

FACTORISATION OF QUADRATICS USING A
WEB-BASED SPREADSHEET FOR GRADE 10
MATHEMATICS LEARNERS

by
JEREMIAH SICELO MASEKO

MINI-DISSERTATION

Submitted in partial fulfilment of the requirements for the degree



MAGISTER EDUCATIONIS

in

COMPUTER-BASED EDUCATION

in the

FACULTY OF EDUCATION AND NURSING

at the

RAND AFRIKAANS UNIVERSITY

Supervisor: Dr D van der Westhuizen

NOVEMBER 2002

ACKNOWLEDGEMENTS

I wish to convey my sincere gratitude and appreciation to the following people:

- ✚ Dr D van der Westhuizen, my supervisor, for his time, guidance and perceptive comments throughout the course. His insight and guidance was critical to my growth.
- ✚ Mr I Moosa for his help and evaluation of the spreadsheet package.
- ✚ Ms M Motingoa and Ms P Moliki for transcribing and typing the interviews
- ✚ Mr T Phokojoe, the principal of the school, for granting permission to conduct the case study with the grade 10 learners.
- ✚ Ms Mogale, computer studies educator, and Ms Tau, grade 10-mathematics educator and grade 10 learners for their enthusiastic participation during the investigation and interviews.
- ✚ My wife: Nonhlanhla, and my children Siphesihle, Thembelihle and Buhle. Thank you for your understanding, encouragement, sacrifices and support.
- ✚ Finally, to God, who gave me the strength to carry on until the end.

T A B L E O F C O N T E N T S

Table of contents	i
List of tables	vii
List of figures	vii
Synopsis	ix

CHAPTER 1

GENERAL ORIENTATION

1.1	INTRODUCTION	1
1.2	RATIONALE OF THE STUDY	2
1.3	RESEARCH PROBLEM AND QUESTION	6
1.4	AIM OF THE STUDY	7
1.5	THE RESEARCH DESIGN	7
1.5.1	RESEARCH PARADIGM	7
1.5.2	CASE STUDY	7
1.5.3	THE LEARNERS	8
1.5.4	DATA COLLECTION METHODS	8
1.5.5	MEASURES TO ENSURE TRUSTWORTHINESS	10
1.6	DEFINITION OF KEY TERMS	10
1.6.1	QUADRATICS	10
1.6.2	FACTORISATION	10
1.6.3	INSTRUCTOR	11
1.6.4	WEB-BASED CLASSROOM	11
1.6.5	SPREADSHEET	11
1.7	THE RESEARCH PROGRAMME	11
1.8	SUMMARY	12

CHAPTER 2

SPREADSHEETS AND TEACHING AND LEARNING MATHEMATICS

2.1	INTRODUCTION	13
2.2	SPREADSHEETS IN EDUCATION: A THEORETICAL PERSPECTIVE	13
2.2.1	WHAT IS A SPREADSHEET?	13
2.2.2	THE USES OF SPREADSHEET IN MATHEMATICS EDUCATION	16
2.2.2.1	PREDICTION	17
2.2.2.2	GENERATING GRAPHS	17
2.2.2.3	MODELING	18
2.2.2.4	GENERATING PATTERNS	20
2.2.2.5	SIMULATION	21
2.3	SPREADSHEETS AND FACTORISATION OF QUADRATICS	22
2.3.1	FACTORISATION OF QUADRATICS	23
2.3.2	DEFINITION OF FACTORISATION	23
2.3.3	AVAILABLE METHODS	23
2.3.3.1	TECHNOLOGICALLY WORKED-OUT SOLUTION	24
2.3.3.2	THE BOX OR GELOSIA METHOD	25
2.3.3.3	AREA MODEL (GENERIC RECTANGLE METHOD)	26
2.3.3.4	FOIL METHOD	27
2.3.3.5	COMMON TRENDS IN FACTORISATION	30
2.4	PEDAGOGICAL PERSPECTIVE ON MATHEMATICS LEARNING AND THE MEDIUM OF INSTRUCTION AND LEARNING	31
2.4.1	FACTORS AFFECTING MATHEMATICS LEARNING	31
2.4.2	ANTICIPATED LEARNER RESPONSE TO THE MEDIUM OF INSTRUCTION AND LEARNING	32
2.4.3	ASSESSMENT USING BLOOM'S TAXONOMY	36
2.5	SUMMARY	37

CHAPTER 3

THE RESEARCH DESIGN OF THE STUDY

3.1	INTRODUCTION	38
3.2	PURPOSE OF THE RESEARCH	38
3.3	RESEARCH DESIGN	39
3.4	RESEARCH METHOD	41
3.5	DATA COLLECTION TECHNIQUES USED IN THIS STUDY	41
3.5.1	LEARNER OBSERVATION	43
3.5.2	INTERVIEWS	44
3.5.3	TESTS AND ASSESSMENT	45
3.6	DATA ANALYSIS	46
3.7	THE RIGOUR (TRUSTWORTHINESS) OF THE RESEARCH	47
3.7.1	THE CRITERION OF CREDIBILITY	47
3.7.2	THE CRITERION OF TRANSFERABILITY	48
3.7.3	THE CRITERION OF NEUTRALITY	48
3.7.4	THE CRITERION OF DEPENDABILITY	48
3.8	SUMMARY	49

CHAPTER 4

DESIGN AND IMPLEMENTATION OF THE WEB-BASED CLASSROOM

4.1	INTRODUCTION	50
4.2	THE CONTEXT OF THE IMPLEMENTATION OF THE WEB-BASED SPREADSHEET PACKAGE	51
4.2.1	THE SCHOOL	51
4.2.2	THE LEARNING AREA MATHEMATICS	52
4.2.3	THE LEARNERS	52
4.2.4	THE AIM OF DEVELOPING THE WEB-BASED SPREADSHEET FACTORISATION PACKAGE	53
4.3	THE DESIGN AND DEVELOPMENT OF THE WEB-BASED CLASSROOM	53
4.3.1	DEVELOPMENT APPROACH	54
4.3.2	DESIGN CONSIDERATIONS	55
4.3.3	ORGANISATION AND PRESENTATION OF MATERIAL	57
4.4	DESCRIBING THE WEB-BASED CLASSROOM	58
4.4.1	THE WEB-BASED CLASSROOM COMPOSITION	59
4.4.1.1	GRADE 10 INFORMATION	59
4.4.1.2	LINKS	59
4.4.1.3	COMMUNICATION FORUM	59
4.4.1.4	TASKS	60
4.5	IMPLEMENTATION OF THE WEB-BASED SPREADSHEET CLASSROOM	63
4.6	SUMMARY	64

CHAPTER 5

RESEARCH FINDINGS AND RESULTS:

LEARNER AND EDUCATOR EXPERIENCE OF THE WEB-BASED SPREADSHEET

CLASSROOM

5.1	INTRODUCTION	65
5.2	PRE-IMPLEMENTATION INTERVIEW	66
5.3	POST-IMPLEMENTATION INTERVIEW	67
5.3.1	PARTICIPATION IN THE WEB-BASED SPREADSHEET CLASSROOM	68
5.3.2	INTERACTION AND COLLABORATION USING E-MAIL	70
5.3.3	WERE THE INSTRUCTIONS CLEAR AND SIMPLE TO UNDERSTAND?	70
5.3.4	THE SECTIONS THE LEARNERS FOUND CHALLENGING OR MOST HELPFUL	72
5.3.5	COMPARISON BETWEEN FACE-TO-FACE AND WEB-BASED SPREADSHEET CLASSROOM	73
5.3.6	GENERAL COMMENTS ON THE EXPERIENCE AND THE WAY FORWARD	73
5.4	OBSERVATIONS	74
5.5	SUMMARY	75

CHAPTER 6

OVERVIEW OF THE STUDY, CONCLUSION, LIMITATIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

6.1	OVERVIEW	77
6.2	CONCLUSION	77
6.3	RECOMMENDATIONS FOR FURTHER RESEARCH	78
6.4	LIMITATIONS OF THE STUDY	79
6.5	FINAL WORD	80
	LIST OF SOURCES	81
	APPENDICES	90



LIST OF TABLES

	Description	Page
Table 1.1	Performance of African candidates in mathematics and physical science in 2000 (Adapted from Department of Education, 2001)	3
Table 1.2	Senior Certificate Mathematics Percentage of factorisation in 1997 to 2000 examination papers in Gauteng Department of Education.	4
Table 2.1	Pay plans calculations to choose a better one	17
Table 2.2	Arithmetic and geometric series and their spreadsheet functions	21
Table 2.3	Summary of factorisation methods	29
Table 2.4	Bloom's Taxonomy	36
Table 3.1	Representation of Ellington's stages of learning	39
Table 4.1	Characteristics of the learners	53
Table 4.2	McCormack and Jones (1998) and Skaalid (1999) design principles.	56
Table 4.3	Components of the web-based spreadsheet classroom	59
Table 4.4	Exercises covered in the spreadsheet package	60
Table 4.5	Example of questions and Bloom's Taxonomy	63

LIST OF FIGURES

	Description	Page
Figure 2.1	Parabola graphs generated from a spreadsheet: (Garner 1995).	18
Figure 2.2	Great Pyramid Model: Garner (1995)	19
Figure 2.3	The Biggest Box Model	20
Figure 2.4	Weight comparisons on planets	22
Figure 2.5	Graphical representation of Factorisation Methods	24
Figure 2.6	Representing the box used in the box method	25
Figure 2.7	Tiles representing the area model method	26
Figure 2.8	Rearranged tiles representing the area model method	27
Figure 2.9	Web-based class entrance stages (McGonigle and Eggers (1998))	35
Figure 3.1	Data collection methods	42
Figure 3.2	An example of the summary worksheet	45
Figure 3.3	Summary of the trustworthiness (rigour) criteria	49
Figure 4.1	The home page of the web-based classroom	58
Figure 4.2	An example of the positive c exercise	61
Figure 4.3	Spreadsheet Factorisation package dimensions	62
Figure 5.1	Ellington's stages of learning	69

APPENDICES

	Description	Page
Appendix A	Pre-implementation interview	90
Appendix B	Post-implementation interview	94
Appendix C	Some teaching pages from the web-based classroom	100

SYNOPSIS

Hierdie studie fokus op die rol wat 'n web-gebaseerde sigblad kan speel in die faktoriserings van algebraïese kwadratiese vergelykings in die onderrig van graad 8 leerders. Die algemene gebruik van 'n sigblad om inligting binne 'n tabel te organiseer, berekeninge te maak en grafieke te genereer is reeds gedokumenteer in die literatuur. Die faktoriserings van algebraïese kwadratiese vergelykings vaardigheid is belangrik vir ongeveer 36,5% en 42,25% van die graad 12 standaard graad en hoër graad vraestelle onderskeidelik.

Die rol van die sigblad binne wiskunde kan 'n belangrike rol speel met die onderrig van faktorisasie, as gevolg van die formule-skakelingseienskappe van sigblaaie. Hierdie eienskappe is nuttig aangesien die onafhanklikheid van die leerder bevorder word en die terugvoer onmiddellik plaasgevind het. Die interaktiwiteit van die werksomgewing het die leerders se onafhanklikheid van die opvoeder aangemoedig. Die web, as medium van die kommunikasie, het baie bygedra tot die interaksie tussen leerders, die onderwyser en navorser. Die onderrigmodus kan suksesvol wees as die opvoedingsbenadering, voorbereiding en toetsing van die sigblaaie (sigblad pakket) deeglik begrond, is.

Waarnemings en onderhoude is gebruik om die persepsies, opinies en ondervindinge van die leerders te monitor en te noteer. Die studie genereer kwalitatiewe data wat die effek en invloed van die sigblad binne die faktoriserings van algebraïese kwadratiese vergelykings uitwys. Van die data is ook kwantitatief geanaliseer.

Die bevindinge van hierdie studie wys daarop dat leerders entoesiasties en gemotiveerd was tydens die studie en het aktief deelgeneem. Die les binne die projek onderstreep en bevestig 'n positiewe houding met betrekking tot leer deur middel van die web en sigblad.

CHAPTER 1

GENERAL ORIENTATION

Increasingly what educators need to do - our major value added, if you will - is to convey the concepts, the structure, and the basic skills of our fields, thereby enabling the student to continue self-instruction long after class is over.

John Bowes

UW School of Communications

1.1 INTRODUCTION

As the information age evolves, society is undergoing massive changes that have tremendous impact on the educational systems, (Khan, 1998:67). This information evolution makes demands on society, which in turn transfers the demands to education. This transfer is made in the light of the fact that education is seen to prepare people for the future, a future which is likely to be technology driven.

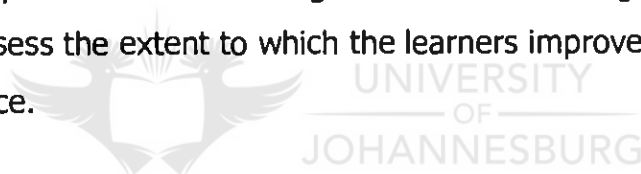
The demands from society do not allow 19th century models of teaching practice to persist. Technology can provide education with a means to facilitate the necessary changes (Carl, 2001:[online]), as computers can increase the scope of strategies, methods and approaches of teaching to benefit more learners. Forcier (1996:2) indicates that technology in education includes among other things, the application of the computer as a multifaceted tool. Furthermore, advances in information technology (IT), coupled with changes in society, are creating new paradigms for education. These paradigms are evident as new methods in the education system in South Africa, where approaches and techniques are designed and implemented, based on the educational needs of the society.

The use of technology can extend to mathematics teaching, especially factorisation. Spreadsheets are a technology that is essential in mathematics teaching and learning as that influence and enhances students' comprehension through graphing, visualizing, and computing effectively and well (National Council for Educators of

Mathematics (NCTM), 2000:[online]). Factorisation as a process needs this efficient technological tool to facilitate understanding of the concept than the mechanics of iterations of finding the correct factors manually (Bakeman, 1992:5). Considering the changing views on how people learn mathematics, new educators must be challenged to understand the necessity for new models of teaching (Artzt, 1999:11).

However, it appears that little information exists in the South African context about the use of computer-based mathematics teaching, especially using a spreadsheet, and it is important that a contextualised investigation into this matter is made. According to Khan (1998:67), learners in this new educational paradigm require rich learning environments, supported by well-designed resources.

The purpose of this research study is to attempt to find out how grade 10 learners of a high school experienced the teaching of factorisation using a spreadsheet, and furthermore, to assess the extent to which the learners improved their factorisation skills and confidence.



1.2 RATIONALE OF THE STUDY

With the societal changes influencing educational practice and the increasing role of technology in education, computers have a role to facilitate learning. Stohl-Drier (2001:[online]) asserts that educators can learn to use spreadsheets to create open-ended, interactive teaching and learning environments that can facilitate learners' conceptual development. The use of spreadsheet can be extended to mathematics teaching especially factorisation.

This is because factorisation runs through every section of the school mathematics curriculum like Algebra, Trigonometry, Geometry, and Calculus in the grades 10 to 12 classes. In the process of being a tool in many sections of mathematics, factorisation influences performance in mathematics nationally as indicated in the table 1.1 below. Of these low numbers, the number of African candidates who participate and succeed is disturbingly low. An analysis of the 2000 Senior

Certificate results indicates that out of a total population of about 489 900 candidates, only 20 243 African candidates wrote mathematics in the Higher Grade. Of these candidates, 3 128 passed (15%) with less than a percent contribution to the general pass rate in the senior certificate examination nationally (see table 1.1 below). On the Standard Grade performance, the table indicates a 23% pass rate in mathematics but a low 8.4% contribution to the general pass rate.

Total number of African candidates who wrote Mathematics exam: 2000									
		489,900 = Total number of candidates							
		Mathematics HG				Mathematics SG			
Province	Candidates	Pass	% Maths	% Overall	Candidates	Pass	% Maths	% Overall	
1 WC	78	21	27%	0.004%	3,889	662	17%	0.135%	
2 NC	12	9	75%	0.002%	671	218	32%	0.044%	
3 FS	471	115	24%	0.023%	12,066	2,454	20%	0.501%	
4 EC	362	113	31%	0.023%	36,736	11,101	30%	2.266%	
5 KZN	5,772	746	13%	0.152%	40,367	10,309	26%	2.104%	
6 MP	1,381	159	12%	0.032%	16,451	3,235	20%	0.660%	
7 NP	7,780	1,041	13%	0.212%	36,884	5,683	15%	1.160%	
8 GAUTENG	812	329	41%	0.067%	20,497	5,478	27%	1.118%	
9 NW	3,575	595	17%	0.121%	12,644	2,200	17%	0.449%	
Total	20,243	3,128	15%	0.638%	180,205	41,340	23%	8.438%	
			AVG					AVG	
			28%	0.071%				23%	0.938%

Table 1.1: Performance of African candidates in mathematics and physical science in 2000 (Adapted from Department of Education, 2001)

The national results of senior certificate mathematics examination for the year 2000 indicates that average percentage pass is **28%** and **23%** for HG and SG respectively whereas the mathematics contribution to the overall pass rate is less than a percentage in both HG and SG (**0.071%** and **0.938%** respectively).

On the other hand the influence of factorisation in the Gauteng Department of Education is about **36.5%** and **42.25%** (Table 1.2 below) of the senior SG and HG certificate examination papers, respectively.

The portion of factorisation in the question papers is about 50% of the total mathematics examination.

YEAR	SG	HG
1997	36.00%	43.50%
1998	34.67%	39.00%
1999	34.00%	46.50%
2000	41.33%	40.00%
AVG	36.50%	42.25%

Table 1.2: Senior Certificate Mathematics Percentage of factorisation in 1997 to 2000 examination papers in Gauteng Department of Education.

There are various ways and methods of factorising quadratics, all of which are time consuming to make sure the learners understand the concept. A spreadsheet package will do this time consuming work at a fraction of the time (Jonassen, 1996:89). Langhorne (1989:130) indicates, in integrating computers into the mathematics curriculum, that students and the educator will be free to concentrate on the concept being illustrated, rather than on the complicated work of finding factors. The spreadsheet has many features that benefit computations of complex functions. Jonassen (2000:86) indicates that the most important function of spreadsheet is to support calculation functions such that any numerical contents of any combination of cells can be mathematically related in just any way the user wishes. An interactive spreadsheet working as an electronic simulator can be used as a tool to greatly extend and enhance the teaching and learning process of mathematics to assist learners with the exploration and discovery of concepts (Stohl-Drier, 2001:[online]). Mathematics and technology can be integrated but mathematics must retain its integrity (Flores, Knaupp, Middleton & Staley, 2002:[online]). Jonassen (1996:69) aptly labels the chapter on spreadsheets as "speculating with numbers" which ties in very well with the factorisation of quadratics.

One of the problems facing schools is access to technology, especially computers, to avail information on latest practices in teaching and learning to both educators

and learners. Through the GautengOnline project, every public school in the Gauteng Province will receive a networked set of about 25 computers with Internet access to facilitate new technology to influence education practices. GautengOnline is an initiative by the Gauteng Provincial Government and the Gauteng Department of Education to provide every learner and educator in all public schools within Gauteng with free Internet access, a free e-mail address and electronic curriculum delivery. The project will create a networked public schooling system, able to harness the full power of information and communication technology, by massively improving the flow of information and resources through the education system to benefit educators, learners, administrators and communities (Petje, 2002:7). The shortage of mathematics educators per school as well as the number of under-qualified or even unqualified mathematics educators can be coordinated to learn from those producing good results through the communication technology this project will afford to schools. This resource can also be utilized to facilitate sharing of ideas, methods and approaches to teaching mathematics more efficiently. The access to Internet can widen the scope of strategies to teaching mathematics sections from all over the world (Mangena, 2001:[online]).

Pogrow (1993:216) argues that computers provide a private environment in which learners can test their ideas at their own speed before having to display their thinking publicly. The confidence growth of learners in mathematics is sometimes inhibited by the reaction of classmates to incorrect responses to mathematics problems. The computer then will provide the protection as it also provides further opportunities to succeed.

With the scarcity of information on factorisation of quadratics using a spreadsheet in South Africa, the study is looking at an area that people in this discipline have not looked at before. I hope it will be adding to knowledge in a way that has not previously been done before.

With the capability of a spreadsheet and the nature of factorising quadratics, the aims for the study are then to:

- Make a contribution towards enabling more mathematics interested learners master the skill of factorisation of quadratics.
- Widen the scope of resources on factorisation for both learners and educators, and
- Boost the confidence of learners of mathematics in basic factorisation skills.

The experiences of the learners who participated in the factorisation of quadratics using a spreadsheet will indicate that it improved their confidence in factorisation of quadratics.

