contexts in which the mathematics was embedded and specific boundaries that demarcated the contexts within which the girls worked. There were the contexts of school mathematics, everyday knowledge, the real world of the sites on the Internet, etc. To enable the learning of school mathematics it is important that the Internet lessons allowed the learners to work together towards a common understanding, without blurring their understanding of the concepts.

In the 'pizza' and 'fraction' lessons the working together towards a common understanding was very evident in the 'visible' mathematics involved in the different tasks. In the 'pizza' lesson the mathematics of the circle - particularly calculating the areas - was very explicit. Despite the context of the party, all the girls were aware that they were constructing mathematical concepts about circles. There were also questions to do with the calculation of percentages, which elicited much discussion. Similarly in the 'fraction' lesson the construction of concepts to do with numbers, fractions and shapes was very obvious.

The 'whales' lesson, with the mainly information-seeking actions by the learners, showed little of this aspect of a LCP. Although the girls were looking for the answers for specific questions in the task, the quantity of information they had to read through, the many different hyper links they had to make and their uncertainty of what to do with the information once they had found it, resulted in limited common understanding about mathematics.

The structure of the questions in the 'hot tub' lesson also appeared to mitigate against the formation of a common understanding to a certain extent. While the girls were aware of the positive and negative aspects of the slope of the graph, the story-telling context of the first question was misleading for some girls.

The common understanding therefore seemed to become an issue only when the boundaries between contexts blurred. Sometimes the negotiation of the task demands or the embeddedness of the mathematics contributed to the blurring of understanding. In the lessons, those activities that required crossing boundaries or blurring of boundaries meant that the common goals became less clear.

6.1.4 THERE ARE SHARED WAYS OF BEHAVING, LANGUAGE, HABITS, VALUES AND TOOL-USE

This feature of 'shared ways of behaving' with the Internet for learning mathematics was perhaps the most notable feature that was evident in the lessons in this research. Being able to participate in and draw on the characteristics of the

'community' gave it identity and meaning and contributed to enabling the mathematical learning.

Though some aspects of their actions were more pronounced in some lessons, the main actions of the girls as they used the Internet to learn mathematics were:

* reading of web pages and scrolling through the different sites;
* discussing the tasks with their partners;
* talking about the mathematics with their partners;
* calculating mathematics.

These have been discussed in greater detail in the previous chapter, when I described the learners' actions with the 'tool'. It was apparent that the ways of behaving and talking in the 'pizza', 'hot tub' and 'fraction' lessons were slightly different to those in the 'whales' lesson. In the 'whales' lesson there was very little talking about, or doing mathematics, while this was very evident in the other lessons. The interaction with the Internet in the 'fraction' and 'pizza' lessons was determined by the mathematical learning that was involved in the lessons. The girls used the 'help' sites for assistance and there was significantly more mathematical discussion between partners in these lessons than in the 'whales' lesson.

The Internet therefore facilitated the possible 'shared ways of behaving, language, habits, values and tool-use', and as the learners participated in the different lessons they adopted these habits and characteristics.

6.1.5 THE SHAPE OF THE LESSON IS DEPENDENT UPON THE ACTIVE PARTICIPATION OF THE STUDENTS

Successful mathematical learning is dependent on the active participation of learners. As already mentioned the highly interactive and connective environment of the Internet allows for a unique active participation by the learners.

As the girls accessed different Web pages and answered questions of a mathematical nature in the lessons, they could actively build on prior knowledge, develop their understanding and construct mathematical concepts in a unique way. The Internet and the particular mathematics lessons formed an especial community within which the learners engaged in activities in a specific way. This was particularly true in the 'pizza' and 'fraction' lessons that require many levels of interaction with the Internet. The 'hot tub' lesson being a static web page cannot be described in the same terms. The 'whales' lesson also involved much interaction with the Internet environment but the mathematical focus was lost in the real-life context of the sites visited.

The active participation of the learners in the lessons therefore contributed towards those aspects of the community already mentioned – the recognition of

competence, the working towards common understandings and the shared ways of behaving. In this way the participation contributed towards the enabling of the learning of school mathematics.

6.1.6 LEARNERS AND TEACHERS SEE THEMSELVES AS ENGAGED IN THE SAME ACTIVITY

This notion, of learners and teachers engaged in the same activity, was particularly relevant for the 'Internet Maths' lessons. The lessons for learning mathematics using the Internet were either specifically designed or chosen for the study. They made use of aspects in the school mathematics curriculum for Grade 8 and, in line with recent ideas on relevance, some were embedded in real-world contexts. (The implications for learning mathematics within such embedded contexts will be discussed in more detail in the next chapter.)

The sessions during which the Internet lessons were held were not the normal school mathematics lessons - they had a specific character of their own. This was emphasised by the nature of the sessions - the after-school hours, the limited number of girls involved and the use of the Internet. Learners and teacher/researcher were definitely participating in a particular activity, which in the context of PGH School was unique.

6.1.7 LOCAL COMMUNITIES OF MATHEMATICAL PRACTICE

Based on the discussion above I argument that the learners, the teacher/researcher, the Internet and the specific mathematics lessons do created unique LCMPs in some instances. This is particularly true in the 'pizza' and the 'fraction' lessons with their very visible mathematics, less so in the 'hot tub' lesson and almost not at all in the 'whales' lesson. The high level of embeddedness of the mathematics in the 'whales' lesson, combined with the structure of the questions in the task, which led to some confusion on the part of the learners, mitigated against it forming a LCMP. In particular the learners in this lesson did not 'see themselves as functioning mathematically', nor as 'working towards a common understanding'.

The purpose of the practice in these LCMPs is the learning of school mathematics, using the Internet. The specific lessons were chosen or designed with this purpose in mind and therefore as LCMPs that might enable the learning of mathematics. The learners participated in a particular way within the practice for a particular purpose and there was a shared way of 'behaving, language, habits, values and tool-use' as they engaged in specific activities designed for learning mathematics. As they participated their position as newcomers within the practice moved from the periphery to one of greater and greater involvement. This was evident in the 'hot tub' and 'fraction' lessons in particular, and such participation involved not only skills using the Internet but also their 'doing' of school mathematics.

In their new 'community' the way the learners 'did' the mathematics when using the Internet was not the same as in regular mathematics lessons; nor was it the same in each of the different lessons using the Internet that form the basis of this study. The different levels of embeddedness of the mathematics within the different lessons meant the learners thought about the mathematics differently.

Other aspects of the different lessons and the use of the Internet that are relevant to this study are dealt with in the sections that follow.

6.2 THE INTERNET

As already mentioned the Internet is a uniquely interactive environment in which the learners at PGH School were involved in a special way. Their expectations of lessons that use the Internet, their perceptions of the mathematics when using the Internet and their interactions with each other, the 'tool' and the teacher, are all significant in this analysis of the learners' actions and reflections.

6.2.1 THE INTERNET AND THE LESSONS

Many of the girls were aware of the possible implications of computers for educational purposes – typing and presentation of assignments and project; and for learning mathematics – the school uses a remedial mathematics programme to help students in their learning. But their perceptions of what the Internet can do initially seemed to be limited to finding information:

353 **Me** Oh. OK. Do you think that possibly the computer or the Internet could help you ...?

MA The computer is - if you think about it - it helps with so much of the project if you type it.

Me If you were stuck on some maths could it help you?

C I think so! - you could - like the CAMI[1] maths - it gives you tables and speed tests and things like that. It gives you all
360 different things. You can always go into a specific place and just practice.

Me Looking at something like the Internet? Do you think it could help?

C I don't know.