The research question is formulated from the above-mentioned context.

1.3 RESEARCH PROBLEM AND QUESTION

As the need to change the teaching approaches and methodologies has been indicated, the computer as a tool will go a long way to facilitate the process. There seems very little information on the use of a spreadsheet in factorisation of quadratics is available. The focus of the study is on the role a spreadsheet can play in factorisation of quadratics and the experience of the learners using it.

The main research question investigated in this study is:

"How can a web-based spreadsheet be developed for grade ten learners and how can their experiences assist in developing guidelines for web-based mathematics teaching? "

The research question therefore firstly focuses on how grade 10 learners experienced factorisation of quadratics using a web-based spreadsheet, and further, what guidelines may be offered to educators who want to implement spreadsheet-based teaching and learning in similar context.

Specifically, the following sub-questions are to be answered in order to answer the research question:

- How did the learners experience factorisation using a spreadsheet package?

- How did the learners experience collaborative interaction while learning?
- How do learners compare this teaching approach with conventional teaching?
- How could a spreadsheet be implemented in similar situations?

1.4 AIM OF THE STUDY

The study aims at recording and reporting the experiences of learners who attempted to learn using a spreadsheet to factorise quadratics at a high school in the West of Gauteng Province. In order to achieve the aforementioned aim, the objectives are mentioned as follows:

- To describe how spreadsheets are used in Mathematics education
- To describe are the design principles for effective electronic web-based teaching environment including a spreadsheet
- To describe how the learners experienced the spreadsheet-based learning environment
- To provide recommendations for further implementation in the similar situations as compared to conventional approach.

1.5 THE RESEARCH DESIGN

The paragraphs to follow will briefly outline the research design of this study. In chapter four the research design is described fully.

1.5.1 RESEARCH PARADIGM

The study can be classified as a case study using a qualitative approach. The methods of data collection will be qualitative as described in 1.5.4. The nature of this study is explorative and descriptive.

1.5.2 CASE STUDY

The design of this study is a case study. A case study, according to Gay (1990:207) and Huysamen (1994:168), is the "in-depth investigation of an individual, group, or

institution". The primary purpose of a case study is to determine the factors, and relationships among other factors, that have resulted in the current behaviour or status of the subject of the study. A case study's purpose is to answer why, not only what.

The study aims at gaining an holistic idea of the intervention of a spreadsheet course on learners' experiences in one specific institution. This study will be done in natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings learners bring to them.

1.5.3 THE LEARNERS

The learners of this research were Grade 10 mathematics learners at a particular high school in the West of Gauteng Province and their mathematics educator. The factorisation method the learners have been exposed to the face-to-face explanation of factorisation. The number of learners at the beginning was seventeen at the first interview. Ten learners continued with the project for the next four weeks.

1.5.4 DATA COLLECTION METHODS

The research data was collected through observation, interviews and tests and assessment "involving multiple sources of information rich in context" (Creswell, 1994:61). The learners were novice to spreadsheet software and would need basic help with introductory entry to the spreadsheet navigation around the cells. My role then was learner, non-disguised, and direct to help them when they need help (Joppe, n.d.: [online]).

- **Observation:** learners were observed while working on the spreadsheet as field notes were taken during the implementation stage. The notes were useful for describing behaviour of the learners involved in the project. The approach included these two types of observation strategies:

1. **Descriptive observation:** Descriptive observational variables require no inference making on the part of the researcher. When I saw something I wrote it down as observed.
2. **Evaluative:** Evaluative observational variables require the researcher to make an inference and a judgment from the behaviour. I evaluated my observations to distinguish between the factorisation difficulties and computer software problems. I intervened at the critical moment such that the computer issues are out of the way of the learners as they were novice to using spreadsheet. I made an effort to observe and document what occurs in the setting without manipulating variables. Mainly field notes were collected from this natural setting.

④ **Interviews:** I used the benefits of interviews as mentioned below.

- The researcher made extensive probing can to collect detailed information.
- I made sure that the environment was convenient for the respondent in terms of language and time of participation (afternoon).
- The respondent's body language was a guide and was recorded to help interpret comments.

Two interviews (pre- and post-implementation) were conducted for the whole participating class in the presence of their mathematics educator. All the interviews were recorded and transcribed to text. Semi-structured interviews were used with the intention of determining how the learners experienced a spreadsheet in factorisation of quadratics.

④ **Tests and assessment:** The package included assessment test under SUMMARY to determine to what extent the skill to factorise quadratics has improved. The speed at which they finished the work in summary gave an indication of their confidence in finding the correct factors and their combinations.

1.5.5 MEASURES TO ENSURE RIGOUR (TRUSTWORTHINESS)

Strategies and criteria to ensure trustworthiness in this study will be described in chapter four. Morse and Field (1996:118) and Streubert and Carpenter (1995:25-26) suggest four criteria, namely: truth-value or credibility, applicability or transferability, neutrality or confirmability, and consistency or dependability.

1.6 DEFINITION OF KEY TERMS

Some of the key terms will be defined to enable common understanding and help everyone to participate in this project. These terms will be quadratics, factorisation, instructor, web-based classroom and spreadsheet.

1.6.1 Quadratics

A quadratic expression is defined as a polynomial in one or more variables all of whose terms are of degree 2. The general **quadratic** expression in one variable is $ax^2 + bx + c$, in which a , b , and c are arbitrary constants (or parameters) and a is not equal to 0. In the form an equation it will have two roots (not necessarily distinct) (Encyclopædia Britannica, n.d.: [online]).

1.6.2 Factorisation

Alejandre (2001:[online]) defines factoring (factorisation) as the science of redintegration and the reunion of broken parts. Redintegration is the process of making whole again or restoring to a perfect state. An expression is factored completely when it is represented by a product expression that consists of two or more prime numbers, comments Kennedy and Tipps (2000:234). Factorisation is a tool of simplifying, solving for unknowns and building sections of Algebra, Trigonometry, and even Geometry (Euclidian and Analytic). At grade 10 the learners get the basics to build their skills in the matriculation mathematics.

1.6.3 Instructor

An instructor is defined as one who teaches, demonstrates, tutors, trains or provides information on how to do or use something (Wordsmyth, n.d.:[\[online\]](#), the Concise Oxford dictionary, 1991:614 & Collins gem English Dictionary, 1995:284).

1.6.4 Web-based classroom

Turroff (1995:[\[online\]](#)) defines a web-based classroom as a teaching and learning environment located within a computers-mediated communication system. The environment enables access to learning collaboratively between classmates, classmates and instructor/educator and improves the quality and effectiveness of education by using the computer to support a collaborative learning process. Collaborative learning emphasizes group or cooperative efforts among the learners and instructor, active participation and interaction on the part of both learners and instructors, and new knowledge that emerges from an active dialog among those who are sharing ideas and information. It is computer-generated environment that seems real to the user.

1.6.5 Spreadsheet

Carter (1993:200) defines a spreadsheet as a software package that organises data in the form of a table or worksheet. Furthermore, Cartwright (1993:4) calls it a number-processing program, optimized to deal with numbers rather than text. It a computer program allowing manipulation and flexible retrieval of especial tabulated numerical data (the concise Oxford dictionary, 1991:1179).

1.7 THE RESEARCH PROGRAMME

The following is a summary of the stages of the enquiry as set out in the research report.

Chapter 2: Provides an overview of literature on the use of spreadsheets in education and teaching of mathematics with spreadsheets.

Chapter 3: This chapter contains the research design of the study.

Chapter 4: Provides the design and implementation of a spreadsheet-supported learning course on factorisation of quadratics.

Chapter 5: This chapter reports on research findings on the experience of the learners in this study.

Chapter 6: The overview of the study, summary of the findings, conclusion, and recommendations for further research, and limitations of the research findings, will be covered in this chapter.

1.8 SUMMARY



This chapter served as an orientation for this study. It was indicated that computers have found a place in education, especially mathematics education. The different methods of factorisation are mainly used in face-to-face contact. A spreadsheet in mathematics is utilised for drawing and generating graphs. The question that remains to be answered is whether learners can benefit from using a spreadsheet for factorisation of quadratics.

The rationale for the study was placed within a South African context, specifically in the grade 10 mathematics factorisation of algebraic quadratics.

From the above context, the research question was formulated and this in turn generated sub-questions. These sub-questions were used to formulate a set of objectives for the study. The research design was described, and then followed by the research program. In the next chapter, an overview of literature on the use of the spreadsheets in mathematics education is given.

CHAPTER 2

SPREADSHEETS AND TEACHING AND LEARNING MATHEMATICS

2.1 INTRODUCTION

Mathematics performance at school level especially grade 12 is 28% and 23% for HG and SG respectively. Factorisation of quadratics plays a very important role as shown in the Gauteng Department of Education 1997 to 2000 question papers (table 1.2). With the scarcity of information on factorisation of quadratics using a spreadsheet in South Africa, the study is looking at an area that people in this discipline have not looked at before.

This chapter presents a review of literature on spreadsheets, the use of spreadsheets in education, and mathematics learning and teaching in particular.

2.2 SPREADSHEETS IN EDUCATION: A THEORETICAL PERSPECTIVE

2.2.1 WHAT IS A SPREADSHEET?

Carter (1993:200) defines a spreadsheet as a software package that organises data in the form of a table or worksheet. Furthermore, Cartwright (1993:4) calls it a number-processing program, optimized to deal with numbers rather than text. James (n.d.:[online](#)) also defines a spreadsheet as the computer equivalent of a paper ledger sheet consisting of a grid made from columns and rows.

Spreadsheets can be regarded as computerised, numerical record-keeping systems and has three major functions, namely storing, calculating and presenting information. It is an environment that can make number manipulation easy and somewhat painless.

Spreadsheets are made up of

- columns (vertical space up and down) designated by letters.
- rows (horizontal space across) designated by numbers, and
- their intersections are called cells

In each cell there may be the following types of data

- text (labels like a name or day anything that is just text). Labels are text entries. They do not have a value associated with them. Typically they are used to identify what we are talking about.
- number data (constants like 5 or 5.73 or -87.4 or any number). Constants are entries that have a specific fixed value.
- formulas (A sequence of values, cell references, names, functions, or operators in a cell that together produce a new value (Bakeman, 1992:8). A formula always begins with an equal sign (=) or plus/addition sign (+). They represent mathematical equations that do all the work that calculates the value to display. The formula or equation is typed and not the numbers we are looking for. This equation will be updated upon the change or entry of any data that is referenced in the equation.

Features that distinguish the spreadsheet for mathematics utilization include the quick calculations, formulas and referencing. Referencing as much data as possible as opposed to typing data into equations has benefits. A reference identifies a cell or a range of cells on a worksheet and tells Microsoft Excel where to look for the values or data to be used in a formula. With references, data contained in different parts of a worksheet is used in one formula or in several formulas.

There are two kinds of formulas available to use in a spreadsheet. There are functions and those that can be formulated as the need arises. A function is a pre-written formula that takes a value or values, performs an operation, and returns a value or values (Bakeman, 1992:9). The use of functions is to simplify and shorten formulas on a worksheet, especially those that perform lengthy or complex calculations.

The features to be used in the spreadsheet package were:

- Comments: to facilitate interactivity in the form of instructions to follow, steps of factorisation, questions to be answered and general comments
- Formulas: to facilitate combinations of numbers (data) to produce an answer. The data will be in the form of factors, amongst other numbers, in this study.
- Calculations: to facilitate immediate feedback on entries like factors.
- Colours: to facilitate and enhance the look and drawing attention to the family or similar or related cells using filling of cells and or font colours for related data.

Cartwright (1993:7) mentions that spreadsheets are easy to program to a working model, easy to modify as nothing is hidden (e.g. formulas) from the user. The user can understand how the model works and what happens to the data as entered to get the results. He further states that spreadsheets are flexible and powerful because of the inbuilt functions as Carter (1993:205) indicates that a spreadsheet can be particularly good for handling numerical data and calculating results instantly. Carter (1993:204) and Jonassen (2000:104) further say a spreadsheet can easily and quickly enhance investigation and facilitate decision-making and planning for the next step. The charts and graphs that a spreadsheet can generate are a great summary and expression of a lot of data into meaningful information (i.e. spreadsheet integrate graphics with computation). Sorting and searching for data or information are some of the strengths embedded in the spreadsheet (Carter, 1993:204). They allow the user to see all of the numbers at one time. This is important in trying to keep track of a lot of different things, or when dealing with the "What if" questions scenarios. With a calculator, changing a number means retyping the entire problem. With a spreadsheet, when one cell is changed, the computer does the recalculations. A spreadsheet is a content-free piece of software that needs exploring.

Although a spreadsheet is a versatile tool, it is most effective in solving quantitative problems. A spreadsheet with its cellular nature can be slow and inelegant compared to the command and procedure-based programmes which are

able to compute many different results (Cartwright, 1993:8). For a spreadsheet one needs to write many formulas to get those results. They are mainly intended to manipulate and represent quantitative information. They are most useful in mathematics and science and in some social science applications like economics, psychology and sociology (Jonassen, 2000:105).

However, a spreadsheet is already popular in mathematics education as well as other learning areas mentioned in the following paragraphs.

2.2.2 THE USES OF SPREADSHEET IN MATHEMATICS EDUCATION

Hunt (1996:[online]) asserts that a spreadsheet's versatility allows a wide range of activities including dynamic graphical demonstrations of statistical concepts, simulations, investigations, interactive "What if ...?" scenarios and simple animations. A spreadsheet is generally used for putting data on a table and analyse it into information to be assigned meaning and displayed or summarised. The information comes as graphs, models, patterns and simulations and assist in decision making like prediction.

The examples that will follow demonstrate the categories spreadsheets have been usefully utilized to support the learning of mathematics by showing graphical representations of the concepts involved. The brief discussion of the examples highlights the aspects of the spreadsheet that is used in the section of mathematics. Generally these examples take advantage of the quick calculations through formulas and immediate updates of the graphic representations after changes to data have been done.

2.2.2.1 PREDICTION

Garner (1995:[online]) uses the strength of the fast calculations a spreadsheet can do to prepare pay plans as an example of prediction using “what if ...” scenarios.

● Pay Plans – predicting calculations to help decision-making. The learner got a job with Gina's Tape Shop. He had a choice of two different pay plans:

- Plan A Earnings: R120 per week plus 10% of sales

- Plan B Earnings: R90 per week plus 15% of sales

The average sales per week were R400.

They calculated how much one would earn with each payment plan over 4 weeks and decide which plan would be better in the same period?

	A	B	C
1	Sales	Plan A	Plan B
2	R400	=120+10%*A2	=90+15%*A2
3	4 weeks	R640	R600

Table 2.1: Pay plans calculations to choose a better one

Plan A was better as it yielded **R640** against **R600** for plan B.

The spreadsheet functions used were: percentage calculation and referencing for a value (i.e. A2 in this case). The value at A2 can be changed to predict an outcome.

2.2.2.2 GENERATING GRAPHS

Graphs summarise the numeric data into a picture representing information about the collected data. The most popular use of the spreadsheet is to generate graphs from tables. The graphs below represent a parabola where the values of a and b change whilst c equal to 0 in this parabola graph formula $y=ax^2 + bx + c$ ($a > 0$; $b < 0$ and $c = 0$) illustrated by figure 2.1.

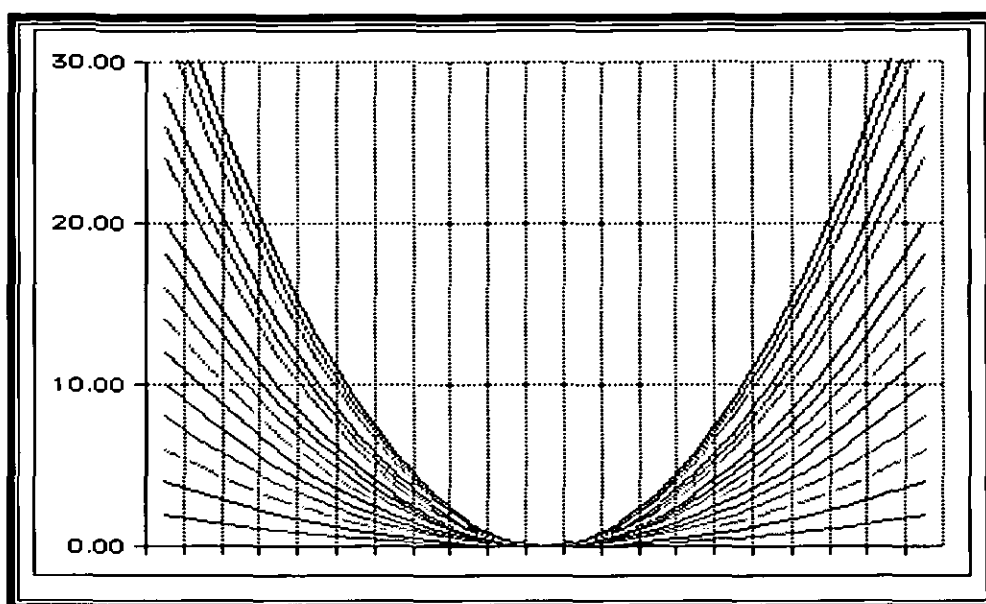


Figure 2.1: Parabola graphs generated from a spreadsheet: (Garner 1995).

2.2.2.3 MODELING

The next common use of spreadsheets is symbolic modeling through the spreadsheet where mathematical relationships are expressed in terms of variables (Monahan, 2000:6). Modeling, as Morgan (1984:2) defines it, is a process where a complicated reality or process with some features stripped off in order to work with just the minimum to facilitate understanding and insight of the process. Monahan uses a lease/buy problem where a group is supposed to decide whether to buy or lease a photocopying machine to save after three years. The learners had to find the total number of copies that will make them breakeven against their present usage of the machine. Leasing the machine proved less costly in their circumstances (Monahan, 2000:13 – 21).

However, the pyramid and box models use the strength of spreadsheet where changes are effected instantly to trace the progress towards finding the solution.

■ Pyramid model

The Greatest Pyramid problem (Garner, 1995:[online]) demands that the learners find the best dimensions for the pyramid. The height of the pyramid is a function of the other lengths. The graphic image of the pyramid structure shows the effects of the changes as they are made on the tables.

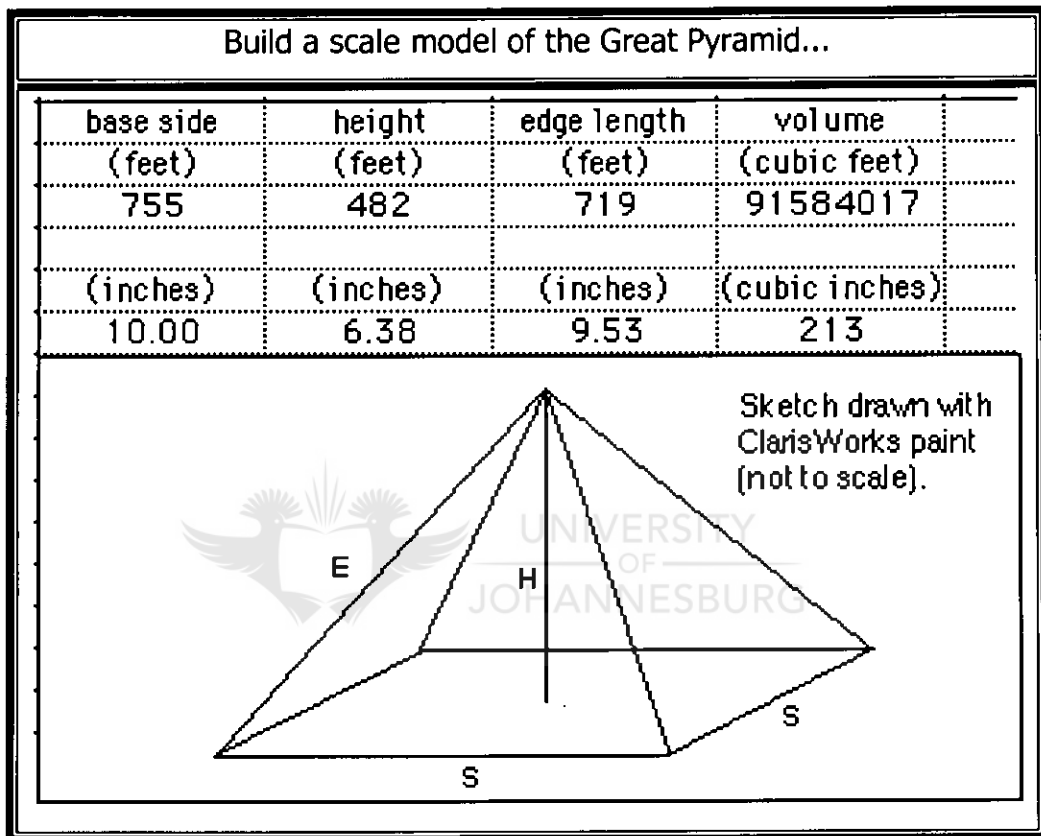


Figure 2.2: Great Pyramid Model: Garner (1995)

■ The Biggest Box Model

The model of "The Biggest Box" demands fast calculations (Garner, 1995:[online]) for decision-making calculus. Cutting a particular size of squares on the corners of the original open square board of three metres will make the biggest box. The accompanying graph shows effects of the changes as they are made on the tables as the size of the side of the square corners is increased or decreased. The graph indicates the biggest box will be made when a square of 0.5 cm side is cut (maximum volume). The link between table, graph (parabola) and graphical

representation of the box demonstrate the effects of changes on the table instantly making the learning of calculus concept on maximum or minimum real to the learners (figure 2.3).

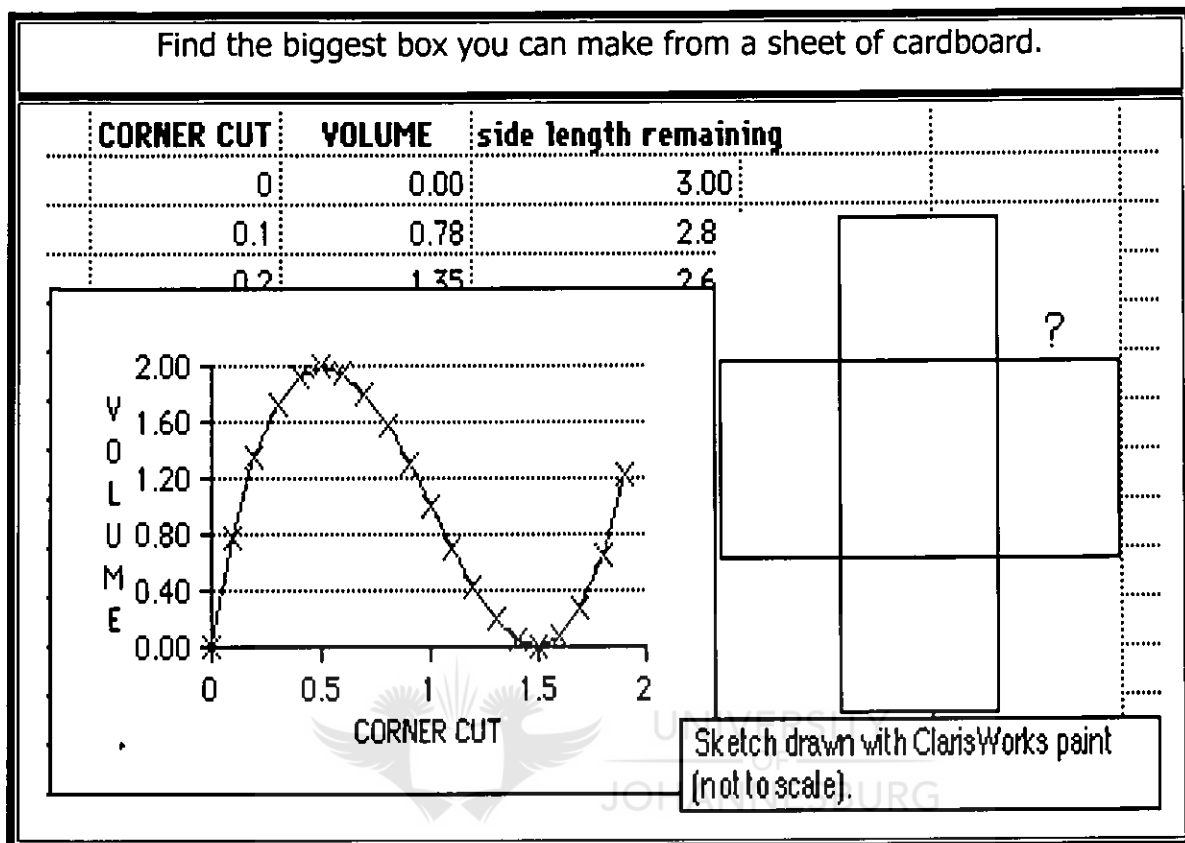


Figure 2.3: The Biggest Box Model

2.2.2.4 GENERATING PATTERNS

The spreadsheet is used again to generate patterns by means of formulas like in developing Pascal's triangle where the formulas of adding cells diagonally up to the left and diagonally down to the left (sum of up and down left diagonal cells) in Bakeman (1992:43-45). The formulas are copied in a pattern to facilitate the calculation. The strength of instant computing of the spreadsheet facilitates the quick calculation of the triangle values (table 2.2).

Using similar formulas Arithmetic and Geometric Series are developed as patterns.

		L	M	N	O	P		
Terms (n)		1	2	3	4	5	Formula	Sum total
Series	Arithmetic	2	7	12	17	22	=+L3+5	=SUM(L2:P2) (60)
	Geometric	2	8	16	32	64	=L\$4*\$N\$5^P\$2	=SUM(M4:Q4) (122)

Table 2.2: Arithmetic and geometric series and their spreadsheet functions

Arithmetic series uses referencing cells (+L3), and sum of cells functions as the geometric series uses locked cells (\$) and exponent function (^) with the sum function. The locked cells had the first terms, the constant difference (arithmetic series) or ratio (geometric series) and the term counters (1, 2, ... 5) for reference.

2.2.2.5 SIMULATION

Simulation is mimicking the real world or actual process to help understand and test the rules of a model and spreadsheets are beneficial in teaching a concept that is remote and almost abstract to the learner (Sully, 1993:9; Morgan, 1984:1). The calculation in Physics about weight in Mars versus on earth is a typical investigation. The calculations are instant and can be viewed graphically to show the changes.

- How Much Would I Weigh on Mars? – a person with a mass of 75 kg weighs 28.4 kg in Mars and weighs 189.7 kg in Jupiter as indicated in figure 2.4 below.

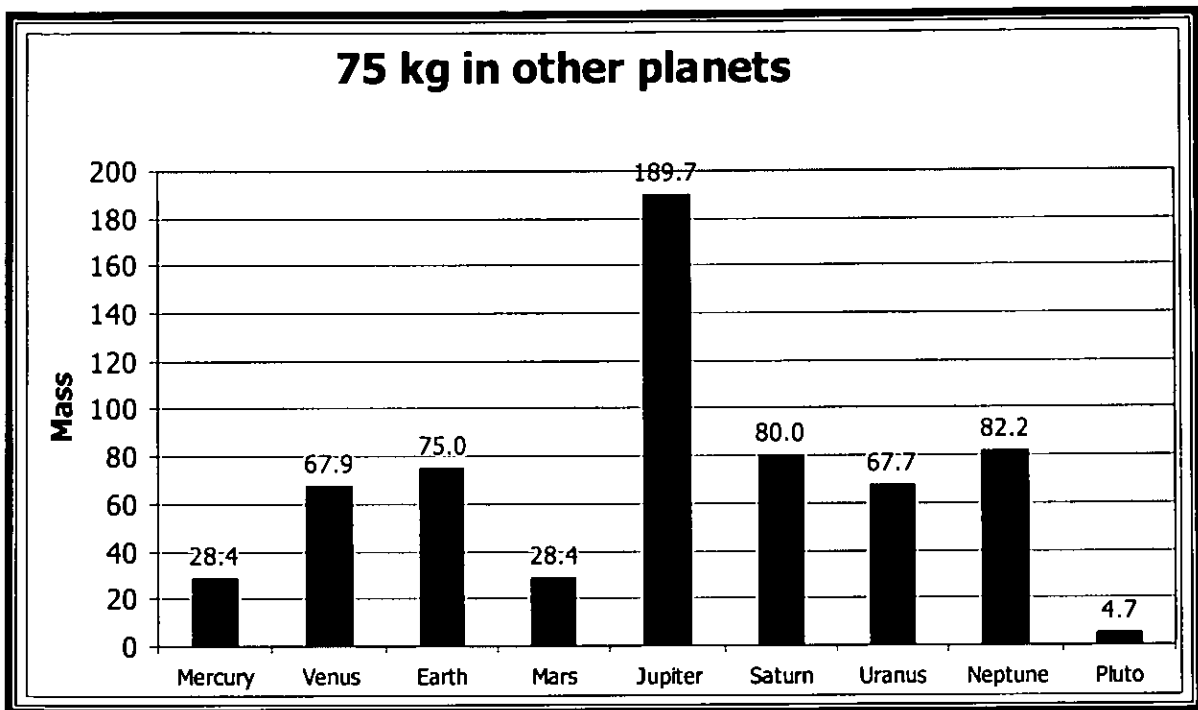


Figure 2.4: Weight comparisons on planets

Spreadsheets are also utilised in subjects or learning areas other than mathematics. The sciences and commercial sciences learning areas also utilize spreadsheets as an indication to the wider use of spreadsheets in education.

2.3 SPREADSHEETS AND FACTORISATION OF QUADRATICS

Mathematics and the spreadsheets have a lot in common: they both work very well with number processing as Carter (1993:205) indicates that a spreadsheet can be particularly good for handling numerical data and calculating results instantly. This study focuses on another use of a spreadsheet because of the efficiency in fast computations from formulas. The use of the spreadsheet in mathematics learning has been indicated but has a further contribution to make in the factorisation of quadratics.

The use of spreadsheets in the teaching of Mathematics is often construed to be an innovation that brings a change to the subject matter from a computational perspective alone. A further reason for using a spreadsheet is to allow exploration of possibilities, particularly to ask "what if?" questions in the search of the correct

factors in the factorisation process (Edwards & Finlay, 1997:4). While spreadsheets do aid computations in powerful ways, it is possible to use this technology towards conceptual enhancement of traditional approaches to mathematics teaching and learning through a tool kit approach. Factorisation of quadratics needs this strength of the spreadsheet.

2.3.1 FACTORISATION OF QUADRATICS

Factorisation of quadratics as a process will benefit from spreadsheet computational abilities and speed. This section will deal with the definition of factorisation and the available common methods used in the classrooms.

2.3.2 DEFINITION OF FACTORISATION

Alejandre (2001:[online]) defines factoring (factorisation) as the science of reintegration and the reunion of broken parts. Reintegration is the process of making whole again or restoring to a perfect state. An expression is factored completely when it is represented by a product expression that consists of two or more prime numbers, comments Kennedy and Tipps (2000:234). A spreadsheet will be used to do factorisation of expressions like trinomials and binomials.

The types of factorisation methods towards factorising quadratics of the form $ax^2 + bx + c$. The emphasis is more on the independence of the learner to progress in mastering the skill of factorisation.

The researcher briefly described available methods, approaches and tools used to simplify the skill of factorisation.

2.3.3 AVAILABLE METHODS

There is variety of methods used in schools and online support or even distance learning programmes or courses. The researcher looked at these four methods and approaches.

There are many varieties of ways and methods of factorisation of trinomials. The methods are used in face-to-face classrooms and/or web-based and online lessons.

- a) Technologically worked-out solution supplied to the user online.
- b) The box or gelosia method
- c) Area model (Generic rectangle method)
- d) FOIL method

Figure 2.5 below is the graphical representation of the factorisation methods that will be discussed in the next sections.

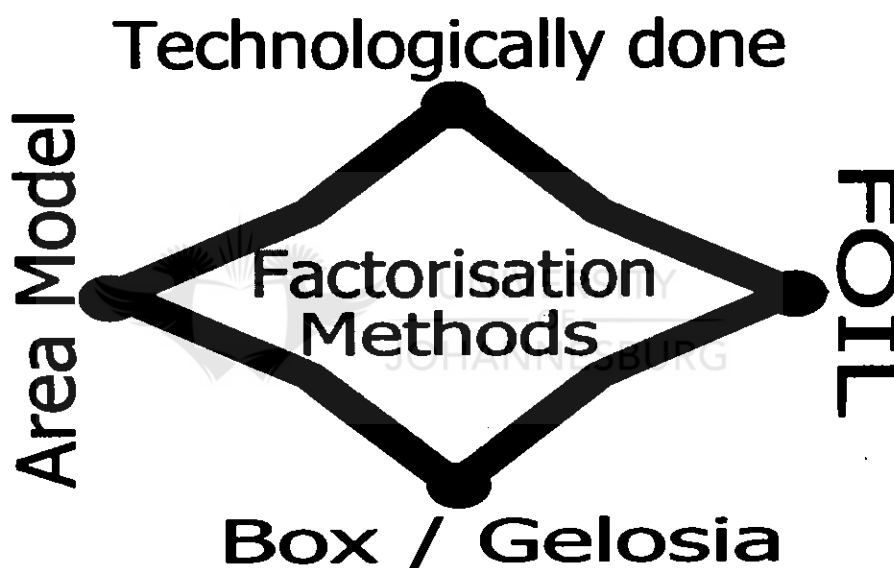


Figure 2.5: Graphical representation of Factorisation Methods

2.3.3.1 Technologically worked-out solution

The learner types the expression and a solution is given. The solution will be correct but the learner might not be able to explain the solution. Quickmath Automatic Math Solutions (2002:[online]) is one of the internet-based service providers with a program that factorizes a quadratic and supply solution instantly.

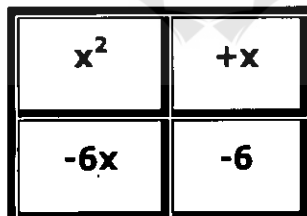
The automatic solutions have limits as many institutions do not have the technology to use. The hands-on methods include the box or gelosia, area and FOIL that will be discussed below.

2.3.3.2 The box or gelosia method

The method in the Educator2Educator discussion "Factoring quadratics using a box divided into fourths" was posted by Ballew (2000:[online]) and described as "more reachable by students". The method is described in the example that follows:

The box, or gelosia approach is one of many ways educators try to make factoring trinomials (and some tetranomials) more reachable by students.

Let's use $x^2 - 5x - 6$ as an example step-by-step to illustrate the method. One looks for the combination that will fit the box as shown in figure 2.6 below:



x^2	$+x$
$-6x$	-6

Figure 2.6: Representing the box used in the box method

Now $(x-6)(x+1)$ is checked to see that does indeed multiply together to make $x^2 - 5x - 6$ and the task is completed.

The weakness of the approach is the "good guess" the learner must make to get the combination for the middle and last term. If the possible pairs are many, time to search can be against the learner. For the weak one, the search can be frustrating and may lead to despair.

The method also depends very much on other sections that should have been done before this actual factoring a trinomial. The method of distribution or removing of brackets is used to check the correctness of the factors. The strength of the method, on the other hand, is the transparency of the approach. The learner notices that the factors are sought and checked before making a decision. The problem solving skill is learnt and put to practice.

The area model is connected to the above-used box or gelosia method.

2.3.3.3 Area model (Generic rectangle method)

Alejandre (2000:[online]), Cleveland (2000:[online]) and Stapel (2000:[online]) suggest this method as modified a-b-c method, or "box". The method uses Algebra tiles in "factoring using a generic rectangle" and is based upon an area model of multiplication. This method uses tiles to represent the process of factorisation as shown in figures 2.7 and 2.8 below.

Example:

$x^2 + 5x + 6$ looks like this with algebra tiles

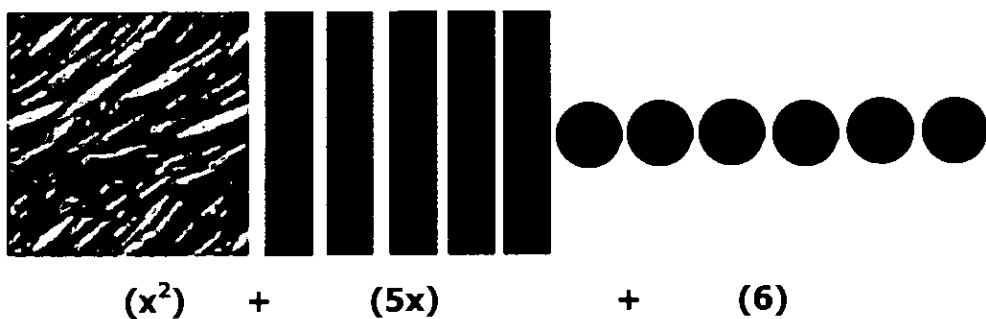


Figure 2.7: Tiles representing the area model method

When the tiles are rearranged to make a rectangle it would look like this:

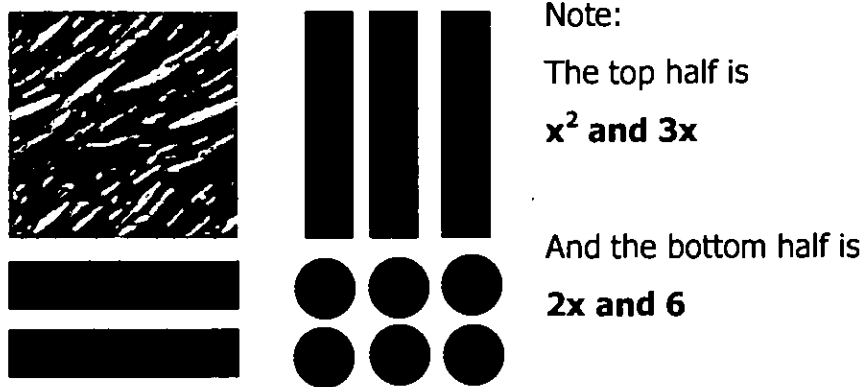


Figure 2.8: Rearranged tiles representing the area model method

The solution is $(x+2)(x+3)$

The strengths and weaknesses of this method are similar to the box's above.

2.3.3.4 FOIL METHOD

The FOIL method emphasizes the link between the processes of factorisation and multiplication of factors as its strength. Nichols, Edwards, Garland, Hoffman, Mamary and Palmer (1992:174) and Taylor and Myburgh (1986:60-61) use the FOIL method. FOIL represents the positions of terms in the expression (product of two binomials). FOIL stands First term, Outer terms, Inner terms and Last term during the pairing of terms in the multiplication out of the brackets. The method relies on testing combinations of factors until the correct one is found.

Example: Factor $x^2 - 7x + 12$ into two binomials.

12 has these factors as **6 x 2**, **3 x 4** and **1 x 12**

This method lays down a lot of combinations in search for the correct combination. Below are some of the combinations to illustrate the method that will give the correct middle term, **- 7x**

- 6x	- 12x	- 3x
<u>- 2x</u>	<u>- 1x</u>	<u>- 4x</u>
- 8x	-13x	- 7x

Check by multiplying. $(1x - 3)(1x - 4)$

$$- 3x \text{ and } - 4x = - 7x$$

Thus, $x^2 - 7x + 12 = (x - 3)(x - 4)$ or $(x - 4)(x - 3)$

The weaknesses of the method are really the amount of written numbers in search of the correct combination. The many combinations in front of them could confuse learners. The method is similar to the other two methods in the approach of getting many factors and combines them into a solution to the problem.

The strength of the approach however is the openness of the steps toward the solution. The learners can appreciate the trial and error steps in the search for the correct factors.

Table 2.3 summarises all the factorisation methods and their characteristics as discussed above.



METHOD	COMPUTATION OF FACTORS	WEAKNESSES	STRENGTHS
Technology worked out	Hidden and done by the calculator or computer	No explanation of method of factorisation	Very quick and trial and error is removed
BOX OR GELOSIA: Ballew (2000:[online])	Use box to graphically show the factoring process	Trial and error in finding factors open to mistakes and time consuming	Transparent to the learner in finding the factors
AREA MODEL: Jeanne and Stapel (2000,:[online])	Use tiles to represent the terms and rearrange the tiles to try different combinations and test back to the original quadratic.	Trial and error in finding factors and time consuming and open to mistakes	Transparent to the learner in finding the factors by manipulating tiles to form a rectangle with a particular area
FOIL: Nichols, Edwards, Garland, Hoffman, Mamary and Palmer (1992:174)	Tests combinations and remove the brackets to test whether the original quadratic is obtained again, otherwise try another set of factors	Trial and error in finding factors and time consuming and open to mistakes of choice of factors and signs.	Transparent to the learner in finding the factors by choosing factors and signs in the bracket format and test them to the original quadratic

Table 2.3: Summary of factorisation methods

2.3.3.5 COMMON TRENDS IN FACTORISATION

There are critical points and steps in all the methods. The methods highlight the cycle of the equation: **MULTIPLICATION** (FOIL) \Leftrightarrow **FACTORISATION**. The process of factorisation must be reversible to the original expression (quadratic). The process is then focusing on finding the correct combination to satisfy the equation.