365 **MA** I'm sure it could. I know it helps with research a lot. If you were using the Internet and you were doing a research project in maths or some subject, I'm sure it could.

(Int. 1 - MA & C)

Another pair of girls, while admitting to the fun side of using the Internet for learning referred to the information available when using the Internet as more than books:

179 **S** Yer, it's fun.

Z It's fun! You get more information.

Me Ya. OK.

Z Than books and stuff.

(Int. 4 - Z & S)

However, the way the lessons were designed using the Internet meant a different approach to its use, something more than just seeking and organising information.

55 **Me** What do you think made the lessons – were they different? Or not?

[1] CAMI is used as a remedial mathemat' - program at this school.

MA They were! They were – very different. I never thought that you would be able to do something like that on the Internet. When I first thought of Internet maths – we didn't really think we'd have too go into a web site and look up information. That's a bit different than what I expected it to be. It's very fun!

(Int. 1 - MA & C)

These two girls, when talking about their expectations of the lessons using the Internet compared them to the remedial mathematics programme used by the school, and said:

69 MA ... one of the programmes - you just got to sit there. It's going to give us a whole section on, say, geometry to do, and we must – just got to sit there and work out answers. But it wasn't anything like that (laughter).

C It wasn't anything like that!

.....

.....

75 MA It also helped – if you think about it – it could also help in the way you – your story sums. Because the questions – they haven't given you – do this, do this – they haven't really said – given you numbers to work with. You had to sit there – use the information given – pick out what was generally the most important numbers or whatever it was – and use that to get your answer.

(Int. 1 - MA & C)

6.2.2 THE INTERNET AND THE MATHEMATICS

In the lessons using the Internet there was a lot of discussion relating to the tasks and working with the mathematics. This was less so in the 'whales' lesson, but particularly true in the more decontextualised lessons – the 'hot tub ' and 'fraction' lessons. The work in the 'pizza' lessons also elicited much discussion

about the areas of circles and percentages as discussed above. However it appeared that the way the girls thought about the mathematics when using the Internet was slightly different.

In the first questionnaire MA wrote that using the Internet "gave me a better understanding of maths" and when I asked her about this in the interview she said:

103 **MA** Sometimes when we're doing maths in class – sometimes in class when we're doing maths - it just feels - just going in one ear and out the other - then I just - I don't know what's going on at all.

(Int. 1 - MA & C)

MA seemed to be interacting with the mathematics in the Internet lessons in a different way to the way she did in regular mathematics lessons. MA and C worked together for most of the lessons using the Internet. C was the more confident about her mathematics. She said that she usually did well in Mathematics, while MA confessed to being uncertain in some sections. When I asked MA and C, who of them knew how to do the graph in the 'whales' lesson the response was:

195 **Me** So how did you know how to do this one?

C MA knew how to do this one (laughter).

204 **Me** How did you know about them?

MA It's ... my mum's a nurse and she's got a couple of textbooks with graphs like that, so I just .... I happened to be glancing through this textbook one day and saw all these graphs and so I thought back to that page. And we did it like that. (laughs)

(Int. 1 - MA & C)

As already mentioned, when 'acting' with the Internet MA appeared to work as a 'bricoleur' - as described by Turkle and Papert (1993) - and was able to build on her previous experiences and ideas to make mathematical meaning in the lessons. She seemed to work well in the less structured environment of the Internet and was able to make connections between her mathematical learning at school and her own 'real world' and was not restricted by the 'rule' of the mathematics classroom.

In the interviews when I asked the girls whether they would like to learn their mathematics using the Internet or during ordinary classroom lessons there was a mixed response. S was positive about learning with computers:

210	**Me**	If you had a choice between, say, learning maths in the ordinary maths class and learning it with computers – what would you choose?
	S	I would choose computers.
	Me	Can you say why?
215	**S**	It's just like fun more. Interesting.

(Int. 4 - Z & S)

She obviously enjoyed the novelty of working with the Internet. Other girls appeared to feel more uncomfortable in the less rigid environment of the lessons using the Internet and said they would rather learn mathematics during normal lessons.

	Me	Do you think using the Internet for lessons at school might
300		be a good idea?

A I don't know what you mean!

Me Like we did for the maths.

.....

.....

305 **A** I really enjoy it in class

and

336 **Me** OK. So for you, even though you loved using it – the Internet, you'd still rather do maths in ordinary lessons?

A Yes. Because you do the lessons, and then you've got to write on the paper - and - it's a bit - . it's a bit like looking at

340 one thing and then - starting something else.

(Int. 5 - A)

The Internet environment also seemed to make the girls more aware of mathematics as something other than only a school subject. S said:

"It made you see that you use maths – like – in lots of things".

(Int. 4 - Z & S)

Whereas A was aware that mathematics was 'useful' but she hadn't really realised to what extent.

225 **A** No, I ... my father is a mathematician and he tells me that it has a lot of uses. But I didn't think about whales (giggles)

(Int. 5 - A)

6.3 TRANSPARENCY OF THE MATHEMATICS.

Issues of transparency have been discussed in Chapter Three and they form an important part of this analysis. As mentioned, access to participation within a LCP is through a variety of activities, contexts and resources. Their transparency is an importance function of their use and to access to the community. In terms of this research therefore, to enable the learning of mathematics within a LCMP the context of the lessons needs to become invisible and no longer be an object of attention.

In the 'whales' lesson the mathematics is embedded in the real-life context of the whales and dolphins of the Cape Whale Route and Sea World in USA. It was apparent that for many of the girls the mathematics was too embedded in this real-world context. While a couple of the groups were able to see through the context to the mathematics, most of the girls became too involved in the information about the whales and the dolphins to be able to engage in mathematical meaning making. The context of the whales and dolphins was too 'visible' and so the mathematics became too 'invisible'. The comments below illustrate this:

13 **A** Um - we started with whales I think. And I found it a bit of a problem, looking through all the pages and stuff. It was quite interesting ... um ...

and

27 **Me** At the beginning there were questions that were more about the whales ...
A Yes. I wasn't quite sure of - is that to do with maths.
30 Because it was more like the information.
Me OK.

A I found that a bit confusing.

(Int. 5 - A)

and

28 **S** Well - like - the whales one was more – sort of like a comprehension.

(Int. 4 - Z & S)

and

100 **B** Ya the whales – was like going nowhere. -

(Int. 2 - B & TL)

As already stated the 'information seeking 'involved in this lesson seemed to divert the girls attention away from the mathematics.

While the contextualised nature of the mathematics in the 'whales' lesson appeared to make the mathematics almost 'invisible' for the majority of the girls, in the 'pizza' lesson the mathematics was far more 'visible'. As a consequence most of the girls got involved in mathematical activities. When I asked one pair of girls which lesson had more mathematics in it, their response was:

81 **S** 'Pizzas' – I think?

Z Ya

Me Why do you think that?

S I don't know. It just had more – like – working out.

85 **Me** OK, what sort of things did you work out?

S Like fractions ...

Z Division and multiplication ...

(Int. 4 - Z & S)

and:

47 **Me** And now that you're doing the pizza one?

B Yes there's maths in there ...

(Int. 2 - B & TL)

MA made an important connection between the 'visible' mathematics in the 'pizza' lesson and how this made the lesson seem 'clear'.

308 **MA** The pizza lesson was a bit more maths.

.....

317 **MA** **... So it was a bit more clear. Pizza was a bit more clear than whales.** The whales more - more - understanding.

320 **C** Yes. And the whales topic was like serious and the pizza party was more like a fun thing.