The variation in the methods is a search to make factorisation "more reachable by students" indicates Ballew (2000:[online]). While others view the wide scope of methods as rich resources, learners might still be looking for some method or approach accommodating independent response or correction. The response needs to be immediate but still allow opportunities to try again immediately. The long wait of confirmation of work well done or "your choice of factors is not leading to the solution", the next morning, is removed in the spreadsheet design.

The methods above are an expanded version of a process that could be accomplished by a spreadsheet's strengths of formulas and calculations.

The study will look at the key and critical steps and values in the route to factorising an expression. Important features embedded in the design of the programme are:

- Steps are always available on the corresponding cells
- Immediate checking of the answers (factors) towards a solution

The factors must be able to yield the original expression when reversed (brackets have been removed).

Every method uses "trial and error approach" (Waner & Costenoble, 1998:[online]) to the solution of factorizing a trinomial. The factors get more difficult as bigger numbers are used in the expressions. When the learner is

still at the stage of learning the skill, the factors of the numbers are a matter of trial and error.

The approaches to learning a skill, specifically of factorisation, in a new platform (i.e. a web-based spreadsheet environment) where the learners have never used it before, a help-along view need to be followed. There are stages of entry to the learning environment that will be briefly discussed below.

2.4 PEDAGOGICAL PERSPECTIVE ON MATHEMATICS LEARNING AND THE MEDIUM OF INSTRUCTION AND LEARNING

The pedagogical perspective refers to the educational activities that enhance or make it possible for teaching and learning to occur. These pedagogical activities are discussed in the following paragraphs:

- Factors affecting mathematics learning
- Anticipated learner response to the new medium of instruction and learning
- Assessment in mathematics using levels in Bloom's Taxonomy

2.4.1 FACTORS AFFECTING MATHEMATICS LEARNING

Many learners consider mathematics very difficult and thus low expectations of success then choose other subjects (Grouws & Lembke, 1996:43). Challenges learners meet and experience in learning mathematics do influence this attitude and performance. The understanding of how people learn mathematics is now more than just how one does sums but instead how people make sense from signs and symbols, how they operate with these symbols and how meaning is developed. Factorisation of quadratics learning by doing is the motto of the new medium and things that can be learned by doing are different than things than can be learned by listening.

Brissenden (1980:6) suggests two main working principles in teaching mathematics as action by educator and the kinds of feedback to be looked for in the lessons. The principles are to maximize the mathematical work of the pupils and minimize the

mathematics the educator does; and the educator must try to find out as much as possible about what the learners are thinking.

Learners need to be actively involved rather than passively listen to the lesson of mathematics as the educator maximizes the mathematics of the learners. Effective discourse between the educator and the learners, and among learners, is a key to mathematics teaching and learning, Kloosterman (1996:142) and Ball (1986:27) explain. The sharing of ideas in class irrespective of whether the answer is correct or not, is important to facilitate this discourse.

Regarding feedback, the educator must listen to the thinking of the learners very carefully; watch what they do in the process of working out the solution. The feedback must be immediate as needed and questions must be preferred to explanations of planned expositions. Marking is another important form of feedback that makes more impact when done frequent and immediate.

Grouws and Lembke (1996:58) advocate strongly that the educator work to create a classroom atmosphere in which learners come to see mathematics as something requiring exploration, representation and reflection. Ball (1986:28) asserts that a computer as a medium can go long way to facilitate exploration, verification and reflection more effectively using the features of the spreadsheet to be helpful in the teaching of factorisation.

2.4.2 ANTICIPATED LEARNER RESPONSE TO THE MEDIUM OF INSTRUCTION AND LEARNING

There are three levels a computer plays in education to enhance and to provide an extra hand to better education delivery in the form of a tool, an environment and as a medium of instruction or learning (Blythe, 1997:[online]).

- Computers can operate as **tools** located within the larger "walk-in" mathematics center itself. The computer can be a tool located on desks that helps with storing and organizing data.

- Computers can also operate as **environments** as a shift the focus from the computer as a tool to the computer as an environment in which students can work and interact as it provides the context in which discussion could take place (Ball, 1986:22-23).
- Computers, finally, can operate as a **medium** that presents tools in a particular environment. A given computer can offer a space filled with tools and symbols, thereby creating a medium through which one reads and writes, a medium that delivers and presents information in a way unique from other media.

Consequently, each application of computer technology creates a medium that, through the arrangement of tools and space, enables doing mathematics using applicable software.

The experience to use a computer as a medium of learning has a few challenges awaiting educators and learners at the beginning. In contrast to the presentation-based approach of conventional instruction: "teaching by telling", the emerging paradigm is being shaped by the "learning-through-doing" environments made possible by the new media. Nonetheless, volitional control of learning by learners rather than by the instructor (Palloff & Pratt, 1999:5) was key to participation. Entry stage in this new medium focuses on the situational activities, which will encourage the learner to participate willingly in the web-based classroom.

McGonigle and Eggers, (1998:[online]) provide the transitional stages, affecting both instructors and learners, into this new medium of instruction. For an instructor, there are seven basic stages through which the instructor typically passes when designing and teaching a web-based course. Some stages are more difficult than are others. The stages are: Excited Stage, Apprehensive Stage, Questioning Stage, Determined Stage, Over-stimulated Stage, Questioning Stage Revisited, Exhausted Stage. McGonigle and Eggers (1998:[online]) suggest that learners have their own five stages of progression.

Students also have their own stages of new medium entrance. The first time through the stages involved in taking a web-based course is the most difficult. The

stages are confused stage, shock stage, timid stage, and frustrated and final stages.

● **Confused stage**

This stage is marked by questions like: "How does this work?" and "How can one do that?" The learners are confused when they are told about web-based material available on the WWW and spreadsheet. The learners are expected to understand the concept of how the spreadsheet works, especially when it comes to basics. It was further explained that to reduce the amount of negative impact on the learners, the instructor should anticipate the needs and concerns of these inexperienced learners.

● **Shock stage**

The shock stage normally occurs when learners try to access the course materials and, after surmounting all of the technical difficulties that they encounter, learners enter the "Shock Stage" when they realise that they have "Got in!" It is during this phase that learners become more comfortable with the technology, barring other techno-problems sending them back through this phase.

● **Timid stage**

The learners are hesitant to face danger or difficulties; fearful and nervous about breaking the computer or cause it to switch off by mere touching. This stage enables the learners to access the learning materials and experience the feeling of isolation. They become aware that they don't have visual contact with other learners in the web-based classroom.

● **Frustrated stage**

Glitches, as they always crop up, drive learners to quickly move to the "frustrated stage". Simply accessing the Internet causes frustration for learners. The unavailability of the computers because of the time chosen by everyone else, when learners are attempting to access the Internet from home and not being able to get in via the modem, or getting disconnected after they have accessed the Internet. It was recommended that one of the most basic things the instructor should do to

alleviate this frustration, is to alert learners to the possible problems that may occur when accessing the Internet.

● **Final stage**

At the end of the process of new medium, the learners finally reach the "Eureka stage". This is when everything goes smoothly, without techno-problems and learners feel that all course materials could be offered via the Internet (web-based). When learners mastered Internet web-based classroom skills, they enjoy learning by means of the Web and become eager and want to explore more.

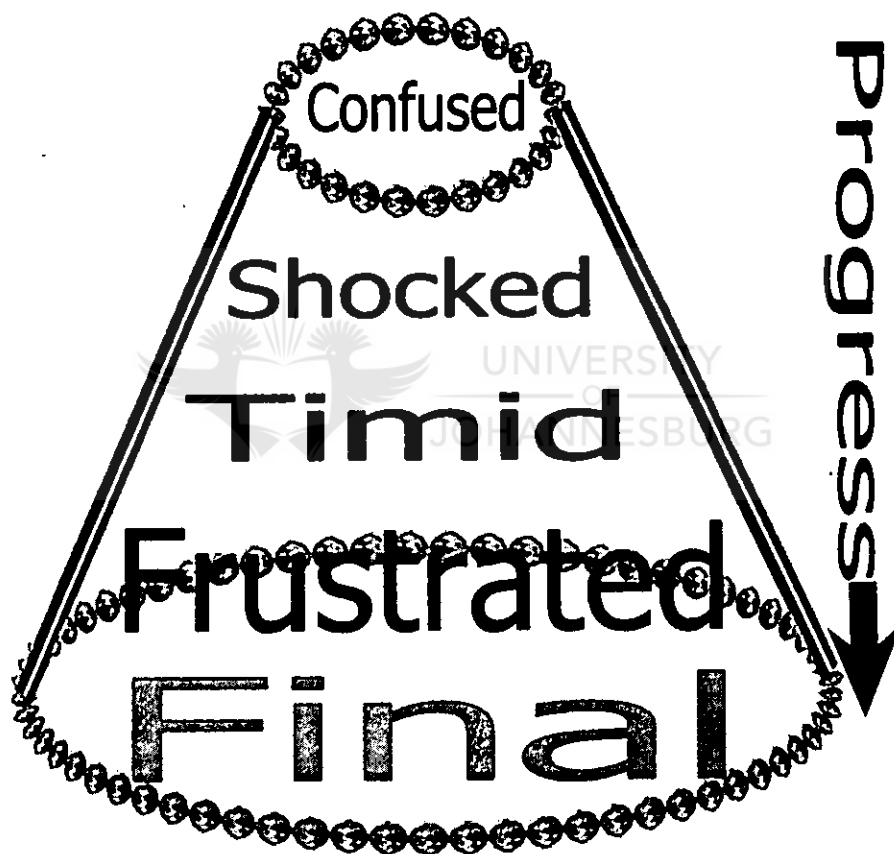


Figure 2.9: Web-based class entrance stages (McGonigle & Eggers (1998))

The stages of entry to the new medium of learning for learners are seen to be progressing from a small door and opening to a wider one as the learners understand and appreciate the experience and instruction as illustrated in **figure 2.9** above.

2.4.3 ASSESSMENT USING BLOOM'S TAXONOMY

This paragraph will describe the assessment levels from Bloom's Taxonomy. Fowler (1996:[online]) looks at the role Bloom's Taxonomy play in improving critical thinking and problems solving skills development. Bloom's Taxonomy divides the way people learn into three domains. One of these is the cognitive domain that emphasizes intellectual outcomes. This domain is further divided into categories or levels. The three domains are cognitive, affective, and psychomotor. Domains can be thought of as categories. Cognitive is for mental skills (Knowledge), affective is for growth in feelings or emotional areas (Attitude), while psychomotor is for manual or physical skills (Skills). This taxonomy of learning behaviours can be thought of as "the goals of the training process." That is, after the training session, the learner should have acquired these new skills, knowledge, or attitudes in the following levels in table 2.4 below:

Level 6: Evaluation	Presenting and defending opinions by making judgments about information, validity of ideas or quality of work based on a set of criteria.
Level 5: Synthesis	Compiling information together in a different way by combining elements in a new pattern or proposing alternative solutions.
Level 4: Analysis	Examining and breaking information into parts by identifying motives or causes; making inferences and finding evidence to support generalizations.
Level 3: Application	Solving problems by applying acquired knowledge, facts, techniques and rules in a different way.
Level 2: Comprehension	Demonstrating understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions and stating main ideas.
Level 1: Knowledge	Exhibits previously learned material by recalling facts, terms, basic concepts and answers.

Table 2.4: Bloom's Taxonomy

The levels were used in the setting of questions to encourage some development of critical thinking in the learners deeper than the level of knowledge. The types of questions were dealt with in chapter 4 (**section 4.4.1.4**).

2.5 SUMMARY

The chapter provided a theoretical perspective on spreadsheets in education, factorisation of quadratics, methods and tools used in South Africa and other countries, pedagogical perspective on mathematics learning and new medium of instruction and learning.

The focus of the study is the role a spreadsheet can play in the factorisation of quadratics. The common trends in the factorisation of quadratics were isolated in **paragraph 2.3.3.5** to help focus the development of the spreadsheet package.

The study on spreadsheet use in mathematics will inform the research design in the next chapter.



CHAPTER 3

THE RESEARCH DESIGN OF THE STUDY

3.1 INTRODUCTION

This chapter will describe the research design that was followed in order to answer the research question identified in chapter one. The collecting, recording and interpreting of the data that was used in this research project will be focused on. Research is defined as a systematic process of collecting and logically analysing information for some purpose (McMillan & Schumacher, 1993:8).

3.2 PURPOSE OF THE RESEARCH

The study aims at recording and reporting the experiences of learners who attempted to learn factorisation of quadratics using a spreadsheet at a high school. In order to achieve the aforementioned purpose, the objectives are mentioned as follows:

- To define and describe spreadsheet instruction in the context of this study;
- To describe learners experience of confidence during the presentation of the course;
- To determine whether learners experience interaction leading to deeper learning; and
- To provide recommendations for further implementation in the similar situations as compared to conventional approach.

In short the purpose of this study is to determine whether Grade 10 learners found a spreadsheet-supported factorisation course was more helpful and beneficial to their skills and knowledge of factorisation. The study also wants to determine whether their attitudes towards the spreadsheet-based learning were positively influenced by the particular project design.

3.3 RESEARCH DESIGN

Mouton and Marais (1994:32) define research design as the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure. Therefore research design is to align the pursuit of a research goal with practical considerations and limitations of the project and implying that research is planned. The aim of a research design is to plan and structure a given research project in such a manner that the eventual validity of the research findings is maximized.

This study used qualitative research design approach to examine the effects of Web-supported learning of Grade 10 learners' attitudes towards web-based spreadsheet instruction and their acquired skills and knowledge of the use of spreadsheet tools in education. This study was based on a qualitative research approach and was as such descriptive, exploratory and explanatory (Merriam, 1998:5) and (Mouton & Marais, 1996:51). According to Merriam, qualitative research does not test a theory, or measure anything. The qualitative research is a method that provides a way to understand the experience of the learners in the project. Therefore this approach has been selected to understand the experiences of first time users of the spreadsheet in the web environment.

This study is focused on understanding how learners experience spreadsheet-supported course with respect to the natural ways of learning (Ellington, 1993:22-27, 179-180). Ellington indicates four overlapping stages of learning. They are

● Wanting to learn	motivation, enthusiasm, interest and so on
● Doing	having a go, trying things out, learning from mistakes, etc
● Feedback	finding out whether it was right or wrong, seeing the results
● Digesting	making sense of the learning experience and of feedback, etc

Table 3.1: Representation of Ellington's stages of learning

Computer-based learning has a chance to fit into this natural way of learning as it affords the learner with all the four stages with ease. Pogrow (1993:216) agrees also that learners need to get feedback while they remember exactly what they are getting feedback about. The learners have a great deal of control even repeating parts of the package until it makes sense to them. Pogrow (1993:216) argues that computers provide a private environment in which learners can test their ideas at their own speed before having to display their thinking publicly. The feedback on the work does not wait for the next moment the educator sees the work.

This case study qualitative design as an approach will focus on intensive descriptions and analyses of the learners' feedback on their experiences (Merriam, 1998:19). Learners in this study described their experiences through qualitative interviews. The research employed the descriptive, explorative and explanatory study design in approach.

- **Descriptive** research design aim at the researchers' goal, which is to describe that exists as accurately as possible (Mouton & Marais, 1988:44; Merriam, 1998:7) as it considers the total context of the environment and setting. The researcher described the learners' perception of web-supported learning as compared to conventional teaching. The learners described their perceptions of Web-supported lessons in their school as they experienced them. This was to enable them to present an accurate description of what was being studied.
- **Explorative** research aims at the exploration of a relatively unknown research area. Therefore in the context of this study, spreadsheet-supported factorisation learning can be considered as a relatively unknown field of study. The lesson has been planned, where grade 10 learners were to explore the capabilities of spreadsheet in supporting conventional learning approach. Learners were expected complete a given project learning via the web on their own.

Commitment to the learners' point of view is critical in the search for the reality of the study, indicate Streubert and Carpenter (1995:11). The qualitative exploratory approach enabled the researcher to share in the understanding and perceptions of

others and to explore how people structure and give answers to their natural context (Streubert & Carpenter, 1995:11). Therefore, the researcher was able to hear from the learners how they experienced spreadsheet-supported course at a West Gauteng Province High School.

3.4 RESEARCH METHOD

The research method in this study was that of a case study. The methods of data collection were qualitative involving fieldwork as described in 1.5.4. The researcher went to the school physically in order to observe behaviour in its natural setting (Merriam, 1998:7). The nature of this study was explorative and descriptive as this was first time that learners learn to factorise using a spreadsheet. The approach used is qualitative, and the interpretation of data was descriptive. The case study used an emic approach, meaning from within (Burns & Grove, 1997:77). An in-depth investigation of the implementation of a spreadsheet-based instruction course at a West Gauteng Province High School was done. Learners were observed, interviewed and their responses were analysed to determine the effects of a spreadsheet-based instruction course.

A case study, according to Gay (1990:207) and Huysamen (1994:168), is the "in-depth investigation of an individual, group, or institution". The primary purpose of a case study is to determine the factors, and relationships among other factors, that have resulted in the current behaviour or status of the subject of the study. A case study's purpose is to answer why, not only what. However, data consists of words in the form of rich verbal description, rather than numbers. Case studies are particularistic, descriptive and heuristic, and rely heavily on inductive reasoning in the handling of multiple data sources.

3.5 DATA COLLECTION TECHNIQUES USED IN THIS STUDY

Burns and Grove (1997:78) suggest that data collection involves primarily observation and interview in qualitative research. The study used various data generation techniques for analysis and collection purposes. Data triangulation,

Patton (1990:187), Burns and Grove (1993:32) indicate, involves gathering accounts of a situation from a variety of sources in a study. Burgess (1984:146) suggests that the account in the teaching situation must be taken from three quite different points of view: namely those of the educator his/her pupils, and a learner/observer. Furthermore, these different qualitative techniques could provide verbal descriptions, the goal of each being to capture the richness and complexity of behavior that occurs in natural settings. The researcher became a learner/observer in the process as the technology, (spreadsheet package) was foreign to the learners.

Mason (1996:36) disputes the use of "collecting" data concept for qualitative research. Mason prefers generating data as the researcher cannot find ready-to-collect data but must generate it. The researcher then used both terms to mean the same effect.

The research data will be generated through:

- ④ **Observations.**
- ④ **Interviews**
- ④ **Tests and assessment**

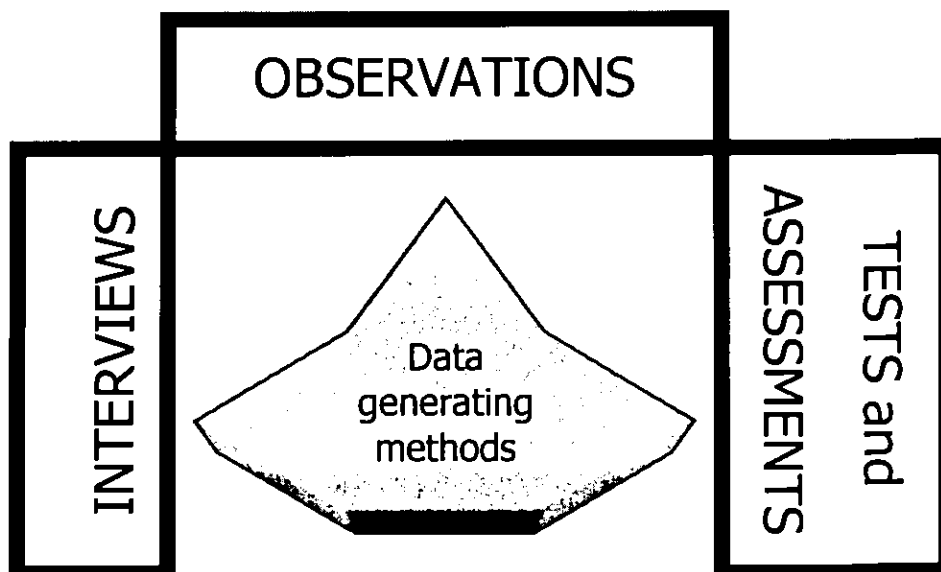


Figure 3.1: Data collection methods

The data generation techniques are described in the following paragraphs:

3.5.1 LEARNER OBSERVATION

The Grade 10 learners were given a briefing at the beginning with regard to the prepared web-based classroom in the computer laboratory and the research project. Observations are amongst the major divisions of collecting data for descriptive statistics, normally done in a naturalistic setting in their laboratory. The learners were urged to be as free and natural as possible as they were going to be observed in the process. They were communicating electronically, i.e. by sending e-mail to the researcher and classmates as they contribute to the solutions of the problems.

The observation of the learners focused on the language, navigation in the spreadsheet, reading and using comments as provided as steps and questions, ease of doing the exercises and collaboration amongst the learners and the researcher. The researcher used learner observation as "one of several methods" and entered into and became involved in the social world of the learners he was researching to "gain your understandings", Mason (1996:63-64) suggests. The involvement was informed by possible language barriers in the communication between learners themselves and also with the researcher. An observation entails looking, listening, asking questions, and collecting artifacts. According to Streubert and Carpenter (1995:98), observations can be descriptive, focused and selective observations. Descriptive observation was used to enter, got an overview and determined what the learners knew about factorisation. The researcher carefully considered the findings in the construction of the spreadsheet package.

Field notes were taken during the implementation stage throughout the observation of the learners.

3.5.2 INTERVIEWS

Best (1977:182-183) rates interviews very highly as a tool that is able to produce more in-depth data due to follow-up questions. Holstein and Gubrium (1997:113) also take interviewing as providing a way of generating empirical data about the social world by asking people to talk about their experiences. In this study interviews were used to follow up on observation of the focus group. The researcher used the formal and open-ended interviews. All the interviews were recorded and transcribed to text. Semi-structured interviews were used with the purpose of determining the extent to which the spreadsheet influence mastering factorisation of quadratics.

The interview styles that have been reported in this study were conversational formal interviews with the researcher and the learners. In the formal and open-ended interview, structured and semi-structured questions were prepared and designed to generate data about learners' experience in the factorisation using a spreadsheet. The interview employed probing and follow-ups to responses the learners were giving. There were two sets of interviews. There were pre- and post completion of the project interviews.

The pre-completion interview aimed at finding out the mode of factorisation the learners were taught in class. The learners were asked to define factorisation and describe the process and steps used to finally factorise an expression. The interview also looked at the learners' depth on computer skills (i.e. which application software have they done already). The skills of computer use of the learners were established in the same interview, as well. The entire interview was recorded (Appendix A contains a transcript of the pre-completion interview) and was analysed in the next chapter.

The learners were invited to attend a focus interview after the completion of the project. The learners were interviewed on the last day of their final submission of the project. This interview used a combination of structured and unstructured questions approach. A question was raised to start the conversation, aiming at

obtaining the learners' experiences and their perceptions of spreadsheet-based instruction. The context of the questions was the feedback on the whole journey of entering the web-based world. Other sub-questions were allowed to emanate during the interviewing process.

The entire interview was recorded (Appendix B containing a transcript of the post-completion interview) and also analysed.

3.5.3 TESTS AND ASSESSMENT

The spreadsheet package included tasks (exercises) for each type of expression an assessment test to practice and learn the skill of factorisation using the steps as provided.

There was a summary assessment task at the end to determine to what extent the skill to factorise quadratics has changed. This summary (figure 3.2) task combined all the types of expressions covered in the package, there were no tools like steps to factorise provided in this task, and still had its own set of questions like the other tasks. This section had a time limit for them to complete the tasks to determine the confidence in using the spreadsheet package and factorisation.

MIXED EXPRESSIONS; a=1 [x² -/+b -/+c]; b=0 also												
x ² means x squared	FACTORISED				Isolate terms		Factors		Check			
	Trinomial	Bracket 1	Bracket 2		MT	LT	F1	F2	MT	LT		
	ax ² +bx+c	F1	F2		b	c	F1	F2	+	F1+F2	*	F1*F2
I	x ² + 6x - 27	x 0	x 0						0	0	0	0
II	x ² - 19x + 18	x 0	x 0						0	0	0	0
III	x ² - 3x - 28	x 0	x 0						0	0	0	0
IV	x ² + x - 2	x 0	x 0						0	0	0	0
V	x ² - 9x - 580	x 0	x 0						0	0	0	0
VI	x ² - 7x - 44	x 0	x 0						0	0	0	0
VII	x ² + 3x - 10	x 0	x 0						0	0	0	0

Use e-mail to answer the questions given above from problem I to VII.

Figure 3.2: An example of the summary worksheet

3.6 DATA ANALYSIS

Merriam (1998:178), Burns and Grove (1997:51) looked at data analysis as a process of making sense out of one's data, and this could be achieved by consolidating, reducing, and to some extent, the interpretation thereof. The analysis of data is done in conjunction with data generation as observation and qualitative interview are done. The goal of data analysis is to come up with reasonable conclusions and meaning to the generated data.

At this data analysis stage of the research, the researcher typed verbatim transcriptions of the interviews. The researcher has to dwell on, or be immersed in data as Streubert and Carpenter (1995:24) put it. Thus, the researcher read and re-read the verbatim transcriptions and played and re-played the videotaped interviews to get the themes, concepts and ideas of the learners' experiences of Web-supported learning at a high school in the West of Gauteng Province.

The researcher and an independent coder used the open-coding method of data analysis. The researcher followed the Tesch's method with the following steps as covered by Creswell (1994:155):

- Getting a sense of the whole. Reading through all the transcripts carefully. Writing down some ideas as they come to mind;
- Choose the most interesting, shortest document and go through it, asking oneself what it entails whilst underlying the meaning. Thoughts are to be written in the margin;
- Having completed all the documentation, list all of the topics. Group similar topics together and arrange them into major topics, unique topics and those left over;
- Take a list, go back to the data, abbreviate topics as codes and write the codes next to the appropriate segment of the text. This will enable one to realise new categories and codes;

- ④ Find the most descriptive wording for the topics and turn them into categories. Grouping together topics that relate to each other. One may draw lines between categories to show relationships;
- ④ Make a final decision on the abbreviation of each category and code them alphabetically;
- ④ Data material belonging to each category should be assembled and put in one place for preliminary analysis; and
- ④ Record existing data.

Finally, the results were transcribed and recorded. With the assistance of an independent coder, the analysed categories, concepts and ideas were discussed to reach some consensus.

3.7 THE RIGOUR (TRUSTWORTHINESS) OF THE RESEARCH

The researcher ensured that a measure of rigour was observed in this study. Morse and Field (1996:118) and Streubert and Carpenter (1995:25-26) suggest four criteria, namely: truth-value or credibility, applicability or transferability, and neutrality or confirmability, and consistency or dependability.

3.7.1 THE CRITERION OF CREDIBILITY

The purpose of the exercise is to have those who lived the described experience validate that the reported findings represent them. Some call the exercise "member checks". Credibility of evidence is obtained from the findings of the research as authentic experiences of the learners of spreadsheet-based Instruction, as lived and perceived by them. Prolonged engagement with the project and learners can also be used to give the evidence credibility. During the observations and interview the researcher put the respondents at ease to verbalize their experiences. The situation enabled the respondents to reveal even uncomfortable facts about their experiences of Web-supported learning.

3.7.2 THE CRITERION OF TRANSFERABILITY

This criterion is also called fittingness or applicability (Streubert & Carpenter, 1995:26). The findings of the study must be able to have meaning to others in similar situations, context or groups (Morse & Field, 1996:118). Dense description of background information about the respondents and research context has already been given. Other users of the findings will have to rely on available data from this study to ensure transferability. This will enable others to assess how transferable the findings are to another settings. The representative of situational context serves as a deciding factor as the efficiency in the language of the medium (i.e. English), novice in the use of spreadsheet, and the ability to factorise quadratics need consideration in the transferability of the findings.

3.7.3 THE CRITERION OF NEUTRALITY

Neutrality or confirmability is a process criterion according to Streubert and Carpenter (1995:28). To ensure that the data is not biased, the researcher ensured confirmability through engagement, member checks and periods of observation of learners using the spreadsheet, Morse and Fields (1996:118) suggest. The types of quadratics to factorise were changing whilst the structure of the spreadsheet did not change. The focus was on the experiences of the learners on using a spreadsheet to factorise quadratics. The researcher solicited assistance from an independent, qualitative researcher to analyze and reduce the data.

3.7.4 THE CRITERION OF DEPENDABILITY

Consistency is another important criterion used to evaluate trustworthiness. Morse and Field (1996: 118) argued whether the findings would be consistent if the enquiry was replicated with the same subjects or in a similar context. The qualitative research design emphasizes the uniqueness of human situation, so that variation in experience rather than identical repetition is to be expected. There can be no dependability without credibility (Lincoln & Guba cited by Streubert & Carpenter, 1995:26).

The above-mentioned criteria of credibility, transferability, neutrality and dependability are interrelated and all work together towards a measure of rigour as summarized in figure 3.3 below.

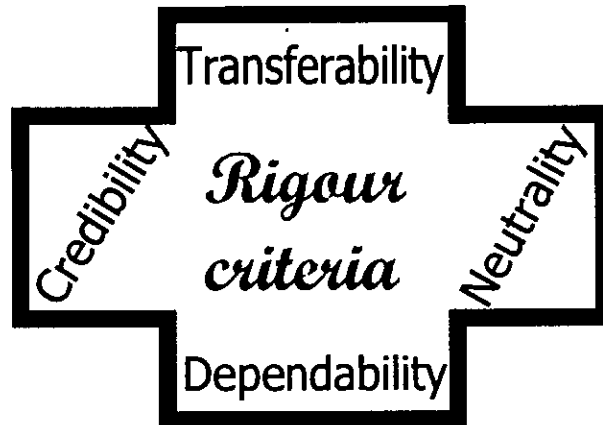


Figure 3.3: Summary of the trustworthiness (rigour) criteria

At the end of the research, a focus group discussion was held with all the learners to make sure that the findings were credible enough. Questions were asked, and from the responses it was noticed that the project was complex because of technical, on-line communication and motivational issues.

3.8 SUMMARY

This chapter has given an overview of a theoretical framework for research methods and techniques within this specific field. The research design of the study, approach that was employed in the study, data generation techniques and analysis were fully described as well as the research strategies used, were described. Lastly, the trustworthiness was also explained.

The next chapter covers the design and implementation of the web-based spreadsheet.

CHAPTER 4

DESIGN AND IMPLEMENTATION OF THE WEB-BASED SPREADSHEET

4.1 INTRODUCTION

The focus of the study is on the role a spreadsheet can play in the factorisation of quadratics. The common trends in the factorisation of quadratics were identified in **paragraph 2.3.3.5** to help focus the development of the spreadsheet package.

Streibel (1993:159) says "Because all people exercise practical judgment in the process of constructing meaning while teaching and learning, instructional designers will have to find ways to create useful resources for educators and learners that support the meaning-making process". The designer can do that by posing problems and critical questions rather than pre-digested puzzles. Streibel argues that the human factor, needs, pre-understandings brought to the situation must be accommodated in the design. The design will combine both ideas as the available methods (**paragraph 2.3.3**) to accommodate the needs of the users.

Jonassen (2000:104) explains that people working with numbers, including mathematics educators, need to take full advantage of the potential of the spreadsheet's ability to eliminate the need for time consuming manipulation and calculation of numbers. The trial-and-error nature of finding the correct factors in factorisation of quadratics will benefit from the spreadsheet as a tool or a manipulative in the hand of a skilful user.

To assess the feasibility of the delivery of effective factorisation of algebraic expressions using the spreadsheet, a project was planned and implemented for grade 10 learners. Learners from a high school in the West of Gauteng Province were requested to participate to answer the research question in **paragraph 1.3**. This project focused on the experience of learners who participated in a web-based

classroom. From the literature review emerged ideas on methods and media used to facilitate the learning of factorisation within the context of this particular High School, the project designed and implemented.

This chapter will consider and map the development of the design and the eventual implementation of the spreadsheet-based factorisation of quadratics package.

4.2 THE CONTEXT OF THE IMPLEMENTATION OF THE WEB-BASED SPREADSHEET PACKAGE

The context of implementation refers to the school, class, subject and aim, which are discussed in the following paragraphs: Nominal sample (i.e. the purposive sample) method was used in this research to bring the group together. The criterion for the sample was that the learners were doing Mathematics and Computer Studies as choice subjects in grade 10.

4.2.1 THE SCHOOL

The case study was carried out at a high school situated at Mohlakeng Township near Randfontein in the Westrand. The school has grade 8 to grade 12 classes. The school caters for learners with various economic, social, cultural and language backgrounds coming from the township and nearby farms that do not have a secondary level of education. Although English is the medium of instruction, English is their second, third or even fourth language as they offer Afrikaans, English, Setswana, IsiXhosa and IsisZulu.

The school has two sets of computers. The first set is stand-alone computers and the second set is networked computers connected to the Internet. Computer Studies is offered to the learners as a standard grade subject from grade 10 to grade 12. The learners must also take mathematics as a subject in their package of subjects.

4.2.2 THE LEARNING AREA MATHEMATICS

The school is gradually introducing information technology in education curriculum. There are learners who are doing Computer Studies from grade 10 up to grade 12. The learners in the study are the group that does Mathematics as well as Computer Studies.

The group had done factorisation of expressions in mathematics earlier in the year already. Factorisation is introduced properly more at grade 10 as a preparation for grade 11 mathematics curriculum. Factorisation is then used as a tool on sections like Algebraic functions and Trigonometry. A web-based classroom was created for the implementation of spreadsheet-based instruction lessons for grade 10.

4.2.3 THE LEARNERS

The learners are encouraged to choose and enrol for Computer Studies to acquire computer skills. The school will be delivering its second matriculation class for the Computer Studies at the end of 2001.

The learners attend school on a full-time basis and had not had access to a web-based spreadsheet prior to the project. The grade 10 web-based classroom was structured around their mathematics syllabi and has the following features:

- A home page with various links and graphics (**figure 4.1**) below;
- Clearly defined project and instruction pages;
- A discussion forum page;

CHARACTERISTICS	DESCRIPTION
Learner status	Full-time learners (grade 10)
Age range	15 to 18 years.
Gender	6 girls and 4 boys.
Computer literacy	Learners are literate in the use of hardware and MS <i>Word</i> .
E-mail and Internet literacy	Some learners are still learning to use e-mail and struggling to access specific sites on their own and need guidance.
Spreadsheet (Excel)	No learner had used Excel before the project.

Table 4.1: Characteristics of the learners

4.2.4 THE AIM OF DEVELOPING THE WEB-BASED SPREADSHEET FACTORISATION PACKAGE

The aim of the web-based spreadsheet factorisation package is to provide information at the right time (in-time rather than just-in-case). The courseware will be available at the time of need to facilitate independent access to factorisation with little outside help. The software tool used for creating this web-based classroom was *Microsoft FrontPage 2000*, and the factorisation of quadratics used *Microsoft Excel 2000*.

4.3 THE DESIGN AND DEVELOPMENT OF THE WEB-BASED CLASSROOM

The web-based classroom was designed and developed with many components bearing various characteristics. In this case, the web-based classroom was designed to be user friendly. The classroom consisted of six pages including the home page. Graphics, related to the content in each page, are used to guide the learner. The design also displayed both text and animation, but learners were not expected to

change or alter the web-based classroom. A folder was created for saving all the graphics to be used in creating a web-based classroom. A home page created with some graphics and text was hyper-linked to specific pages of the web-based classroom. The e-mail address of the researcher and instructor also appear on the home page.

4.3.1 DEVELOPMENT APPROACH

The study looked at the key and critical steps and values in the route to factorising a quadratic. Strengths embedded in the design of the programme were influenced by the pre-implementation interview (Appendix A). The interview revealed some critical information in the knowledge of the learners about factorisation:

- Definition of factorisation was a problem
- Factors of numbers was a problem for some learners
- The role of the values of a, b and c in $ax^2 \pm bx \pm c$ expression
- The role of the signs of b and of c in the expression
- The class used FOIL method in factorisation
- Steps to follow to factorise quadratics are made clear
- Immediate feedback on factors is important to build confidence

FrontPage 2000 was used to develop the web-based classroom. Microsoft Excel was used in the development of the task material of factorisation of the quadratics. The spreadsheet was used to draw from its many features that benefit computations of complex functions. Jonassen (2000:86) indicates that the most important function of spreadsheet is to support calculation functions such that any numerical contents of any combination of cells can be mathematically related in just any way the user wishes. HTML editor like Front Page enables Web page designers to design Web pages without having prior knowledge and skills of HTML.

Alden (1998:23) indicates that most of these editors use menus and drag-and-drop capabilities to construct the necessary coding, which normally include a WYSIWYG interface ("What you see is what you get"), meaning that the developer can see what the page would actually look like on a browser.

In this regard, a web-based classroom was created or designed to be user friendly and consisted of six pages including the home page. Graphics relating to the content in each page was used to guide the learner. The design is based on text and number viewing. Various animations were used where applicable. A folder was created for saving all the graphics to be used in creating a web-based classroom. A home page created with some graphics and text was hyper-linked to specific pages of the web-based classroom.

4.3.2 DESIGN CONSIDERATIONS

Alden (1998:16) emphasizes the layout and appearance of the Web pages will have a significant impact on the actions of the learners. The Web page is, above all, a teaching tool, so it should be appealing and easy for learners to use. Writing for the web is very different to writing for print. Time is of the essence to most people using the Internet, so users don't want to read reams of text on-line. It is also harder to read from a computer screen than it is from paper. The content on the computer monitor should be readable and able to engage the learners' attention in presenting the content. Criswell (1989:83) reported that people read 25% faster from paper than from a computer screen.

The design will follow simulation sequencing (Criswell; 1989:124) as opposed to a tutorial. Criswell further indicates that simulation allows trial and-error learning necessary in the factorisation. The single-skill-level simulation approach will be followed where learners get a practice for a skill in similar situations or exercises to gain experience and lead to mastering the skill as suggested by Criswell. The learners have acquired the skills of factorisation through the face-to-face teaching in the conventional classroom. The emphasis is more on the new medium.

Ingram (1999:[online]), citing McCormack and Jones (1998:[online]), and Skaalid (1999:[online]) also suggests some design principles of an instructionally efficient Web page as discussed in **table 4.2** below. The researcher used the guidelines in designing and developing the particular instructional Web pages.

Analysis	The goals and objectives were specified accommodating learners' level of language and their local context (including the technological context).
Development	Use one of the available Web editors to do the actual pages for your site. Microsoft FrontPage 2000 was used.
Page Design, interface and simplicity	<p>The page layout was made clean and simple, where graphics, bullets, headings, etc. were used discerningly. The design of the interface should not distract the user from the content.</p> <p>The designer must keep message as simple as possible to the level of the audience. Only the amount of text and graphics to get a point across and promoting understanding must be used. Limited animation or decoration on the screen was used to keep the look of the page simple. Those elements were used wisely and selectively. The page length was short to avoid too much vertical scrolling.</p>
Content accuracy and clarity	The content was accurate and at the correct level of the learners' competencies, topic, relevance and scope. Spelling was checked and links were made fully functional at all times to avoid distracting the user.
Consistency and balance	Instructional web pages must show formal balance with symmetry on the screen being similar in shape, size and colour to the items on the other side of the screen. This made it easier for the learners to navigate the system.
Harmony, Unity and uniqueness	Harmony was fostered through similar fonts and colours, pictures relevant to the topic with graphics similar in tone. Ensuring that all the items present on a page appear to belong together and different pages in the site are similar in content and design fostered unity.

Table 4.2: McCormack and Jones (1998) and Skaalid (1999) design principles.

The website of the web-based spreadsheet package used the above guidelines, as suggested by McCormack and Jones and Skaalid, to make it as instructionally user friendly as possible.

4.3.3 ORGANISATION AND PRESENTATION OF MATERIAL

Ingram (1999:[online]) further deals with the organisation of the website as covered by McCormack and Jones (1998:[online]). Ingram distinguishes between the presentation structure and the storage structure. The presentation structure is the interrelationships of pages as someone navigating through the site experiences them. The storage structure on the other hand consists of the actual files and directories that exist on the hard drive.

The website package will focus mostly on the presentation structure, as it is user friendly, defines how a visitor to the site can access and traverse the Web-based classroom, and the quality of presentation will influence whether or not visitors can find what they are looking for or not.

Alden (1998:28) explains the term *navigation* as referring to the process of using links to help the learners move through the materials that make up a course. Alden (1998:29) identifies the following navigation functions: Home, top of page, next (forward) and previous (back).

The structure of the web-based classroom has the following pages:

- *Home page* – entrance to the whole site
- *The structure of the website is non-linear* - all pages are linked to each other. The frame is the banner and content format. The format has the heading, table of content and the current page.
- *Table of contents* - with each unit title serving as a link;
- *Tracing procedure* – all browsers provide "Back" and "Forward" buttons that allow learners to move backward and forward along the path through the pages that they have already taken.