(Int. 1 - MA & C)

This comment seems to imply that the more 'visible' the mathematics the easier it is to understand it. This links with dominant views and expectations of mathematics.

Despite the very 'visible' mathematics even in this lesson it seemed as though the context of the pizza party was too 'visible'. For some groups far more effort and discussion focussed on their party decisions - who to invite and the choice of different toppings - than on the mathematical decisions. While some girls did

discuss the different sizes and how to share them, many in the first session on this lesson were engrossed in the entertainment-value of the site.(FN 3)

It was because of this dilemma relating to the 'invisibility' of the mathematics in the more contextualised lessons, particularly the 'whales' lesson that I decided to use another Internet site for further sessions in the fourth term. The site designed by Cynthia Lanius - already mentioned - has lessons in which the mathematics is much more explicit and 'visible'. In using these other lessons I hoped to be able to observe more of the girls' actions with the mathematics in the lessons than had been apparent in the first two lessons.

In the 'hot tub' lesson the mathematics can be seen both figuratively and literally - in the graph and in the second question relating to the positive and negative aspects of the slope. However even here the context of the first question – to 'describe what happens' or to tell the story of the graph – almost made the mathematics become 'invisible' and the girls admitted to finding this confusing.

113	**T**	It was difficult.
	Me	Was it? Why did you find it difficult??
115	**T**	First we couldn't find out what was going on. (laughter)
		.....
		.....
124	**K**	- because at first we didn't know what the first question meant, and so we went to the next one and then came back to that one.

(Int. 3 - K & T)

This raises interesting issues of working within everyday contexts. The assumption is that such contexts enable mathematical meaning making where in this instance it did not.

In terms of creating communities of practice for learning mathematics, the transparency of the mathematics within the lessons using the Internet certainly played an important role. Those lessons with very embedded contexts - the 'whales' lesson and to a certain extent the 'hot tub' lesson - did not work towards creating such LCMPs, whiles those with the more visible mathematics did.

6.4 MEDIATION THROUGH THE ZPD

As mentioned in Chapter Two the Internet on its own cannot be envisaged as a 'tool' for learning mathematics. Rather it is a unique system of information that can provide an exciting resource from which to build mathematics lessons. But how does the learning of mathematics actually take place?

While the concept of a LCMP provides a useful explanation for such learning in specific lessons, it cannot account for any purposeful instruction within the community, or for the role of the teacher or the 'tool'. Within the notion of a 'community of practice', learning of mathematics takes place as learners participate within the practice. In such a community, learning "has no necessary connection with deliberate teaching" (Winbourne and Watson, 1998:177) and occurs as a result of participation in the practice. However, the way such

participation actually unfolds within the LCMP is not sufficient to explain the process of mathematical learning. I therefore argue for the inclusion of notions of mediation within the LCMP – not as a separate feature, but intermingled with the participation.

From a Vygotskian viewpoint it is instruction that leads the learning through a ZPD, and the creation of meaningful ZPDs for learners through suitable activities in lessons, and their subsequent mediation by 'tool', teacher or more able other, are what enables the learning of mathematical concepts. In the context of this study this can be by means of the teacher, the help sites on the Internet or through a more able partner. The participation of the teacher within the LCMP can provide invited or uninvited mediation that facilitates learning through a ZPD.

6.4.1 THE MEDIATING ROLE OF THE TEACHER

My realisation of the importance of the mediating role of the teacher when using the Internet was during the 'hot tub' lesson. One pair of girls was being videoed during this lesson and the greater degree of interaction between teacher and learner, and consequently the greater depth of detail in their discussions, were very apparent. This more involved engagement raised some interesting issues for me. In observing the girls whilst they were working, I had wanted to focus my attention on how they interacted with the Internet environment. While I was happy to answer their questions I really wanted them to discuss these with their partners or try to find the answers on the Internet – as with the 'Pi' site. I wanted

to intervene in their working as little as possible. However the more detailed discussion and written response of the pair who were being videoed for the session and who therefore received more assistance and suggestions from a teacher, highlighted the importance of teacher intervention in the learning situation. It almost seemed as though the girls needed the mathematics pulled out and/or highlighted for them in order to enable them to fully engage in mathematical thinking.

The active participation within the more embedded lessons seemed to require a more able other to see and pull out the mathematics. The role of the teacher in this mediation appears to be crucial in creating a LCMP to enable mathematical learning. The role of the teacher in mediating the learning through questioning and other interventions, such as probes and hints, appears to be an important part of the construction of mathematical concepts

Perhaps I should have intervened more during the sessions of the 'whales' lesson in order to help highlight the mathematical activities? In the early stages of the 'Internet Maths' lessons there was no doubt that the girls were learning all sorts of things during the sessions, but were they learning mathematics? Had the lessons extended their ZPDs sufficiently to be of value, or was it just fun to work with the Internet?

When A said she would rather learn mathematics in the classroom she mentioned an interesting feature of classroom work that she obviously found missing when using the Internet:

> 305 **A** I really enjoy it in class – because like you're talking directly to the teacher – and you can ask the teacher. I feel like when you're on the computer its like – you're breaking the tie that's between the teacher and the pupil – because – um …
>
> (Int. 5 - A)

This highlights the importance of the teacher in the learning process. The computer or the Internet alone cannot change the learning. It is how it is used that changes the learning situation and the teacher is an integral part of this. This relates back to my dilemma of intervening in the girls interactions with each other and with the Internet mentioned earlier.

This prompted me to think carefully about how I would have used the Internet in my mathematics class. I think I would have intervened more during the lessons to try to make the learning using the Internet and the learning in regular lessons a coherent whole. The Internet lessons as used in this research were isolated and may have appeared irrelevant to some of the girls. This is one of the disadvantages of an outsider coming into a teaching/learning situation to conduct research and is one of the limitations of such a case study.

6.4.2 THE MEDIATING ROLE OF A PARTNER

When talking about mediation one is usually referring to a Vygotskian notion of mediation through a ZPD. However, a similar aspect of working with others is noticeable within a 'community of practice'. The interaction of the different members of the community – learners or master – is an important feature of a 'community of practice'. A significant feature of the lessons using the Internet was that the girls worked in pairs in front of the computers. This meant that they were not only interacting with the Internet, but also with each other. From the questionnaires it appeared that they did not often work in groups. The school had an 'integrated studies' programme where they worked in groups, but from their comments on this during the interviews it was evident that they did not find it very successful. However, using the Internet and working in pairs raised a lot of positive response. The girls talked about getting

> "help from the other person" (Int. 4 - Z & S)

when they got stuck with some aspect of the work,

and

> "two minds that can think" (Int. 3 - K & T)

and

"... it's more teamwork – than individual" (Int. 1 - MA & C)

Sometimes they liked to work on their own – A expressed being able to work quicker on her own, and she highlighted the significance of the negotiation of understanding that is required when working with someone else:

172 **A** I think it's because we work in groups so - we have to negotiate - and stuff. Like when you work on your own you tend to work a bit faster. Well that happens with me.

175 **Me** OK

A Because I know what I'm doing. When you're working with someone else you've got to - like - try and explain it so they understand. And you've got to understand as well. You've got to come to an agreement on how to do a specific thing.

(Int. 5 - A)

MA and C appeared to enjoy working together and they obviously felt it helped their thinking to work this way:

330 **MA** There're some questions where C knows more where we're going and in some I know and in some we just –. I say something and then she says something – then we've said the same thing in different ways. In some we know – C knows exactly what to do, and in some I know and in some

335 we haven't got a clue. It's more teamwork – than individual.