The home page is the orientation page for the whole class. The home page links all the different pages of the website and is stable. This page also serves as the entrance to the next level that has the table of contents. This level takes the user to various pages of the web-based classroom.

4.4 DESCRIBING THE WEB-BASED CLASSROOM

The Web-based classroom was designed to enhance learning and interaction between the learners and the instructor.

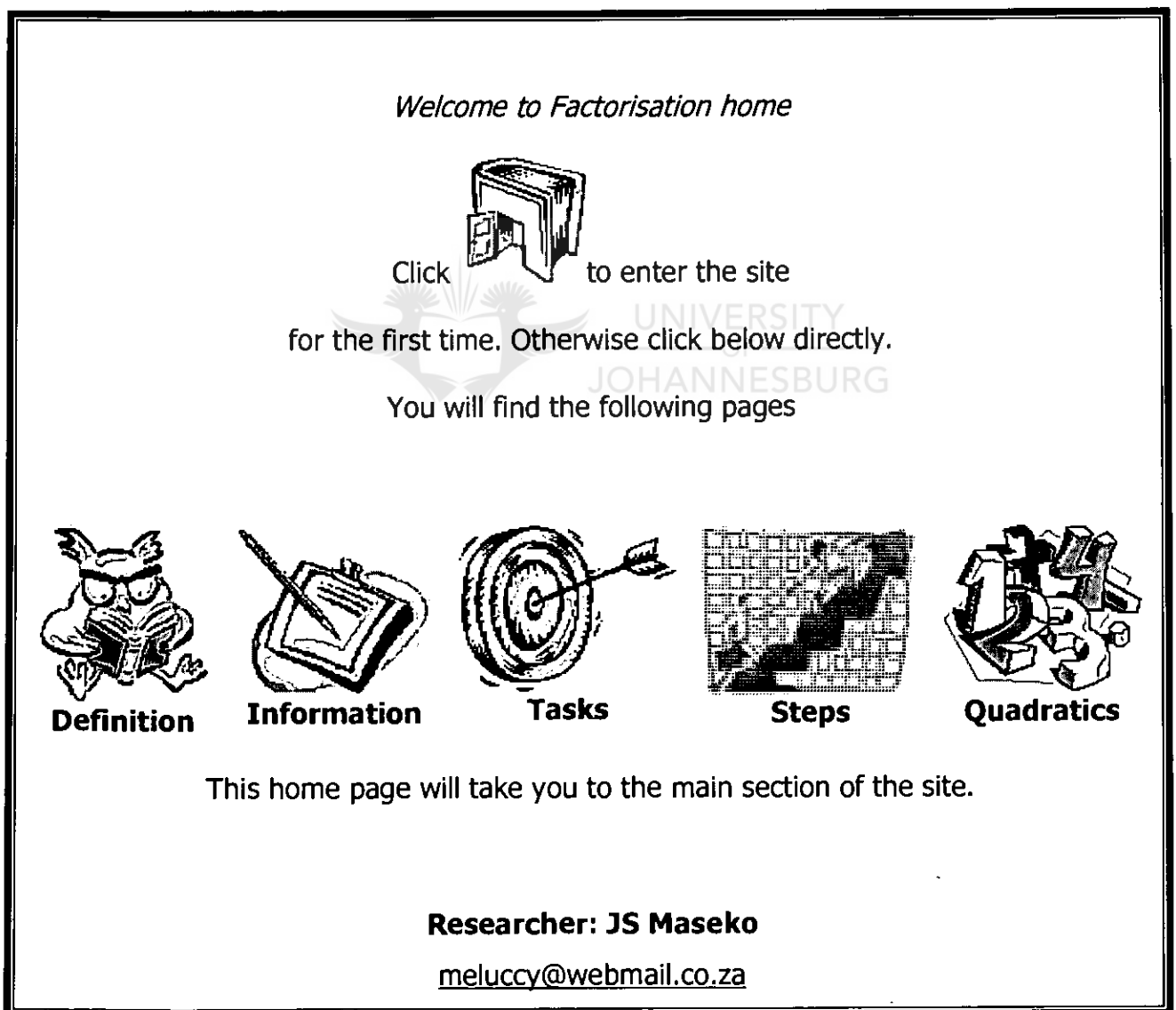


Figure 4.1: The home page of the web-based classroom

4.4.1 THE WEB-BASED CLASSROOM COMPOSITION

The web-based class consists of the following components:

A home page containing six links to different components of the web-based classroom.

The components of the home page are as indicated in table 4.3 below:

Web page	Contents
■ Definition	Definition of Factorisation answering what is factorisation;
■ Information	Class information names and e-mail addresses of the learners;
■ Tasks	Factorisation exercises to be done;
■ Steps	Procedure of factorisation; and
■ Quadratics	The types of quadratic expressions to be factorised

Table 4.3: Components of the web-based spreadsheet classroom

Figure 4.1 above represents the home page. Graphics and text that are hyper-linked to a specific component of the classroom are described below.

4.4.1.1 GRADE 10 INFORMATION

This page consists of the class information, names and the e-mail addresses of the learners.

4.4.1.2 LINKS

The links lead learners to the spreadsheet that has activities for the factorisation work and back as well as between pages. The links lead to posting of the responses by means of e-mail.

4.4.1.3 COMMUNICATION FORMAT

The page for posting responses has links to the spreadsheet and submits through to the researcher. The e-mail was the vehicle to send their responses to each other

and to the researcher. This is a area where learners communicate with one another about certain steps of the project.

4.4.1.4 TASKS

Tasks are all the work components that the learners are expected to complete and submit to the instructor and educator via e-mail using the links. The whole process was taking place electronically in a web-based classroom.

All the information received from the pre-implementation interview in section 4.3.1 above was used in the design of the tasks in the spreadsheet. The tasks in the spreadsheet were covering the expressions to be factorised. The form of the expressions is $ax^2 + bx + c$ and exercises include:

Type of quadratic	Values			Steps provided or not
	a	b	c	
Positive c	a=1	b is ±	C is pos	Yes
Negative c	a=1	b is ±	C is neg	Yes
Difference of squares	a=1	b is 0	C is neg	Yes
Common factors	a≠1	b is ±	C is ±	Yes
Summary	a=1 & a≠1	b is ±	C is ±	No
	Combination of every section done above. No steps in this exercise are provided			

Table 4.4: Exercises covered in the spreadsheet package

The hyper-link from the **positive c** in the Tasks page leads to **figure 4.2** in the spreadsheet below.

TRINOMIALS WITH POSITIVE C (+c); a=1 [$x^2 +/- bx + c$]													
X ² means x squared		FACTORISED		Isolate terms		Factors		Check					
Trinomial		Bracket 1	Bracket 2	MT	LT	F1	F2	MT		LT			
ax^2+bx+c			F1		F2	b	c	F1	F2	+	F1+F2	*	F1*F2
e.g	$x^2 + 9x + 18$	x	3	x	6	9	18	3	6	0	9	0	18
I	$x^2 - 6x + 8$	x	0	x	0					0	0	0	0
II	$x^2 - 11x + 30$	x	0	x	0					0	0	0	0
III	$x^2 - 7x + 6$	x	0	x	0					0	0	0	0
IV	$x^2 - 14x + 45$	x	0	x	0					0	0	0	0
V	$x^2 + 15x + 54$	x	0	x	0					0	0	0	0
VI		x	0	x	0					0	0	0	0
The solution of e.g. is then $(x+3)(x+6)$													
NB 1. Always check the cells with red corners for information and steps to follow													
2. You only work the sections: Isolate terms (i.e. b and c) and													
Factors (i.e. F1 and F2)													
everything else is helping you to get the solution to the problem													
Use e-mail to post your answer to the 5 questions given above from problem I to V.													

Figure 4.2 An example of the positive c exercise

Remarks: The importing of the activity from the spreadsheet to this document has caused a loss to the comments indicators (red corner) during transfer. Comments indicators (red corner) are **steps** to be followed, and **questions** to be answered.

The main features of the package are these five dimensions:

- **Original quadratic – trinomial or quadratic,**
- **Factorised brackets – two brackets in the form of $(x \pm F1)(x \pm F2)$,**
- **Working area - isolate terms and factors,**
- **Check area – MT (middle term) and LT (Last term) are verified against isolated terms in the working area, and**
- **Questions**

The factorisation of quadratics package has the features resembling a representation below (figure 4.3).

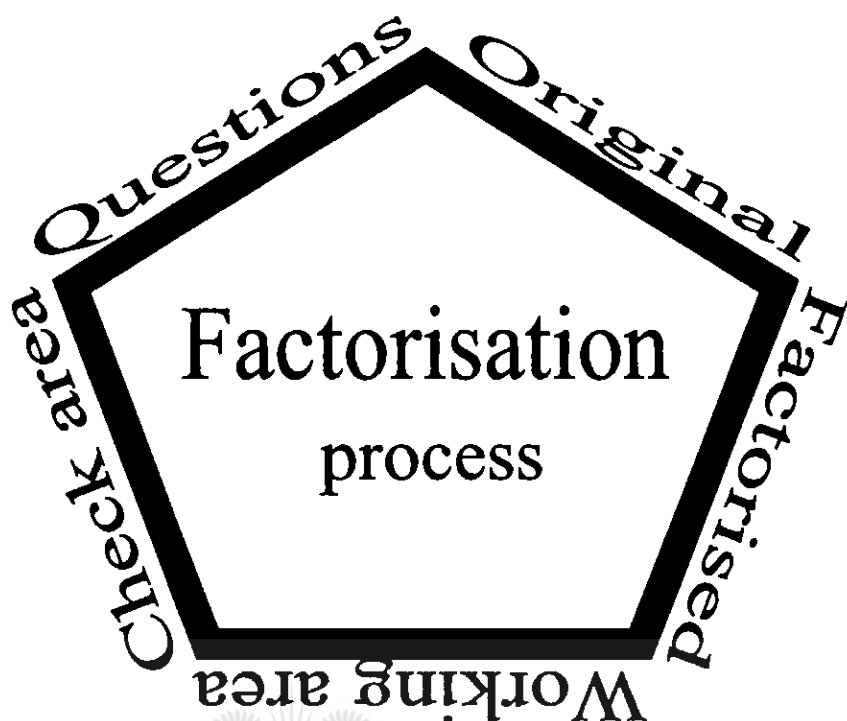


Figure 4.3: Spreadsheet Factorisation package dimensions

The dimensions are now discussed below.

- ❶ **The original quadratic** is the one that fits the types in the different tasks
- ❷ **Factorised brackets block** is linked to the factors **F1** and **F2**. The factors bring the signs with them to the brackets.
- ❸ **Working area** is the only place where the learner works. The learner must isolate the terms (MT and LT) correctly (sign and value) to facilitate the correct search of the appropriate factors that will fit the original quadratic. The factors (value and signs) will be the correct one if the check area agrees.
- ❹ **Check area** is the feedback section that informs the user about success attained or not attained yet. The factors are added together to get the middle term (MT) (isolated earlier). The same factors must be multiplied together to get the last term (LT) isolated earlier also. The zeros on both MT and LT must be attained to conclude the factorisation of the quadratic. The correct isolation of the terms is critical to the check area's value in the process of factorisation

- **The questions' range** applies the Bloom's Taxonomy as covered in **section 2.4.4** above. There are questions in each task to facilitate awareness around important and key sections of the process of factorisation. Examples of some questions included in the spreadsheet package are in table 4.4 below:

Questions	Bloom's Taxonomy level
What is the sign of this factor?	L 1: knowledge
What are the values of MT and LT if you entered -5 here?	L 2: comprehension (comparing and interpreting).
If the check area was not there, was it going to be easy/difficult for you to be sure of your factors?	L 4: analysis (making inferences to support a generalization).
What do you notice about this value and the one at b?	L 2: comprehension (comparing, translating and interpreting).
What do you notice with two factors in number (equal or not equal)?	L 3: application (applying acquired knowledge and rules)
Send your set of factors to classmates for this problem and reply to their set of factors.	L 3: application (applying acquired knowledge and rules)

Table 4.5: Example of questions and Bloom's Taxonomy

The sample above was used in the implementation of the spreadsheet package's classroom.

4.5 IMPLEMENTATION OF THE WEB-BASED SPREADSHEET CLASSROOM

The project lasted for more than three weeks. In the first week of the web-based instruction lesson the researcher observed that all the learners expected the researcher to lead them through the lesson step-by-step. This indicated that the learners were not yet ready to explore, experiment and make mistakes on their own. The learners were guided to use the numbers pad to enter the data (factors, etc), mouse for the steps to follow (instructions) and the questions to be answered.

The learners had to answer about five questions that employed the Bloom's Taxonomy levels of cognitive learning. The responses to the questions were e-mailed to other learners in the project and to the researcher were always copied to.

The learners were allowed to access the work anytime of the week over the period of the research project. In the process they were able to learn to navigate back and forth the classroom's links but the emphasis was more on the how they experience factorisation using a spreadsheet. The web was a medium to facilitate the communication between the learners themselves and the researcher.

4.6 SUMMARY

This chapter explained the context on the implementation in a simulated scenario, the design and development of the web-based classroom, as well as the description thereof. An exploration of theory in research of Web-based Instruction to develop a theoretical framework for research methods and techniques within this study was done.

The research findings will be discussed in the next chapter.

CHAPTER 5

RESEARCH FINDINGS AND RESULTS: LEARNER AND EDUCATOR EXPERIENCE OF THE WEB-BASED SPREADSHEET CLASSROOM

5.1 INTRODUCTION

The study aimed at recording and reporting the experiences of learners who attempted to learn using a spreadsheet to factorise quadratics at a high school. In order to achieve the aforementioned purpose, the objectives were mentioned as:

- To define and describe spreadsheet instruction in the context of this study;
- To describe learners' experience of confidence during the presentation of the course;
- To determine whether learners experience interaction leading to deeper learning; and
- To provide recommendations for further implementation in the similar situations as compared to conventional approach.

This chapter will present the findings of the research question that have been identified in this study. The findings are a product of the data generating methods based on the pre-completion interview, observations during the case study, interactions with the learners and then the post-completion interview that was conducted.

The chapter will attempt to represent the findings as accurate as possible in the sequence of events as clear as possible.

The observations and interviews inform the findings discussed in the following paragraphs. The tests and assessment were covered by the last tasks as a summary in the package.

5.2 PRE-IMPLEMENTATION INTERVIEW

The purpose of the pre-implementation interview (appendix A) was to find out some facts about their knowledge of factorisation and type of method and steps they used in the face-to-face class. The interview attempted to determine the steps in the factorisation process by using an example to develop some common understanding of terms used in the process.

The findings in this interview included these discussed below. These learners struggled to:

- ❶ come up with the definition of factorisation as shown by the winding ways to or guessing an answer like the four learners' contributions "*Solving for X; When you are looking for a common number; Factorisation is taking out the common;*" and "*grouping all the items together into brackets*", and with a lot of probing produced "*The answer will be in brackets (She laughs but doubts her response)*".
- ❷ find factors of numbers (the last term). When the researcher thought 30 was not too big, one learner gave 7 and 4 as factors of 30 at one point.
- ❸ understand the role of the sign of the last term. The learners were not very convincing when the researcher asked them questions about this role of the sign. The signs of the terms in the quadratic expression are key to factorisation. The sign of the middle term dictates the choice of the signs of the factors as in the example $x^2 - 11x + 30$ was "*..... 11 Negative 11*" responding to "Which one is the second term?" Then the choice of signs to be assigned to the two factors to form the middle term became the next interesting discussion leading to this sequence below:

Learner 1 *5 and 6 (The signs became the new point of interest). The first suggestion was -5 and 6, then -5 and -6*

Mr Maseko *Why - and - (negative and negative signs)?*

Learner 2 *Because negative (-) times negative (-) is positive and add numbers and to write the same sign.*

Mr Maseko *But Learner 1 has a different explanation.*

Learner 1 *If we have negative and positive and we times them, they give us negative. Positive + negative = Negative”.*

- The learners did not have a lot of problems on the steps to factorise a trinomial. Responding to the question “*What is the first step in factorizing $x^2 - 11x + 30$?*” one learner promptly gave this response “*Write two brackets and then put x in both brackets*”. The factorisation process taught in the face-to-face class seems to be the FOIL method. FOIL stands for First term, Outer term, Inner term and Last term. The addition of outer and inner terms must give the middle term in the original quadratic expression. The factors must always lead us back to original expression.

This state of affairs indicated to the researcher that the learners needed immediate feedback on the chosen combination of factors and the associated signs. The spreadsheet package included calculations to facilitate the immediate feedback under working area and checking area.

The observations and interviews together informed the findings on the learners’ experience of the web-based world.

5.3 POST-IMPLEMENTATION INTERVIEW

The post-implementation interview questions were semi-structured and thus had categories. Probing and follow-up questions were posed when and where appropriate depending on the responses the researcher received. So these categories were used in the analysis in conjunction with the coding of responses.

The learners’ experience of the web-based spreadsheet classroom generated data and was recorded. The recorded data from this interview was analysed in order to determine the learners’ experience of the classroom under the following categories:

- participation in the web-based spreadsheet classroom;
- interaction and collaboration using e-mail;
- were the instructions clear and simple to understand?;

- the sections the learners found challenging or most helpful;
- comparison between face-to-face and web-based spreadsheet classroom; and
- general comments on the experience and the way forward.

These categories will now be discussed.

5.3.1 PARTICIPATION IN THE WEB-BASED SPREADSHEET CLASSROOM

The learners went through all the McGonigle and Eggers (1998:[online]) stages of web-based classroom entrance problems as they participated in the classroom. The stages are Confused stage, Shock stage, Timid stage, Frustrated stage and Eureka (final) stage as illustrated in **figure 2.9**.

The learners had totally no idea how to navigate a spreadsheet. One of the learners said (confused to frustrated stage) *"But on the side of No, it was tough and very challenging because it was the first time for me to use a spreadsheet and doing it the web-based classroom"*.

The second learner also felt intimidated ("challenging") by the experience and found it *"interesting"* even when it was the first time to use a spreadsheet for her. The idea of using Microsoft Excel in mathematics kept these learners going and felt that *"Sometimes I struggled with my Maths in class. I think if in this school we were using MS Excel maybe I was going to do better in Maths"*.

Generally the participation in this class was enjoyed by all despite the stages of entry to this new medium of instruction in the form of a computer and spreadsheet as expressed here *"I was factorizing in a computer"* exclaimed in excitement.

I probed whether using MS Word was going to be easier. The response was that *"It was not going to be easier. We are dealing with numbers and we are doing maths"*. These learners had noticed the ability of the spreadsheet to work with numbers better than a word processor.

The researcher observed that some of the learners were doing a yo-yo movement between the stages as technical problems kept coming. When all looked under control, problems like the speed of the computer (*... supposed to get 2 zeros. Sometimes the computer takes very long, you think maybe my factors were wrong, you start to panic, you ask around...*) or the screen did not show “*The red corners were not clear because of the computer I was using. I had to go to other people’s computer*”. Technological problems did not help the learners in reaching the eureka stage as quick as they were hoping. The sharing of the content in the web-based classroom was very slow and frustrated those who would access the material last.

Notwithstanding all the abovementioned problems and challenges, the researcher could see the Ellington’s stages of learning (**figure 5.1**), as discussed in section 4.3 above, keeping the learners hanging on to the project. The drive of wanting to learn, the freedom to try things out (doing), the immediate feedback, and the great benefit from digesting the feedback and learning experienced through the package were the pillars of the learners’ strength to stay in the project.

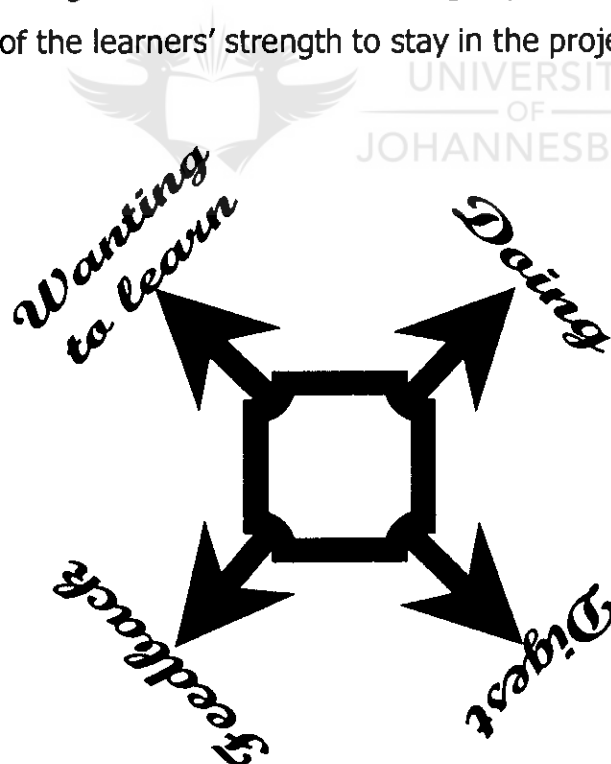


Figure 5.1: Ellington’s stages of learning

5.3.2 INTERACTION AND COLLABORATION USING E-MAIL

The e-mail communication was localized (intranet) and all the learners had addresses and usernames. They were able to use the e-mail for a week before technological problems caused a stop. They had already appreciated the benefits of the e-mail communication by the time it stopped working. One learner responded to "*Was the interaction/collaboration using e-mail helpful in learning to factorise?*" by saying "*We were struggling with factors to factorize the sums. We were going to share views and see if we were right or not. We were going to help each other but not disturb each other with noise and walking around*". The e-mail communication promotes sharing of ideas, collaborative work amongst learners, keep noise levels down and keep the learners on their own work stations according to this learner.