(Int. 1 - MA & C)

Pairs of girls working together with the Internet in meaningful ways to learn mathematics suggests the existence of significant ZPDs. The negotiation and discussion within these ZPDs enabled the learners to engage in the tasks and to construct mathematical meaning.

However, this does not imply that pairs of girls working together will always enter into meaningful learning situations. In an interview I asked B & TL about reading the web pages (Int. 2 - B & TL) - they each had a different approach and this seemed to create a problem for them as they worked together.

155	**Me**	Did you read all the information about the whales and dolphins?
	B	Some of it - it was kind of interesting. Some things we didn't know, but ...
	TL	(indistinct)
160	**Me**	Did you find it difficult to actually read on the screen? Or was it alright?
	TL	I just skimmed through - to look for - like - the words that would help me. Like - length - to find out how long (indistinct) - look for the right answer. Then I'd put it
165		down.
	Me	Oh. So you didn't really read it? You just looked for the bit that might be relevant for that answer. (looks at B) Do you think that's how you did it as well?
	B	Umm – no!
170	**Me**	How did you do it?
	B	I read the whole thing.
	Me	You read the whole thing. OK. Which do you think is the – which do you think you gain most out of?
	B	I think if you read it. – because then – like – in the next
175		question if you want something else – and then you remember – that you've seen it. ... you've read it.
		.....
	Me	What do you think TL?
	TL	I think that way, but the way I do it is much quicker.
180	**Me**	OK. So if you do it quickly then you can finish it?
	TL	Mmm. (laughs)
	B	But if you read it all then you won't have to go back and back again – you just know it. That whales have five babies a day (laughs) or whatever it is.

(Int.2 - B & TL)

It was almost as though their different reading strategies hindered their individual thinking and they were unable to work together effectively. They seemed unable to help each other. B & TL's different approaches to reading on the Internet could be said to contributed to minimising any possible ZPDs that might have been created by the lesson.

This example highlights the importance of mediation through the ZPD as part of working together in a LCMP in this study. In other circumstances such girls working together and helping each other could be considered to be merely an example of collaborative learning.

6.4.3 THE MEDIATING ROLE OF THE INTERNET

An important aspect of this research has been looking at how the learners acted with the 'tool' and their reflections on their use of the 'tool'. The 'tool' in this instance being the Internet and the specifically designed – or chosen – lessons for learning mathematics. In Chapter Five I have attempted to describe these actions and reflections, and in this chapter suggest that the learners, the teacher/researcher, the Internet and the lessons form a 'local' community of practice. The role of the Internet in such a community of practice is specific in that it is the interactive medium within which the learners work on the lessons. But there is another aspect to the Internet that emerged during the research – the ability to act as a more able other and provide mediation through learners ZPDs.

This is particularly evident in the 'pizza' lesson and the 'fraction' lesson when 'help' sites were included in the lessons.

In the 'pizza' lesson the help site – the 'Pi' site – provided clear explicit assistance for working with circles and many of the girls visited this site for help – described above. This is clearly demonstrated by the following extract from the interview with K and T:

I asked them how they knew how to work out the area of a circle.

93	**T**	Um – I don't know
	Me	You don't know. Did K help you?
	T	Yes
	Me	Or …
	K	I do remember that T was absent then. Because I remember that I talked to her at school the next day – what we did -
	T	Oh ya -
100	**K**	… the pizza and that - and - . So I went on there and I found out -
	Me	You found it out?
	K	Ya
	Me	Did you know it beforehand?
105	**K**	No
	Me	So you looked through that help site on finding the area of the circle and things? And then you were able to tell T the next day?
	K	Ya.

(Int. 3 – K & T)

This illustrates the two girls working together within the 'local community of practice' as distinct from the school community, of which they are also a part.

The sense of belonging to a specific group with a specific intention is highlighted as K helps T with work from the 'practice'. It also illustrates the mediating power of the Internet as a more knowledgeable other in assisting learners through their ZPDs.

The symmetry site in the 'fraction' lesson is another such help site that the girls accessed in order to find assistance. In fact there are numerous sites already published on the Internet that can provide help with the mathematical content of lessons; it's a matter of locating them and incorporating them into lessons

6.5 WORKING WITH THE TECHNOLOGY

A final issue to consider, in the analysis of the data collected for this research, is that of working with first world technology, such as computers and the Internet, in a country like South Africa. There is always a high risk of the existence of problems appearing in the infrastructure of the technology that have consequences for learning using the Internet.

Even if working with the latest high-powered machines, with large hard drive capabilities and significant memory, Internet links need to be made through existing structures. With the situation in South Africa this means there are always delays in accessing the WWW. In order to minimise the delay in accessing the Internet, the site in the introductory session was cached onto the school network – this allows a more rapid initial loading from the individual machines. This

worked well in the first session. But it is almost impossible to cache all the different sites that may be visited through different links on a Web page and one of the more interesting aspects of the Internet is the very interactive nature of the environment that allows many links to many different Web pages.

Such technological considerations are definitely something that need to be taken into account when thinking about a whole class accessing the Internet for lessons using the Internet. In some sessions the frustration that resulted when connections could not be made, and the time wasted waiting for links, impacted on the success or otherwise of the work. This was particularly true when trying to sustain interest and motivation in the lessons.

These technological problems are peculiar to the 'practice' of learning using the Internet and while not serious did mean that the girls felt frustrated and irritated when the messages repeatedly appeared and interrupted the sessions while they were working. These delays appeared to effect the overall work ethic of some of the girls. They seemed to work extremely slowly and they appeared to lose interest in the lessons:

31	**Me**	Did you do the ones – did you get as far as converting the units?
	B	(indistinct)
	TL	No, we couldn't ...
35	**B**	No, remember you – um – the thing was taking too long.
	Me	Oh - 'getting in' was the trouble
	B	Ya - you said skip it and do the next one.

Me OK, so did you do the ones on this page?

TL Um - I think we did, um - we tried to do this one - um - the one about ...

B We were on the Southern Right whale.

TL Ya, but we couldn't find how many there were.

(Int. 2 - B & TL)

The technical problems appeared to become an excuse for not completing or handing in the written work:

Me OK. But I noticed also that you didn't manage to finish that one either?

Z/S Mmm!

Me Why do you think that was?

S Um - because - um - the system took too long.

(Int. 4 - Z & S)

Overall the lessons seemed to take far longer than I had anticipated that they would to complete. Was it the technology or the amount of on screen reading that was slowing things down?

K I liked it, but I found the – um – it was a bit – um – too long.

Me Oh! Long? In what way?

K Like - um - the - um - like the computer - um - it was like - um - the pizza one was like - um - more fun, than the computers and the whales.

(Int.3 – K & T)

During one session after a particularly long delay, two of girls appeared to have lost interest in the lesson completely and were trying to log into the computers on

either side to play games or write e-mail messages! I did ask myself whether the Grade 8 girls always worked so slowly, or if they found the on-screen reading rather difficult, or were the technical problems blocking any serious learning?

The above issues to do with the technical side of working with the Internet are important when looking at the use of such technology in a school situation. Delays and breakdowns in connections work against the feasibility of using the Internet for classroom work, and are therefore highly significant factors that need to be taken into account in any future plans for implementation.

CHAPTER SEVEN

CONCLUSIONS AND IMPLICATIONS

In the concluding chapter of this research report I attempt to pull together the arguments presented in the analysis in Chapter Six as I reconsider my original research question:

> In what ways and to what extent do learners respond to specifically designed mathematics lessons that use the Internet?

In answering this question I look at the possible contribution the Internet can make towards learning mathematics at a junior secondary school level. I reflect on the theoretical and practical implications of the research and consider any consequences for the future use of the Internet for learning mathematics. I also consider how these findings may impact on the implementation of Curriculum 2005.

Anyone who has used the Internet cannot doubt its unique characteristics as an interactive medium with great connectivity at unusual levels of intensity. 'Surfing the Web' is an engrossing pastime for many people but its applications for educational purposes are only beginning to be realised. To be a useful tool for learning, the Internet must be approached with care and with a particular purpose in mind. As already stated the Internet alone cannot change teaching or learning – it is how it is used that makes the difference. As a source of information, it has great potential for being used in the classroom. However, I argue that it is more

than a huge collection of information; it is a resource that can be used to make meaningful contributions towards learning mathematics.

In this research project the learners at PGH School worked on four specific lessons for learning mathematics over a period of eight sessions. The girls all thoroughly enjoyed the sessions and found working with the Internet novel, interesting and challenging. Using such innovative technology in a school situation for learning mathematics appealed greatly to the learners and this motivated some of their interactions with the 'tool'. By using the Internet for learning mathematics in real-world contexts – such as the 'whales' lesson – the girls became aware of mathematics outside the classroom and they began to realise a 'use' of mathematics as a tool in everyday life. The girls' responses to the different lessons highlighted the points I have used to argue in support of using the Internet for learning mathematics within the limited scope of this case study.

7.1 REFLECTIONS ON THEORETICAL ISSUES

7.1.1 LOCAL COMMUNITIES OF MATHEMATICAL PRACTICE (LCMPs) AND MEDIATION

While working on the lessons in this study that use the Internet, the learners' interaction with the 'tool' were unique. They were able to make connections with their own experiences and across subject disciplines in a new way.

Consequently they constructed mathematical meaning in significantly different ways to those when working in regular mathematics lessons. By focussing on learners' actions with the Internet in the context of the specific lessons and learners' reflections on their use of the 'tool', I have been able to highlight the existence of *'local communities of mathematical practice'* (LCMPs) in certain lessons. Within a theoretical framework based on Lave and Wenger's theory of social practice, the learners' interactions with the 'pizza' lesson and the 'fraction' lesson clearly demonstrated the features of belonging to a LCP as defined by Winbourne and Watson (1998). Such LCMPs can be said to enable the learning of school mathematics. The characteristics of the learners' interactions with the Internet environment in these two lessons were unique and there existed an especial community of learning that involved the learners, the Internet, the teacher and the lesson. I therefore argue that the Internet can make a significant contribution towards the learning of mathematics – but much depends on the way it is used, the context of the lesson and the mediation provided.

While notions of communities of practice go some way towards providing an explanation for learning mathematics, they are not always sufficient for the teaching/learning environment. In the two lessons in this study which do not show evidence of the existence of a LCMP: i) the 'hot tub' lesson - in which the task boundaries were blurred, and ii) the 'whales' lesson - where the embedded context affected the transparency of the mathematics; - mediation helped to highlight the mathematical aspects of the tasks in the lessons and therefore the effectiveness of the lessons for learning mathematics. For this reason I argue that

it is also necessary to consider *mediation* within a *LCP* as providing a fuller description of a mathematical learning situation. The two notions of *LCP* and *mediation* do not act separately but are intertwined and complement each other as they provide an framework for learning mathematics when using the Internet.

One may ask 'where is the mediation and what form does it takes?' Does it lie in the 'tool' – the specific tasks in the lessons? Does it lie in the teacher intervention or assistance of a more able other? From a Vygotskian viewpoint mediation through a ZPD is by means of a tool or a more able other. In the lessons in this study there were some interesting instances of mediation through ZPDs that were apparent.

The importance of teacher intervention was highlighted in the 'hot tub' lesson, where greater teacher participation resulted in a greater level of learner interaction with the mathematics in the lesson. Such intervention can help to 'pull out' the mathematics in more embedded situations so that it is more visible. Possibly more teacher intervention in the 'whales' lesson might have had a similar effect, thus helping to create a more effective mathematics lesson. The mediation provided by a more able partner was evident in many of the learners' reflections on their work together in the lessons. Together with their partners they were able to negotiate task demands and mathematical demands as they interacted in the lessons.

Other instances of mediation that came to light in this study were those provided by the numerous 'help' sites that can be found on the Web. The Pi site in the 'pizza' lesson and the symmetry site in the 'fraction' lesson are examples of such sites that can mediate learning. The site giving answers in the 'fraction' lesson has a similar potential. The explanations of mathematical concepts in such sites are clear and explicit and have the advantage of being dynamic and readily accessible. In providing mediation the sites act as more able others when the learners' access them for assistance.

In the 'pizza' and 'fraction' lessons the mathematical tasks were very visible. In terms of the LCMP the learners were aware that they were learning mathematics and mediation was adequately provided in the structure of the tasks and the more able others – teacher, partners or 'help' sites. The 'hot tub' lesson needed more teacher intervention to encourage the learners to interact with the mathematics at a deeper level. Similarly in the 'whales' lesson, further teacher intervention might have allowed the learners to interact more fully with the mathematics in the lesson. In the 'pizza' and 'fraction' lessons I argue that mediation helped to intensify the interaction and participation between the 'tool' and the learners and so further enabled the mathematical learning within the practice.

7.1.2 EMBEDDED MATHEMATICS, CONTEXTS AND AN INTEGRATED CURRICULUM

The four different lessons used in this study all featured different levels of embeddedness of mathematics in their tasks. The 'whales' lesson is highly embedded in the real-world context of the whales and dolphin sites on the Internet and the task requires the learners to work within this context in an assumption that the mathematics will be more relevant. The 'pizza' lesson is less embedded in the fantasy context of a party and the task requires the learners to plan the party and to negotiate the mathematics as they work with best buys, percentages and areas of circles. While the mathematics in the 'hot tub' lesson is more decontextualised the context of the task requires negotiation of task demands as the learners attempt to tell a 'mathematical story' around the graph. In comparison the 'fraction' lesson contains the mathematics of fractions within a visual context of shape.

In this study issues of the level of embeddedness of the mathematics in the lessons, linked with notions of transparency. Those lessons in which the mathematics was highly embedded in everyday contexts were the ones in which the mathematics became more invisible to the learners. The contexts were too visible and the learners' attention was diverted away from the mathematics. This raises interesting questions about working within everyday contexts. The assumption is that such contexts make the mathematics more relevant to the learners and therefore easier to learn.

In terms of creating communities of practice for learning mathematics, the transparency of the mathematics within the lessons using the Internet certainly played an important role. Those lessons with very embedded contexts - the 'whales' lesson and to a certain extent the 'hot tub' lesson - did not work well towards creating such LCMPs, whiles those with the more visible mathematics did - the 'pizza' and the 'fraction' lessons.

These findings have important implications for work within an integrated curriculum, such as Curriculum 2005. Tensions arise within such a curriculum when the boundaries between contexts become blurred. Mathematical activities within context embedded tasks may be enabling or constraining for learning mathematics. Enabling in that they may help to make the mathematics more relevant; constraining when the context makes the mathematics invisible.

I acknowledge that within the limits of this study my focus was on the mathematics and such instances of learner participation that would identify the existence of a LCMP. I did not take into account any other learning that might have taken place within such embedded contexts. Such learning became invisible to me as my interest focussed on the mathematics.