At the end of the whole project another learner said "*I have learnt to use e-mail and found it helpful*" as a communication tool.

On the actual factorisation "*The one about negative C in a class. The computer helped me*" was a comment sharing the experience obtained from the interaction with the spreadsheet package. The package insisted on isolating terms before starting with the search for the correct factors. On the role of the zeros in the check columns, "*If you did not know the answer, it was going to help you quickly*" referring to the quick calculations about feedback time on the factors chosen.

5.3.3 WERE THE INSTRUCTIONS CLEAR AND SIMPLE TO UNDERSTAND?

The learners experienced challenges in the actual exercises of factorisation of expressions. On many occasions learners did not read the instructions, steps or comments on the exercises. They would just take a chance and do anything and removed the formulas in the package at the beginning of the project. The researcher had to, for example, take them by hand, literally, to use the arrows instead of the mouse to navigate the cells in the worksheet.

Navigation also frustrated some of the less exploring learners after completing an exercise. It was emphasised that the home page should serve as a table of contents. As an observer/learner the researcher had to demonstrate in the event that learners were unsure.

One of the learners had this challenge "*The red corners were not clear because of the computer I was using*" was one of the technical problems. This learner had to check from other's screen. This learner also mentioned, "*The summary had no instructions*" when actually the aim of the summary was that they had to factorise the quadratics "*without my help*". It was not a technological problem. This learner was aware of the value of the comments and had sought for help in them.

The next challenge came from the questions in the exercises. These questions were "*little tough at the beginning*". "*Even if we were used to factorizing in class, we were not asked those questions*" like these two questions taken from the exercise difference of two squares. These questions were employing the Bloom's Taxonomy level 4 of analysis and making inferences and identifying causes and effects of values in particular areas of work in the factorisation process. The questions were:

[**Question 4.** When this value is not 0 (zero), what should you do to your factors to make the value zero?

Question 5. If the check section was not there, was it going to be easy/difficult for you to be sure of your factors?]

There was also a learner who was simply overwhelmed by the experience on the role of instructions and indicated "*The thing that made it difficult was that I was surprised. It was the first time because we have never done Maths in the computer*".

The learners were able to follow the instructions and managed to complete the exercises per type. Each type of exercise had its new set of rules to look out for.

They completed the project and considered their responses in the summary exercises as a fair reflection of their knowledge and abilities.

5.3.4 THE SECTIONS THE LEARNERS FOUND CHALLENGING OR MOST HELPFUL

Challenges encountered by the learners were expressed with these words "*The questions were challenging*" on behalf of all the classmates. There were questions in every exercise where the Bloom's Taxonomy as discussed in chapter 2 was utilised. Bloom's levels cover knowledge, application, comprehension, analysis, synthesis and evaluation. The levels did not follow a linear progression. The levels could be achieved from any angle but the topmost is the evaluation.

The spreadsheet package, by design, had the Bloom's Taxonomy levels and in mind. The questions in every exercise were stretching their dealings with factorisation. "*My aim was to make you think a little bit. I noticed at the beginning you were using your old class method (pen and paper) until you get the correct answer. I wanted to give you a challenge like "what if this happened. Why this particular point or value here?"*" was one comment the researcher made during the interview.

On the other hand one learner felt "*The one about negative C in a class. The computer helped me*". It appeared that the learner was struggling with the factorisation of difference of two squares in the face-to-face class.

The role of zero's proved helpful as it provided quick feedback on the choice of factors combinations. The learner indicated, "*The package would tell you that you are correct or not yet correct*". They all agreed that the "now" feedback especially "*If you did not know the answer, it was going to help you quickly*" even if it "spoil" them because they must also think as students, added one learner.

5.3.5 COMPARISON BETWEEN FACE-TO-FACE AND WEB-BASED SPREADSHEET CLASSROOM

The computer was preferred over the face-to-face class because of feedback time indicated by one learner as *"it's easier and quicker to know your progress rather than waiting for the educator"*. This learner got very emotional about this preference by further saying, *"For most people suspension is not easy. I can't stand it. To think I'm right or correct. Won't be able to sleep"* and another learner put a similar view like *"You'll know immediately, not tomorrow or what, immediately. I think it is better than the face-to-face classroom"* reflecting on waiting for the educator to make a judgment on the conventional method of homework.

The computer was again preferred over the conventional class because of the protection from being laughed at by others in the class. This privacy as indicated by Pogrow (1993:216), was possible because the feedback on the zero's check area afforded them enough opportunities to succeed on their own as expressed by one learner that *"I'm afraid to answer because they might laugh at me. So I think the computer one is easier for me. No one can see whether I'm wrong or right"*.

The feedback time proved the winner in the web-based class as Pogrow (1993:216) indicated. They all expressed enthusiasm about how much they had learnt and benefited from the lesson, its approach and methodology.

5.3.6 GENERAL COMMENTS ON THE EXPERIENCE AND THE WAY FORWARD

The researcher encouraged co-operative groups of two, especially, where some computers were not functional. Some learners welcomed an opportunity to work in co-operative learning groups, as it gave them the opportunity to seek support from fellow learners in a face-to-face situation, rather than be on their own workstation only.

Whether the package would be useful to teach or revise the factorisation process, one learner indicated, "*it is better for revision!*" and not at the beginning for instruction. This implied that because they had factorisation in the conventional class, it was easier to focus on the spreadsheet package and benefit from the quick feedback on the choice of factors, as "*It will help with quick calculations and immediate feedback!*". During the observation stage, the researcher could see that their computer skill was limited up to the application Microsoft Word. The navigation skills of basic windows and dependence on the mouse were the limiting factors as they thought the mouse must be used all the time and for all navigation.

The researcher conducted an informal interview, during the observation, with the mathematics educator on the strengths of the factorisation using a spreadsheet. The educator indicated that the feedback time was the highlight and encouraging point. The feedback was helping the learners who were struggling with factors. They were not strong in finding factors of numbers as fast as they were expected at the grade 10 level. The role of zero in the package was the indicator of how close the pair of chosen factors was from the correct combination. The educator generally praised the package as a great help in the factorisation process.

5.4 OBSERVATIONS

During the implementation, observations coupled with informal interviews were made. The learners showed that they had the basic skills of computer. They were able to follow instructions like to search or open a file eventually from the server to share the site.

Coming to do the mathematics in the package some critical tendencies were noticed. During the implementation, the learners still used pen and paper to find factors at the beginning (the confused stage). They took some time to get a feel of the spreadsheet package strength of self-calculation and where the instruction clearly said "*use only the four cells (blocks)*". This block is the "*Work area*". These cells wanted them to isolate the middle term (MT), last term (LT), and then work to get the two relevant factors.

The learners still worked on any cell (removing formulas in the process). As a participant observer the researcher explained the access and navigation to utilize the instructions and comments as well as the questions. By the end of the first exercise (positive c), the comments corners were accessed and responded to by the learners.

The feedback given by the spreadsheet's calculations to help decide on whether the factors are correct or not, enabled the learners to depend on the computer. The pen and paper test of factors on a side was soon gone. These learners were noticeably excited at the end of a task (exercise) as they knew that all the solutions were correct and did not need an external feedback (e.g. the educator), later.

The learners became more confident to use the spreadsheet package, as they understood the use of the links with the web-based medium and tools to move from one exercise to another.

When the learners came to the summary task, no help and steps were available to them to lean on. The structure was the same except for the comments. It was a struggle initially to do the task. They were able to workout the solutions after they noticed that the checking area of zero's was active as in the previous exercises.

5.5 SUMMARY

Despite the challenges as indicated in this chapter, this study suggests that learners were able to see their expectations met. There are learners the researcher saw grow in confidence in the factorisation of quadratic expressions as compared to the first interview responses to the questions.

They felt that the package would do well as a revision tool. The researcher thought the package could be used concurrently with the actual teaching of the concepts. The time consuming search for the correct factors will be eliminated with the feedback time the package provides. The package can help those who struggle with

factors of big numbers. Their learning was enhanced by the unusual questions included in the factorisation tasks as it was used to make them think a little deeper than usual

The findings of this study indicated that the learners perceived the lesson with overwhelming enthusiasm. The learners and researcher walked the journey of stages of entering the web-based world together. Learners were motivated to compete to complete the tasks in the shortest time. All of them could say "Eureka" at the end of the journey. In summary it can be said that the project lesson reinforced positive feelings about learning through the Web and spreadsheet. They all felt that a computer especially a spreadsheet could play a critical role in teaching mathematics; in particular, factorisation of quadratics as summarized by this statement "*It will help with quick calculations and immediate feedback*".

The conclusions and recommendations will follow in the next chapter.



CHAPTER 6

OVERVIEW OF THE STUDY, CONCLUSION, LIMITATIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

6.1 OVERVIEW

This chapter covers an overview summary of the study, conclusion, limitations as well as recommendations for further research. The study was investigating with the aim of reporting on the inter-activeness of a factorisation project using a spreadsheet that was presented, through a simulated web, to grade 10 learners. These learners had no experience of the spreadsheet and Internet, in the South African context. The purpose of the study was

- To define and describe spreadsheet instruction in the context of this study;
- To describe learners' experience of confidence during the presentation of the course;
- To determine whether learners experience interaction leading to deeper learning; and
- To provide recommendations for further implementation in the similar situations as compared to conventional approach.

This chapter briefly summarizes the findings, the limitations of the study, and offers recommendations and suggestions for further implementations or research.

6.2 CONCLUSION

The research instruments used to generate and record data in this research were those of observation and interviews. The main purpose of these instruments was to determine the effects of a web-based spreadsheet classroom project on grade 10 learners' skill and knowledge of the spreadsheet and Internet (Web-supported learning).

The main research question investigated in this study is:

"How can a web-based spreadsheet be developed for grade ten learners and how can their experiences assist in developing guidelines for web-based mathematics teaching? "

The research sub-questions stated in chapter one are revisited in the following paragraphs:

- How did the learners experience factorisation using a spreadsheet package?
- How did the learners experience collaborative interaction while learning?
- How do learners compare this teaching approach with conventional teaching?
- How could a spreadsheet be implemented in similar situations?

The quadratic factorisation using a spreadsheet was found to be very exciting. The learners managed to find the strength of the package and stopped worrying about the time consuming practice of pen and paper search for the factors. The "check of MT and LT" part to help with immediate feedback proved the winner.

When learners preferred a web-based classroom to conventional teaching, the winner was the feedback time lapse. This feedback time lapse provided enough opportunities to try and succeed with finding the correct factors. They were concerned about the workload, though, because of the amount of exercises to be done. The Web-based classroom promotes self-discipline in comparison to face-to-face teaching; a web-based classroom allowed flexibility, as the learners can work at their pace.

Notwithstanding the above-mentioned success, there are some recommendations for further research from the observations and findings in the study.

6.3 RECOMMENDATIONS FOR FURTHER RESEARCH

Recommendations for further research derived from observed shortcomings in the literature and field study are:

- ④ The cells in the spreadsheet that have formulas must be protected to avoid changes that can affect the performance of the package.
- ④ Give feedback on the isolate terms working area to facilitate correct entries as in the factors check function. This guarantees the correct factorisation of the original expression.
- ④ Make the spreadsheet work independent of the web and communication tools. In this study the web was a medium to carry the package and the e-mail was to bridge the distance between the researcher and the learners.
- ④ Expand and explore using quadratics that have $a \neq 1$ without a common factor to allow further and higher users of factorisation to benefit from the strength of the package.
- ④ Make them adapt an existing spreadsheet by changing formulas at critical places and respond to the consequences of the changes. In this case let them:
 - Change the quadratic expressions, or
 - Remove the zero columns, or
 - Remove the check column of $F1 \cdot F2$, or
 - Remove the check column of $F1 + F2$,

and analyze the effects of the changes on the package for advanced users of spreadsheets.

The above-mentioned success also exposed some limitations as experienced and associated with the running of the project.

6.4 LIMITATIONS OF THE STUDY

There were and are some limitations experienced and associated with this study. One of the limitations of this study is its case study design. Like in most case studies, the research results cannot be generalized to other situations. The case study was a single event that concentrated on one particular institution and particular topic: factorisation of quadratics. Although the results of this research may be applied in similar situations, they cannot be generalized to similar situations. There are certain implications for similar situations typified in this study.

This web-based classroom approach has not been implemented in any other similar situation and has thus not been verified or researched. The learners were aware that they did not have experience of a web-based classroom and, being part of first-time implementation, they were highly motivated and participated fully.

During the initial stage of the project lesson, learners encountered technical problems when external e-mail addresses did not function as planned. The internal e-mails had no problems and were used by the learners to communicate with each other and the researcher directly or per carbon copy (cc).

6.5 FINAL WORD

The experience of factorisation using a spreadsheet in a web-based class by the grade 10 learners was a learning curve. It was worth the effort for the learners, educator and researcher at a West of Gauteng Province High School. It has introduced them to a new approach of web-based spreadsheet instruction in the South African context. The educators and learners were excited and positive about the manner in which the web-based classroom was implemented. It was a great and fulfilling challenge to the learners.

John Bowes assertion "to convey the concepts, the structure, and the basic skills of our fields, thereby enabling the student to continue self-instruction long after class is over" will be realized in the factorisation of quadratics using a spreadsheet.

LIST OF SOURCES

- ABRAHAM, MR 2001: A Web-Based Molecular Level Inquiry Laboratory Activity. Online. Accessed 22 May 2001. Presentation delivered at 221st Meeting of the American chemical Society San Diego, CA April 1 - April 5, 2001. Available: <http://intro.chem.okstate.edu/2001ACS/Talk.html>
- ALDEN, J 1998: A trainer's guide to Web-based instruction. Alexandria: American Society for Training and Development (Learning technologies series)
- ALEJANDRE, S 2001: Understanding Algebraic Factoring. Online. Accessed 5 August 2001. Available: <http://mathforum.com/alejandre/algfac1.html>
- ARTZT, AF 1999: Cooperative learning in mathematics educator education. Mathematics Educator, 92, Jan. 1999: 11-17
- BAKEMAN, R 1992: Understanding social science statistics: a spreadsheet approach. Hillsdale: Lawrence Erlbaum Associates, Publishers
- BALL, D 1986: Microcomputers in maths teaching. London: Hutchinson
- BALLEW, P 2000: Factoring quadratics using a box divided in fourths. Online. Accessed 1 October 2001. Q&A #5391. Available: <http://forum.swarthmore.edu/t2t/message.taco?thread=5391&message=2>
- BEST, JW 1977: Research in education. Third edition. New Jersey: Prentice-Hall Inc.
- BLYTHE, S 1997: We should consider how we talk about computers. Online. Accessed 19 October 2002. Available: <http://english.ttu.edu/kairos/1.1/owls/blythe/owl9b.html>

- BOWES, J 1998: Uses of the Web in education: Practical experiences in using the Web. Online. Accessed 17 August 2001. Available:
<http://staff.washington.edu/rells/effective/uses3.html>
- BRISSENDEN, THF 1980: Mathematic teaching: theory in practice. London: Harper and Row
- BURGESS, RG 1984: An introduction to field research. New York: Routledge
- BURNS, N & GROVE, SK 1993: The practice of nursing research: conduct, critique and utilisation. Second edition. Philadelphia: W. B. Saunders Company
- BURNS, N & GROVE, SK 1997: The practice of nursing research: conduct, critique and utilisation. Third edition. Philadelphia: W. B. Saunders Company
- CARL, IM 2001: Equal opportunity: Technology can be a bridge to mathematics equity. Online. Accessed on 9 March 2001. Available:
<http://watt.enc.org/online/ENC2286/2286.html>
- CARTER, R 1993: Student's guide to information technology; second edition. Oxford: Butterworth-Heinemann.
- CARTWRIGHT, TJ 1993: Modeling the world in a spreadsheet: environmental simulation on a microcomputer. Baltimore: The Hopkins University Press
- CASIO calculator: Factorisation (CAS,ALGEBRA,TUTOR mode) 2000: Online. Accessed 23 September 2001. Available:
http://www.casio.co.jp/edu_e/product/new_products/algebra_fx20/menu_cmnd/f.html

- CLEVELAND, J 2000: Factoring quadratics using a box divided in fourths. Online.
Accessed 1 October 2001. Available:
<http://forum.swarthmore.edu/t2t/message.taco?thread=5391&message=3> Q&A
#5391
- COLLINS GEM ENGLISH DICTIONARY 1995: Glasgow: HarperCollins Publishers
- CONCISE OXFORD DICTIONARY 1991: The new edition for the 1990s; eighth
edition. Edited by ALLEN, RE. London: BCA
- CRESWELL, JL 1994: Research design: Qualitative and quantitative approaches.
London: Sage.
- CRISWELL, EL 1989: The design of Computer-Based Instruction. New York:
Macmillan Publishing Company.
- EDWARDS, JS & FINLAY, PN 1997: Decision making with computers: the spreadsheet
and beyond. London: Pitman Publishing
- ELLINGTON, H; PERCIVAL, F & RACE, P 1993: Handbook of educational technology.
Third edition. London: Kogan Page
- ENCYCLOPAEDIA BRITANNICA n.d.: Search dictionary. Online. Accessed 20 February
2000. Available:
<http://www.britannica.com/search?query=quadratic&ct=&fuzzy=N>
- FLORES, A; KNAUPP, JE; MIDDLETON, JA & STALEY,FA 2002: Integration of
technology, science, and mathematics in the middle grades: A educator
preparation for contemporary Issues in Technology and Educator Education.
Online. Accessed 16 May 2002. Available:
<http://www.citejournal.org/vol2/iss1/mathematics/article1.cfm>

- FORCIER, RC 1996: The computers as a productive tool in education. Englewood Cliffs, New Jersey: Prentice Hall
- FOWLER, B 1996: Bloom's Taxonomy and Critical Thinking. Online. Accessed 25 September 2001. Available:
<http://www.kcmetro.cc.mo.us/longview/ctac/blooms.htm>
- GARNER, J 1995: Mathematics and...: spreadsheets and mathematics. Online. Accessed 6 March 2001. Available:
http://mathforum.org/sum95/math_and/spreadsheets/examples/bigBox.html
- GARNER, J 1995: Mathematics and...: spreadsheets and mathematics. Online. Accessed 6 March 2001. Available:
http://mathforum.org/sum95/math_and/spreadsheets/intro.html
- GAY, LR 1990: Educational research Competencies for analysis and application. Third Edition. New York: Merrill Publishing Company
- GROUWS, DA & LEMBKE, LO 1996: Influential factors in student motivation to learn mathematics: the educator and classroom culture. (In: CARR, M ed. 1996: Motivation in mathematics. Cresskill, New Jersey: Hampton Press, Inc. pp 39-62)
- HEIDE, A & STILBORNE, L 1996: The educator's complete and easy guide to the internet. Toronto: Trifolium Books Inc.
- HOLSTEIN, JA & GUBRIUM, JF 1997: Active interviewing. (In: SILVERMAN, D ed. 1997. Qualitative research theory, method and practice). London: Sage Publications.
- HORN, L, DU P BRINK, B & JONES, RC 1985: Physical science in action: standard 8. Kenwyn: Juta & Co. Ltd

- HUNT, N 1996: Teaching statistics with Excel 5.0: Computer aided learning. Online. Accessed 24 September 2001. Available: http://www.stats.gla.ac.uk/cti/activities/reviews/96_05/excel.html
- HUYSAMEN, GK 1994: Methodology for the social and behavioural sciences. Halfway: House Southern Book Publishers.
- INGRAM, AL 1999: A Model of Web Design for Instruction. Online. Accessed 30 September 2001. Available: <http://aingram.educ.kent.edu/netclass/WebMaterial/WebDesignModelIntro.htm>
- JAMES, B n.d.: Spreadsheet Tutorial. Accessed 20 May 2002. Online. Available: <http://www.usd.edu/trio/tut/excel/1.html>
- JONASSEN, DH 1996: Computers in the classroom: Mindtools for critical thinking. Englewood Cliffs: Merrill
- JONASSEN, DH 2000: Computers as mindtools for schools. Engaging critical thinking. Second Edition. Upper Saddle River, NJ: Merrill
- JOPPE, M n.d.: Research process: Observation. Online. Accessed 12 May 2001. Available: <http://www.ryerson.ca/~mjoppe/ResearchProcess/Observation.htm>
- KENNEDY, LM & TIPPS, S 2000: Guiding children's learning of mathematics; ninth edition. Belmont: Wadsworth.
- KHAN, BH 1998: Web-Based Instruction (WBI): (In: KHAN, BH ed. 1998: Web-Based Instruction. Englewood Cliffs: Merrill).
- KHAN, BH 2001: Evaluating Web-Based Instruction Design. Online. Accessed 17 August 2001. Available: <http://scis.nova.edu/~henkeh/story1.htm>

- KLOOSTERMAN, P 1996: Students' belief about knowing and learning mathematics: Implications for motivation. (In: CARR, M ed. 1996: Motivation in mathematics. Cresskill, New Jersey: Hampton Press, Inc. pp 131-156)
- LANGHORNE, MJ; DONHAM, JO; GROSS, JF & REHMKE, D 1989: Teaching with computers: A new menu for the '90s. London: Kogan Page
- MANGENA, M 2001: Address by the deputy minister of education, Mr Mosibudi Mangena at the launch of the Maths and science campaign at the convention centre, arc, Hatfield Pretoria, 25 June 2001. Online. Accessed 15 September 2001. Available:
<http://education.pwv.gov.za/Media/Mangena/June01/Maths%20Science%20Tech.htm>
- MASON, J 1996: Qualitative researching. London: Sage Publications
- MCGONIGLE, D & EGGERS, RM 1998: Stages of web-based-instructor and student. Online. Accessed 23 September 2001. Available:
<http://www.sasked.gov.sk.ca/~parkland/web-basedity.htm>
- MCMILLAN, JH & SCHUMACHER, S 1993: Research in Education: A Conceptual introduction. New York: Harper Collins College Publisher.
- MERRIAM, SB 1998: Qualitative Research and Case Study Applications in Education. San Francisco: Jossey-Bass Publishers..
- MONAHAN, GE 2000: Management decision making: Spreadsheet modeling, analysis, and application. Cambridge: Cambridge University Press
- MORGAN, BJT 1984: Elements of simulation. London: Chapman and Hall
- MORSE, JM & FIELD, PA 1996: Nursing research: The application of qualitative approaches. London: Chapman and Hall

MOUTON, J & MARAIS, HC 1990: Basic concepts in the methodology of the social sciences. Human Sciences Research Council. Pretoria.