7.2 REFLECTIONS ON PRACTICAL ISSUES

7.2.1 DESIGNING TASKS

If the Internet is to be used effectively for learning mathematics in the classroom, teacher involvement in designing tasks and lessons becomes a practical issue of some importance. One needs to ask what made some of the lessons in this study more effective for learning mathematics than others? What makes a good task – and therefore a good lesson – when using the Internet? How does the teacher design a lesson that helps create a LCMP?

As mentioned above, the visibility of the mathematics, in the context of the lessons and the tasks, is of crucial importance. Similarly when designing lessons that use the Internet, the interconnectivity of the Internet environment must be taken into account. The 'hot tub' lesson in this study may have been in a textbook, as it did not use any links to other pages on the Web. Notions of relevance of contexts are also important. The 'pizza' lesson, with its party context and entertaining web site, appealed greatly to the Grade 8 learners at PGH School. Although some of the girls found the context of the 'whales' lesson interesting, for others it was, in the words of TL, "too educational"!

The designing of 'good', relevant lessons with appropriate mathematical tasks becomes a crucial consideration when looking at using the Internet for learning mathematics.

7.2.2 THE TECHNICAL ISSUE OF TIME.

When looking into the use of the Internet in schools in South Africa another important consideration is the technical infrastructure that enables links to the WWW. For the Internet to be of value within a classroom, connections have to be quick and problem-free. At our present stage of telecommunication development I question if this is possible despite many arguments put forward encouraging such use. The potential of the Internet to be used for educational purposes is huge, but so is the potential for problems in connections through dubious infrastructural connectivity, limited teacher skills and technical hold-ups.

The 'sitting and waiting' for connections to, and within, the Internet is costly in terms of time and the appropriate functioning of lessons. Similarly the time spent 'reading information' on the Web pages is an issue for consideration when using the Internet in a school situation. Much information on the Web is published in English and while sites may be highly visual the time taken to scroll and read can not be underestimated. At PGH School English is the home language of the majority of learners, but even here different reading strategies effected the learning.

In this study I have not considered any financial implications for using the Internet for educational purposes. These are significant in a country like South Africa where many schools are under-resourced. Many schools do not have basic

electrical connections, let alone computers and telephonic communications that are required for links to the Web.

7.3 CONCLUSION

Within the limitations of this research - a case study in a particular school in Johannesburg - this report begins to open a window on a much larger field of research that may have implications for the future teaching and learning of mathematics in South Africa. While I have argued that the Internet can make a significant contribution towards enabling mathematics learning, there are many issues that still need to be addressed.

The teacher's role in task construction and the mathematical demands within lessons is of great importance in the establishment of *'local communities of mathematical practice'*. Similarly, *mediation* and teacher and learner interaction and participation in lessons play a part in the effective use of the Internet for learning mathematics at school level. The function of the 'tool' for mediating learners through ZPDs becomes a crucial part of the lesson design. The Internet cannot easily replace the teacher, but it's unique character and environment can be used to enable mathematical learning in new, innovative ways. Considerations for using the Internet in an integrated curriculum are also of prime importance for the implementation of Curriculum 2005. Contexts for learning mathematics need to be relevant and meaningful to the learners if they are to be used effectively for learning mathematics. Notions of transparency of tool, context and mathematics

must also be considered. This study begins to look at some of these issues but raises many other questions as it seeks to consider the contribution that the Internet may make towards the learning of mathematics in South Africa. The exciting possibilities for using the Internet in the classroom are only beginning to be envisaged as educators look towards ideas for changing teacher practice and encouraging learners to attain their full potential.

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APPENDIX

The Lessons

The Observation Schedule

The Questionnaires

Mathematics Internet Project.

Thursday 6 August 1998

This afternoon we will be getting to know each other and the purposes of the project. We will be establishing links with the Internet to make sure that everyone is familiar with the system and everyone knows how to access different sites. You will work in pairs at computer terminals and you will be expected to collaborate in your thinking and working. You may ask any questions that you want of the teachers or each other. At the end of the afternoon you will be asked to sign a form saying that you know about the project and that you know it is being used for university research into the learning of mathematics at school.

This afternoon you will be going to a visual fraction site for a fun lesson on shapes and fractions. This is a site developed in America and it is all about fractions and shapes. I hope you will enjoy working with it.

Next week we will start working with lessons that have been developed especially for the project and you will be expected to answer questions related to the different sites that you visit on the Internet. You will be required to hand in your work once you have finished a particular lesson. You can then go on to another lesson. We expect the project to take the whole of this term and we ask that you commit yourselves for the entire term.

FRACTIONS AND SHAPES.



Once you have accessed the Internet type in the following address:

http://math.rice.edu/~lanius/Patterns/

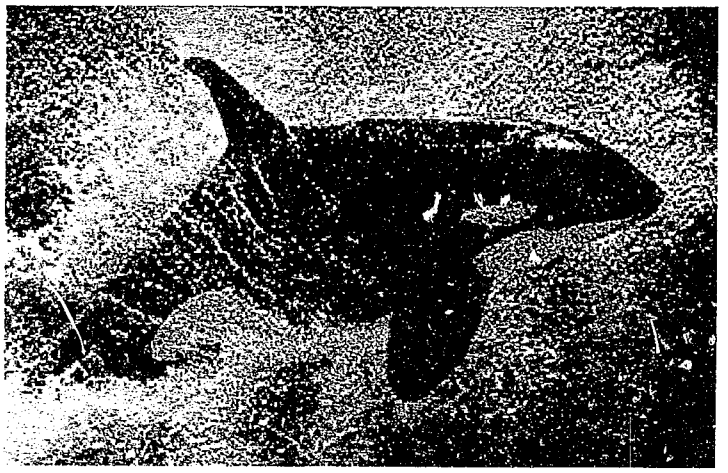
This will link you to:

"No Matter What Shape
Your Fractions are In"

Here you will find there is a small exercise on 'Exploring the Shapes'. Work through this, but DO NOT print the page - copies of the diamond paper are provided for you to work on. Continue to work on this page. When you get to the bottom DO NOT use the online link to JAVA and DO NOT visit 'The Patterns Pal Home Page".
Instead click on FUN FRACTIONS at the bottom of the page and carry on working. If you finish this you can click on DRAWING FUN FRACTIONS and work here. Again DO NOT print the page, use the diamond paper supplied.

HAVE FUN

WHALES AND DOPHINS



In this lesson students will visit sites about whale and dolphins, starting with the 'WHALE ROUTE' off the southern Cape coast. They will make comparisons regarding the size of whales and dolphins and investigate differences in length, weight and volume. They will visit other sites to enable them to convert units of length and mass, to compare size and to access more information about the animals.

Prior knowledge. The students will require some basic knowledge of measurements, volumes and simple graphs. They should have a basic understanding of how "to move" through the internet.

Web sites: Cape Whale Route: http://www.mtn.co.za/whaleroute

Sea World: http://www.seaworld.org/infobook.html

Sea World animal information:

http://www.seaworld.org/animal_bytes/animal_bytes.html

Whale and Dolphin Species: http://www.friend.ly.net/whale/species.htm

Conversion tables: http://eardc.swt.edu/cgi-bin/ucon/ucon.pl

Tennis site: http://www.tennisserver.com/rules.html

Instructions: In this lesson you will first explore the 'Whale Route' off the southern Cape coast. You will find out about the whales and dolphins that visit our shores every year. Any additional information that you need you can find at Sea World – a huge theme park in Florida, USA. One of the main attractions at Sea World is Shamu, a performing killer whale. Answers the question in the TASK, showing all your working as clearly and neatly as possible. Hand in your answers written on A4 paper. Include any other additional information that you think is relevant and interesting.

Tasks:

1. How many species of whales and dolphins visit the Cape coastline every year? Between which months do they come? Why do they visit our coastline?
2. How long is the whale route? How many coastal towns are there on this stretch of coast? Draw a small sketch map to show the position of the whale route in relation to Cape Town, Port Elizabeth and Durban.
3. Look for information of the southern right whale. Why did its population decrease in the late 1700s and early 1800s? Calculate the approximate number of whales killed / year. Why were the whales killed?
4. Use the table below to compare the length and weight/mass of 3 different whale species and one dolphin species found on the whale route.

Length

Whale/dolphin	Meters	Feet	Centimeters

Weight / mass

Whale/dolphin	tons	Pounds	kilograms

5. If you go to the Sea World site in Florida USA, or other sites, you will find information about some other whales. Choose 2 to compare with the Cape whales.

6. If there were 500 southern right whales off the Cape coast this year, assuming they return next year with their calves, how many would there be?
7. If the size of a southern right whale calf at birth is 1½ meters, how long will it take for it to grow to a fully size whale?
8. Draw a simple graph to show the weight of each animal. The weights will be on the y-axis and the name of the animal will be on the x-axis.
9. At the Sea World address find one other large animal and compare its statistics with those of the whale.
10. Find out how long a tennis court is and compare this with the length of a whale. Are you surprised?
11. If one wanted to find the volume of a whale think of a way that one could make an approximation of the volume of the whales you chose in question 4.

PIZZA PARTY

In this lesson students will visit the Internet Pizza site. They will create their own pizzas for a pizza party with some friends. In a 'real life' situation they will consolidate their knowledge of simple fractions and areas of circles and will determine the 'best buy' pizza for their party.

Materials: Internet access Pencil and paper Calculator

Prior knowledge: The students should know how to add and subtract simple fractions, and how to calculate the area of circles. They should have a basic knowledge of how to 'move' in the Internet.

Time: This lesson may need to be spread over two or three lessons, as there are several different sites to visit on the Internet, and decisions to be made when choosing different toppings for the pizzas.

Web Sites:

The Internet pizza server: http://www.ecst.csuchico.edu/~pizza/

Help with fractions:

http://www.xnet.com/~fidler/triton/math/review/mat045/fraction/fract.htm

Help with areas of circles:

http://www.ncsa.uiuc.edu/edu/RSE/RSEorange/application.html

Instructions: You have decided to have some girl friends around for a 'sleep-over' party on Friday evening. Your parents have agreed that you may order take-away pizzas, but your friends will need to contribute to the costs. You will provide cool drinks, crisps and ice cream. To keep the price down you may need to share slices of pizza, and restrict yourselves to a maximum of 4 toppings. Answer the questions in the TASK as a way of helping you decide what to order. Prices on the web site are quoted in Beej bux. For the purposes of this lesson assume R1 = B$1. As this is an American site there is no VAT included in the price. You will have to include this in your working – remember it is 14%. Somewhere you will find reference to a tax of 37% - ignore this. You will also have to tip the person who delivers your pizza. The usual rate is 10 – 15%.

TASK:

Answers the question below showing all your working as clearly and neatly as possible. Hand in your answers written on A4 paper. Include any other additional information that you think is relevant and interesting.

1. Decide with your partner who you will invite to your party – to make things simpler choose not less than 2 and not more than 10.
2. Go to the Internet Pizza Server. Order a small, medium, large and family sized pizza with two toppings so that you can compare prices. Work out the price per slice of each. Is this a good way to compare the price of the pizzas?
3. Decide on the best combination to order so that everyone gets an equal share of different toppings. Then work out how much each of your friends needs to contribute to the costs.
4. Two of your friends are on diet and you know they will only eat half as much as everyone else. Taking this into consideration show how you would decide on which pizzas to choose and how you would share the costs.
5. Another friend suddenly decides she can come to the party after all – what difference is this going to make to your working out?
6. If the measurements of the different pizzas are:

Small:	10 cm radius
Medium:	25 cm diameter
Large:	30 cm diameter
Family sized:	22 cm radius

   Calculate the area of each pizza.

   What size pizza with 2 toppings would be the best buy?
7. With what you originally decide to order work out the area of pizza that each of the people at the pizza party eats.
8. You have decided that ordering different sizes and different toppings makes the working out too complicated, so you decide to order only one size with different toppings. What do you decide to buy and how much will everyone pay?
9. Write a short paragraph about this Internet site and this lesson on choosing pizzas for your friends.

Mathematics Internet Project.

Thursday 22 October 1998

Welcome to our sessions of maths lessons using the Internet. This afternoon we welcome those girls who started last term and any new girls who have joined us for the first time this term. Just to recap what you will be doing in the next 3 – 4 weeks:

- you will access some sites on the Internet.
- work through the lessons that are given,
- write your answers on paper to hand in.

This time the lessons are already on the Internet. You will work in pairs at computer terminals and you will be expected to collaborate in your thinking and working. You may ask any questions that you want of the teachers or each other or you may access 'help' sites on the Internet. At the end of the afternoon you will be asked to hand in your completed work

Once you have got into the Internet type in the following address:

http://math.rice.edu/~lanius/Lessons/

This will link you to:

Mathematics Lessons

by Cynthia Lanius

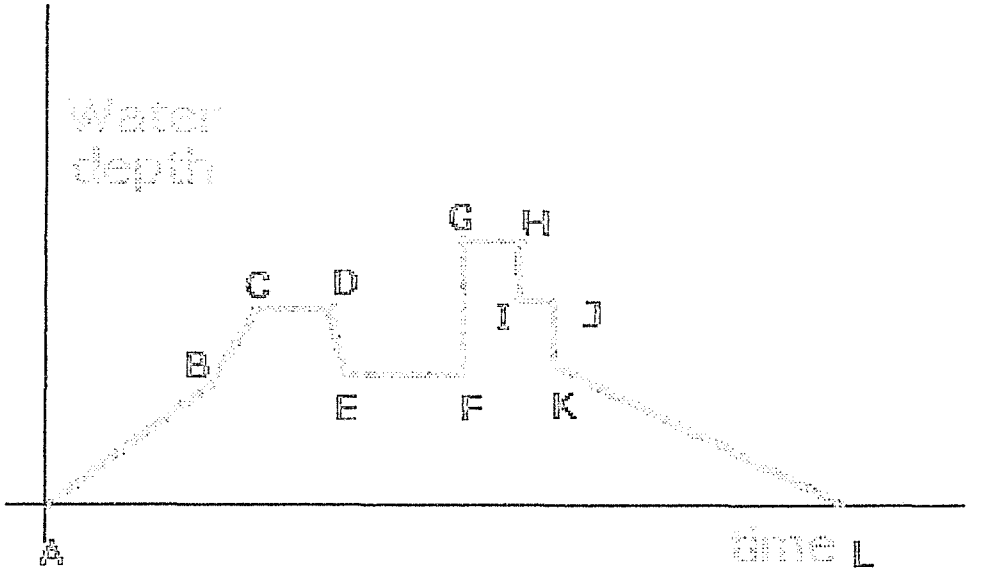
Scroll down until you see

The Hot Tub

Click here to access the first lesson.

Answer the questions that go with this lesson – a copy of the graph is provided to help you.

You MUST finish this lesson today and hand your work in.