NATIONAL COUNCIL OF EDUCATORS OF MATHEMATICS 2000: The Technology Principle. Online. Accessed 16 May 2002. Available:
<http://standards.nctm.org/document/chapter2/techn.htm>

NICHOLS, ED; EDWARDS, ML; GARLAND, EH; HOFFMAN, SA; MAMARY, A & PALMER, WA 1982: Holt Algebra 1. New York: Holt, Rinehart and Winston Publishers

OLIVER, R; HERRINGTON, J & OMARI, A 1996: Creating Effective Instructional Materials for the World Wide Web. Online. Accessed 12 September 2001. Available: <http://elmo.scu.edu.au/sponsored/ausweb/ausweb96/educn/oliver/>

PALLOFF, RM & Pratt, K 1999: Building learning communities in cyberspace. San Francisco: Jossey-Bass Publishers

PATTON, MQ 1990: Qualitative evaluation and research methods. Second edition. Newbury Park: Sage Publications

PARKER, OJ & BRENEMAN, GL 1991: Spreadsheet chemistry. Englewood Cliffs: Prentice Hall

PETJE, M 2002: GuatengOnline takes the country further down the information super highway. Convergence: achieving global competitiveness GautengOnline special edition, volume 3 (2) June 2002: 7.

POGROW, S 1993: A learning drama approach to using computers with at-risk students (In: MUFFOLETTO, R & KNUPFER, NN eds.1993: Computers in education: social, political and historical perspectives. Cresskill: Hampton Press).

- PRESNALL, G 2001: The Greg Presnall Collection. Accessed 23 September 2001.
Online. Available: <http://cesme.utm.edu/resources/other/presnall/presnall.html>
- QUICKMATH 2002: Equations: Quadratics. Online. Accessed 12 September 2002.
Available: <http://www.hostsrv.com/webmab/app1/MSP/quickmath/02/reply>
- ROSS, TW 1993: Bloom and hypertext: Parallel taxonomies. Educational Technology Review. Fall/Winter, 11-16.
- STAPEL, E 2000: Modified a-b-c Method, or "box". Online. Accessed 2 October 2001.
Available: <http://www.purplemath.com/modules/factquad.htm>
- STOHL-DRIER, H 2001: Teaching and Learning Mathematics With Interactive Spreadsheets. Online. Accessed 15 May 2002. Available:
http://ehostvgw2.epnet.com/ehost.asp?key=204.179.122.129_8000_1678211019&site=ehost&return=y
- STREIBEL, MJ 1993: Instructional design and human practice: what can we learn from Grundy's interpretation of Habermas' theory of technical and practical human interests? (In: MUFFOLETTO, R & KNUPFER, NN eds. 1993: Computers in education: social, political and historical perspectives. Cresskill: Hampton Press).
- STREUBERT, HL & CARPENTER, DR 1995: Qualitative research in nursing: Advancing the humanistic imperative. Philadelphia: J. B. Lippincott Company.
- SULLY, P 1993: Modeling the world with objects. New York: Prentice Hall
- TAYLOR, N & MYBURGH, N 1986: Understanding Mathematics 7. Cape Town: Maskew Miller Longman
- TREUHAF, J 1995: Changes in education. Online. Accessed 6 April 2002. Available:
<http://www.algonquinc.on.ca/edtech/change.html>

TURROF, M 1995: Designing a web-based classroom. Online. Accessed 23 May 2002.
Available: <http://www.njit.edu/njit/Department/CCCC/VC/Papers/Desidn.html>

WANER, S & COSTENOBLE, S R 1998: Interactive Algebra Review. Online.
Accessed 23 September 2001. Available:
http://147.4.150.5/~matscw/tut_alg_review/unitA_5.html

WORDSMYTH: THE EDUCATIONAL DICTIONARY – THESAURUS n.d.: Search dictionary.
Online. Accessed 22 March 2002. Available: <http://www.wordsmyth.net/cgi-bin/search.cgi?matchent=INSTRUCTOR&matchtype=exact>



APPENDIX A

PRE-COMPLETION INTERVIEW: transcript

Grade 10 Learners

The aim of this interview is to familiarise myself with you as a group of individuals doing mathematics. I am doing a case study on the use of a computer, spreadsheet and web-based classroom. I am going to request you to be as open as possible in answering my questions to have an idea of the depth of your knowledge and skill in doing factorisation of quadratics.

The second request is that you can use any language you feel comfortable to express yourself with more inclination towards English so that I should not translate your statements and lose the gist of your responses and statements. They matter to me as raw as possible from you.

We will start now.



What is factorisation?

Learner 1 Solving for X.

Learner 2 When you are looking for a common number.

Mr Maseko That's one way of doing it. Someone else. When you find that common number, what do you do?

Learner 4 Take out the common factor.

Learner 3 Factorisation is taking out the common, grouping all the items together into brackets

Mr Maseko What? There's a word you used (bracket). Until you do what? Your answer will be in what form? May-be in trinomials. She laughs. There's something she's leading to, but does not arrive there?

Learner 4 The answer will be in brackets (She laughs but doubts her response)

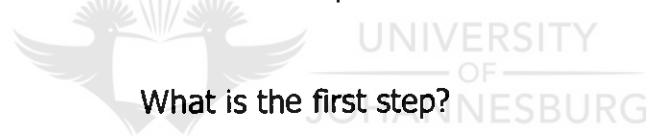
Mr Maseko So factorisation is to ... To group them into brackets.

Learner 4 The answer will be brackets (repeats with more confidence now).

Mr Maseko So factorisation is to turn this trinomial into brackets (a product).

(Mr Maseko Let us use an example to check the method the learners use in factorisation in the face-to-face classroom.)

Let's factorize this example $x^2 - 11x + 30$



Learner 4 Write two brackets and then put x in both brackets. Next step multiply all the number inside the bracket (no one agrees with this part).

Learner 5 After putting the brackets you must look for 2 numbers that you can multiply together to give you positive 30 and with the same numbers that you can add together to give positive 11

Mr Maseko Where are these numbers from?

Learner 4 When you take this two numbers from 30 you multiply them to get 30 and subtract/add them to give you the second term.

Mr Maseko Which one is the second term?

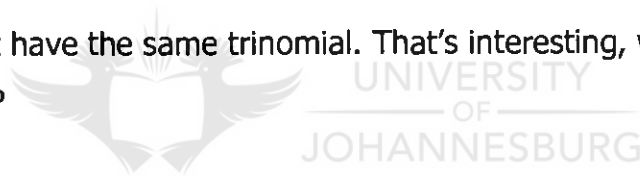
Learner 4 11 ... Negative 11.

Learner 6 Multiply them so that they give 30 and add them so that they give you -11.

Mr Maseko So make the two numbers multiply together so that they give us Let's call it the last term 30 (last term). When you add them (you'll tell, me why you add them) they must give - 11. Why are we adding them?

Learner 6 Because these two brackets they must have (x - the first number), then the second bracket they must have (x + the second number). Then you multiply the brackets. After multiplying the answer (brackets) will be x^2 , multiply the two numbers to get 30, when you add them they must give you - 11x

Mr Maseko You must have the same trinomial. That's interesting, which are the 2 numbers?



Learner 1 5 and 6 (The signs became the new point of interest). The first suggestion was -5 and 6, then -5 and -6

Mr Maseko Why - and - (negative and negative signs)?

Learner 2 Because negative (-) times negative (-) is positive and add numbers and to write the same sign.

Mr Maseko But **Learner 1** has a different explanation.

Learner 1 If we have negative and positive and we times them, they give us negative. Positive + negative = Negative.

Mr Maseko So you are saying -6 and -5 is OK?

Learner 7 If you multiply 5 and 6 you get 30, if you add 5 and 6 you get 11.

Mr Maseko What's wrong with other factors like 15 and 2?

Learner 8 They don't give you the middle term. They give you – 17 other factors 30

Mr Maseko What about 10 and 3?

Learner 2 Gives 7, sorry 13.

Mr Maseko Try the combinations

Mr Maseko We went on to factorise $x^2 - 29x - 30$. And traced the steps again to factorise. The new thing we started talking about adding or subtracting to get the middle term. They had to tell me when do we add or when do we subtract.

- They still struggled with factors.
- Let us assign the signs to the factors. Which factor must have negative and which one is positive?
- I wanted them to summarize the rule on the effects or influence of the positive and negative signs on the last term.

Learner 8 On the first trinomial the last term is positive, so we have to put a sign that when we multiply, they will give you the positive sign and when you add them they give you the middle term. In the second one it was positive and negative because when you multiply positive and negative they will give you negative, when you add them they will give you negative because you are going to take the sign and subtract. The answer will take the sign of the biggest number.

APPENDIX B

POST-IMPLEMENTATION INTERVIEW: Transcript

Grade 10 Learners

Mr Maseko: Grade 10 learners, I am very grateful to see you attending this session, our final day of the project. Your enthusiasm and positive attitude, in sometimes trying circumstances, was noticed while participating in this project.

Issued the learners with a sheet of questions. There are questions that will need your memory and recall of your experiences during the project's life. Your experience and perceptions are based on the project completed in the web-based classroom.

These questions are just a guide to help facilitate the interview. You can express your experience on any issue not included in the questions. I will be making use of my observations in follow-ups to your responses.

Participation

- **Did you enjoy participating in the web-based classroom? Yes/No? Why?**

Learner 1 I think yes. In fact I am in between. Yes I can say it was enjoyable and gave more sense.

But on the side of No, it was tough and very challenging because it was the first time for me to use a spreadsheet and doing it in the web-based classroom.

Mr Maseko What about if we worked on MS WORD?

Learner 1 It was not going to be easier. We are dealing with numbers and we are doing maths

Learner 2 Yes, to me it was interesting. Though it was the first time I was using MS Excel, I was factorizing in a computer. It was challenging to me. Sometimes I struggled with my Maths in class. I think if in this school we were using MS Excel maybe I was going to do better in Maths.

Interaction/Collaboration

- **Was the interaction/collaboration using e-mail helpful in learning to factorise?**

Learner 2 Yes. If we used e-mail, it was going to help some of us. We were struggling with factors to factorize the sums. We were going to share views and see if we were right or not. We were going to help each other but not disturb each other with noise and walking around.

Learner 3 I have learnt to use e-mail and found it helpful.



Instructions

- **Were the instructions clear and simple to understand? Give reasons for your answer.**

Learner 2 To me some were not clear. The red corners were not clear because of the computer I was using. I had to go to other people's computer. The summary had no instructions.

Mr Maseko The Summary sheet had no instructions. Totally. There I was saying you have full mixture of all the work you have done and had to do them without my help.

Learner 3 I think the instructions were a little tough at the beginning because we did not know what to expect. Even if we were used to factorizing in class,

we were not asked those questions. As we went on and began to understand it was kind of simple.

Mr Maseko So you felt it was not easy at the beginning. Was it more the questions or the instructions?

Learner 3 (Sharing files in the network or slow computer). The factor when you write them on paper with a pen it is easy. But when you look at the questions/problems, the first two (MT and LT – isolate terms) were right, OK.

At the end of the whole thing you are supposed to get 2 zeros. Sometimes the computer takes very long, you think maybe my factors were wrong, you start to panic, you ask around. With the e-mail, you could have clicked there and send a message instead of walking around to ask for help.

Learner 4 I support my sister. The thing that made it difficult was that I was surprised. It was the first time because we have never done Maths in the computer.

Challenges and most helpful

- **Which section of the project did you find challenging/most helpful? Why?**

Learner 3 The questions were challenging.

Mr Maseko What was the use of the questions? My aim was to make you think a little bit. I noticed at the beginning you were using your old class method (pen & paper) until you get the correct answer. I wanted to give you a challenge like “what if you” this happened. Why this particular point or value here?

Learner 3 The one about negative C in a class. The computer helped me.

Learner 2 To me I think the section about the summary because the educator must give us sums without an example. In the summary there was no example. I did not know where to start. To me it was the most helpful.

Mr Maseko Did you get all those problems correct?

Learner 2 Yes

Learner 4 Where there was a zero to be found in class we would workout an answer but not sure it was correct or not. The package would tell you that you are correct or not yet correct.

Mr Maseko And it tells you **NOW** that it is correct or not. You are not going to wait for tomorrow to be told your sums were all wrong. You only got 2 of the 23

All Yes

Mr Maseko That was my wish to show this strength. That's why I developed it in MS Excel. The zero is there (pointing on the projected screen). On the right hand side of the zero there is a comment saying." the value here must be equal to 6 or to C", respectively

Do you think we can do the problems without having the zero?

Do you think we can just depend on the MT and LT values only?

Learner 3 You cannot determine that the factors are correct or not. We need the zeros to tell we are not right yet.

Learner 2 I think they were helpful and spoiling us also. As a student we need to think. If you did not know the answer, it was going to help you quickly.

Face-to-face versus web-based class

- **Compare this web-based classroom approach to conventional face-to-face teaching. Which of the two is better in this section? Why?**

Learner 4 I prefer the computer because it's easier and quicker to know your progress rather than waiting for the educator. For most people suspension is not easy. I can't stand it. To think I'm right or correct. Won't be able to sleep. You will be anxious exactly.

Learner 2 For me I think the computer is easier because when the educator is teaching something, I doubt myself. I'm afraid to answer because they might laugh at me. So I think the computer one is easier for me. No one can see whether I'm wrong or right.

Mr Maseko The computer will not laugh at you. (They laughed)

Learner 2 No one can see whether my answer is right or wrong

Learner 6 I think the web-based classroom is very helpful because even if you have a wrong factor you will know there and there whether you are wrong or right. You'll know immediately, not tomorrow or what, immediately. I think it is better than the face-to-face classroom.

Mr Maseko Another advantage? What about time to go to the computer

All Anytime

Summary and way forward

- **Do you think this spreadsheet package can be used in teaching or revision of factorisation of trinomials?**

Mr Maseko The only request I am making to you is: please indicate to Mrs. Mogale that I have requested you to continue working on the problems in the spreadsheet. You can extend the exercises by changing them to new ones. You can ask others who were not in the project to factorize the quadratics. You can also ask the grade 11's to use it for revision.

Remember: You are just going to play with the Isolate terms and Factors blocks (four blocks)

When can we use this package? Do you think we can use it when you are totally new to factorisation or for revision?

Learner 6 Not at the beginning. It is better for revision. It will help with quick calculations and immediate feedback

Mr Maseko Thank you for all your help. I am going to give you the summary and what I have said about the whole project.

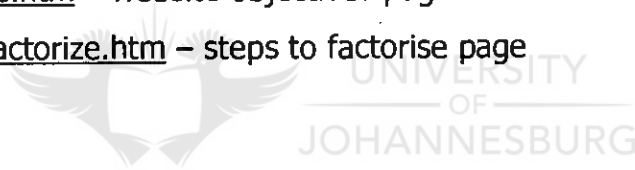
APPENDIX C

Some teaching pages from the web-based classroom

West of Gauteng Province High School Grade 10 Mathematics

File lists file:///C:/Case study/Factor

1. [Factor/default.htm](#) – home page
2. [Factor/definition.htm](#) – definition page
3. [Factor/quadratics.htm](#) – algebraic expressions
4. [Factor/Factor disc cfrm.htm](#)
5. [Factor/Factor disc nav.htm](#)
6. [Factor/Factor disc tocf.htm](#) – table of content
7. [Factor/Factor disc welc.htm](#) – welcome page
8. [Factor/Factortasks.htm](#) – tasks page
9. [Factor/information.htm](#) – learners information page
10. [Factor/objectives.htm](#) – website objectives page
11. [Factor/stepstofactorize.htm](#) – steps to factorise page



Welcome to factorisation home



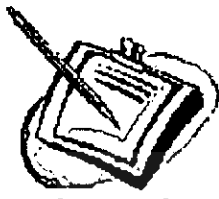
Click to enter the site

for the first time. Otherwise click below directly.

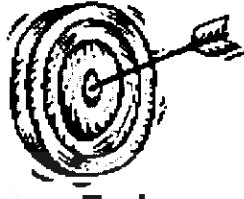
You will find the following pages



Definition



Information



Tasks



Steps



Quadratics

This home page will take you to the main section of the site.

Researcher: JS Maseko

meluccy@webmail.co.za

Figure 3.1 The home page of the web-based classroom: [Factor/default.htm](#)

The steps page from the website: Factor/stepstofactorize.htm

Steps

There are **Steps** to follow to factorize the expressions. These steps are also available at the tasks spreadsheets where they apply.

Read the steps by clicking on the triangle on the right hand side.

Steps 1 and 2: Isolate (and write down) MT(A) and LT(B) 

Note: Enter numbers only at the spaces **b**, **c**, **F1** and **F2** as the steps help you.

- After reading the steps, you will be ready to move to the tasks.
- Click on the tasks (table of contents) to begin.

[to menu](#) [tasks](#) [objectives](#)

A page on the tasks that were done by the learners: [Factor/Factortasks.htm](#)

Tasks

POST YOUR RESPONSES IN THIS PAGE.

There are questions on each type of expressions to be factorized. Please answer them in the space provided **below**. The **subject** is the **type of expression** you are busy with at the time. Then press **submit** to post your responses.

The types of expressions you are going to factorize are:

1. $x^2 \pm bx + c$ [**positive c** and b will be positive or negative]
2. $x^2 \pm bx - c$ [**negative c** and b will be positive or negative]
3. $x^2 - c^2$ [**difference of two squares**]
4. $ax^2 \pm bx \pm c$ [**common factor** and b, c will be positive or negative]
5. **Summary** of all the above

The links, above, will take you to the exercises for each type. The steps ...

Subject:



UNIVERSITY
OF
JOHANNESBURG

Responses:

[to menu](#) [tasks](#) [objectives](#)