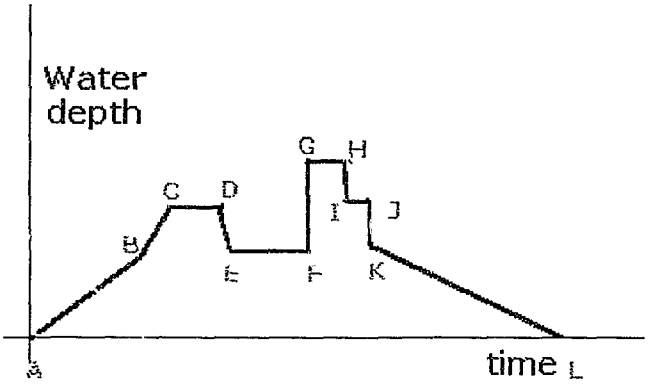
HAVE FUN

Cynthia Lanius

Interpreting Graphs

The Hot Tub

Based upon the graph below, answer the following question with as much detail as you can justify from the graph.



If the tub is filled during AB, describe what happens in the rest of the segments (BC,CD, etc.).

Look at the Maths...

Notice the connection between the slope of the lines and the rate of change of the water depth. On what segments is the slope positive, and the water depth increasing? On what segments is the slope negative, and the water depth decreasing? On what segments is the slope 0, and the water depth is constant?

Mathematics Internet Project.

Thursday 29 October 1998

This afternoon

- you will access a site on the Internet
- you will work through the lesson that is given
- you will write your answers on paper to hand in. Please write EVERYTHING, so that we have an idea of HOW you worked out the answers

Once you have got into the Internet type in the following address:

http://math.rice.edu/~lanius/Lessons/

This will link you to:

Mathematics Lessons

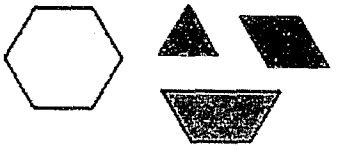
by Cynthia Lanius

Scroll down until you see

Pattern Blocks/
Fractions

Here you will find a lesson called

No Matter What Shape
Your Fractions are In



Some of you saw this lesson when we started these Internet lessons last term - please start at the beginning again.

Here there is a small exercise on 'Exploring the Shapes' and then one on 'Determining the Relations'. **DO NOT print the page** - copies of the diamond paper are provided for you to work on. Continue to work on this page.
When you get to the bottom **DO NOT** use the online link to JAVA and **DO NOT** visit 'The Patterns Pal Home Page" - this takes forever to get to!

Instead click on FUN FRACTIONS at the bottom of the page and carry on working. If you finish this you can click on DRAWING FUN FRACTIONS and work here. Again **DO NOT** print the page; use the diamond paper supplied. You may check your answers with the online links, When you get to 'DESIGNER FRACTIONS' remember to go to the link on 'Line Symmetry'. Do the exercise on 'You Be the Designer'. You may visit the other sites - 'Teachers' Notes' and 'Math Forum's Fraction Tour' if you wish.

You will carry on working on this set of lessons next week. At the end of each of the session you will hand in your work - you will get it back to continue working on the next week.

HAVE FUN

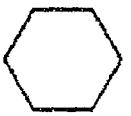
Cynthia Lanius

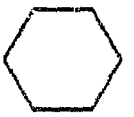
More Fun Fractions

Awesome! Investigate the shapes online (If you have a JAVA-capable browser)

Let's do some *really* fun ones.

1. If  +  = 1 what is  ?

2. If  +  = 1 what is  +  ?

3. If  +  = 1 what is  +  ?

4. If  +  = 1 what is  ?

5. If  -  = 1 what is  +  ?

Check Your Answers

lanius@math.rice.edu

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CLASSROOM OBSERVATION

Date:_____

	2.20pm	2.30pm	2.40pm	2.50pm	3.00pm	Comments
Reading web page						
Reading written task on hand out						
Writing answers to task questions						
Writing maths – calculations etc.						
Discussing task with partner						
Discussing maths with partner						
Asking for help about technology						
Asking computer for help with the maths						
Asking teacher for help with the maths						
Searching for another site						
Waiting for an internet link						
Off task talk						
Other						

INTERNET MATHS LESSONS

Name_____

		Yes	No	Sometimes
1.	In general do you think the Internet can make maths:-			
a	Harder?			
b	Fun?			
c	Interesting?			
d	Boring?			
e	Confusing?			
f	Enjoyable?			
g	Exciting?			
h	Seem useful?			

2. Please tick the boxes according to how strongly you agree or disagree with these statements:

		Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
a	I enjoy working with the Internet.					
b	I do as little work with the Internet as possible.					
c	I'm sure I could do good work in maths with the Internet.					
d	I found using the Internet for maths hard.					
e	Using the Internet helped me understand some maths more clearly.					
f	I enjoy reading the information on the web pages.					
g	I find reading the information on the computer screen difficult.					
h	I spend time outside school using the Internet.					
i	I'm no good with the Internet.					
j	Doing the whales project showed me a use for maths.					
k	Access to computers isn't usually a problem at our school.					
l	I'm usually quite good at maths at school.					

3.a. What did you enjoy most about the lessons using the Internet?

b. What didn't you enjoy?

c. What do you feel you learned about maths during this project?

d. Did using the Internet help in your learning maths?
If so how?

e. Other comments.

INTERNET MATHS LESSONS

Name_____

Please think about the lesson on the PIZZA PARTY as you answer these questions.

		Yes	No	Sometimes
1.	Did you find this pizza lesson on the Internet made maths:-			
a	Harder			
b	Fun?			
c	Interesting?			
d	Boring?			
e	Confusing?			
f	Enjoyable?			
g	Exciting?			
h	Seem useful?			

2. Please tick the boxes according to how strongly you agree or disagree with these statements:

		Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
a	I enjoyed the pizza lesson using the Internet.					
b	I learned more maths in this lesson than in the whales.					
c	I'm sure I could do good work in maths with lessons like this using the Internet.					
d	I found using the Internet for this lesson hard.					
e	Using the Internet helped me understand some maths more clearly in this lesson					
f	I enjoyed reading the information on the web pages.					
g	I'm getting better at using the internet					
h	Doing the pizza lesson showed me a use for maths.					
i	I found the maths in this lesson confusing.					
j	I enjoy using the Internet for maths lessons.					

4.a. What did you enjoy most about the pizza lessons using the Internet?

b. What didn't you enjoy?

c. What do you feel you learned about maths during this lesson?

d. Did using the Internet help in your learning maths?
If so how?

e. Other comments.

INTERNET MATHS LESSONS

Name_____

1. Please think about ALL the different maths lessons you have done using the Internet and then tick the boxes according to how strongly you agree or disagree with these statements:

		Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
a	I thoroughly enjoyed the lessons using the Internet.					
b	I learned more maths in the lessons than I would have in class.					
c	I'm sure I could do good work in maths with lessons like these.					
d	I found using the Internet made the maths more confusing.					
e	Using the Internet helped me understand some maths more clearly					
f	I preferred the Internet lessons that had more reading in them.					
g	I prefer doing maths in class rather than using the Internet.					
h	I found using the Internet made the maths seem easier.					
i	I preferred the Internet lessons that had more maths in them.					
j	The Internet lessons were not really about maths at all.					

2. Please tick which lesson you think applies to the following statement.

		Whales	Pizza	Hot tub	Fractions	calendar
a	I enjoyed this lesson/s most					
b	I enjoyed this lesson/s the least					
c	The lesson/s with the most maths in					
d	The lesson/s with the least maths in					
e	This lesson was too long					
f	I learned most maths in this lesson/s.					
g	I learned least maths in this lesson/s.					
h	This lesson had too much reading in it					

3.a) Have you used the Internet before at school or at home?_____

. b) If yes, ring what you used the Internet for most:

email chat line looking for information school work

Author Dickson M
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