

Factors linked to poor performance for National Certificate
(Vocational) Level 2 mathematics students

by

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DECLARATION

I declare that this dissertation is my own work and it has never been submitted for any other degree at any other university.

Signed: _____ on this day: _____

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ETHICS CLEARANCE CERTIFICATE



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This Ethics Clearance Certificate should be read in conjunction with the Integrated Declaration Form (D08) which specifies details regarding:

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- No significant changes,
- Informed consent/assent,
- Adverse experience or undue risk,
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ETHICS STATEMENT

The author, whose name appears on the title page of this thesis, has obtained, for the research described in this work, the applicable research ethics approval. The author declares that he has observed the ethical standards required in terms of the University of Pretoria's *Code of ethics for researchers and Policy guidelines for responsible research*.

ABSTRACT

This study investigates factors, which might be linked to poor performance of National Certificate (Vocational) Level 2 mathematics students at a Technical and Vocational Education and Training (TVET) College in Tshwane. The main research question was: **What are the possible factors that might be linked to poor performance of NC(V) Level 2 Mathematics students at a TVET College in Tshwane?** In order to answer the primary question, the following sub-questions were formulated:

- Which mathematics misconceptions and errors do these students have or make?
- To what do students attribute their poor performance in mathematics?
- What are the lecturers' views on students' performance?

This study is qualitative in nature. Data was collected through students' examination scripts (12 students) to analyse misconceptions and errors in **Algebra**. The misconceptions and errors were categorised into *false concepts; adding unlike terms; partial application of rules; ignoring rule restrictions and slips*. Interviews with students (17 students) were used to investigate what students attribute their poor performance in mathematics to. Interviews with lecturers (five lecturers) examined what lecturers perceive as contributing to their students' poor performance in mathematics. Factors that could be linked to poor performance in mathematics were revealed by both students and lecturers.

The findings of this study revealed that students fail NC(V) Level 2 mathematics because they have misconceptions. The misconceptions include *false concepts, adding unlike terms and partial application of rules*. False concepts and addition of unlike terms indicate lack of conceptual understanding. Partial application of rules shows that the student has insufficient knowledge required to solve the problem and therefore not difficult to correct as compared to false concepts and addition of unlike terms. The study also revealed that students struggle mostly with fractions, simultaneous equations and factorisation.

The interviews with students and lecturers revealed factors that could be linked to poor performance in mathematics, which were grouped as follows:

Student level factors: absenteeism; late coming; mathematical background; students blaming themselves; failure to do classwork or homework or assignments; negative attitude and fear towards mathematics; enrolling students who come from special schools; socio-economic status; lack of practice; peer pressure.

College level factors: teaching strategies; enrolment, which takes place until second term; students with different mathematical background in one class; un-verified entry qualifications.

LANGUAGE EDITOR'S DISCLAIMER

DECLARATION BY A LANGUAGE SPECIALIST

I the undersigned, declare that I scrutinized the correctness of language usage in Mr. MA Ngoveni's dissertation titled '**Factors linked to poor performance for NC(V) Level 2 Mathematics students**' and suggested corrections where necessary. It is however, the prerogative of both the student and his supervisor to implement the suggestions.

Signed: Dr. CDM Tlale

Date: 23 March 2018

ACRONYMS

DHET	Department of Higher Education and Training
EIC	Electrical Infrastructure and Construction
ERD	Engineering and Related Design
HOD	Head of Department
IT	Information Technology
L	Lecturer
MCK	Mathematical Content Knowledge
N	Nated
NATED	National Accredited Technical Education Diploma
NC(V)	National Certificate (Vocational)
Q	Question
R	Researcher
S	Student
SQ	Sub-question
TVET	Technical and Vocational Education and Training

TABLE OF CONTENTS

DECLARATION	i
ACKNOWLEDGEMENT	ii
ETHICS CLEARANCE CERTIFICATE	iii
ETHICS STATEMENT	iii
ABSTRACT	iv
LANGUAGE EDITOR’S DISCLAIMER	v
ACRONYMS	vi
TABLE OF CONTENTS	vii
List of Tables	x
List of Figures	xi
CHAPTER 1: INTRODUCTION AND OVERVIEW	1
1.1. Background	1
1.2. Rationale.....	3
1.3. Problem Statement	3
1.4. Research Questions	4
1.4.1. Primary Question:.....	4
1.4.2. Sub-questions:	4
1.5. Significance of the study	4
1.6. Concept clarification	5
1.7. Outline of the dissertation	6
1.8. Conclusion.....	6
CHAPTER 2: LITERATURE REVIEW	7
2.1. Introduction	7
2.2. Factors that could be linked to poor performance in mathematics	7
2.2.1. Admission requirement.....	7
2.2.2. Socio-Economic Status.....	7
2.2.3. The role of intelligence in mathematics achievement	8
2.2.4. Teaching strategies	9
2.2.5. Absenteeism.....	9
2.2.6. Fear and negative attitude towards mathematics	9
2.2.7. The role of motivation towards achievement	9

2.2.8. Mathematical Content Knowledge (MCK)	10
2.2.9. Lack of resources	10
2.2.10. Mathematical background	11
2.2.11. The role of gender on mathematics achievement	11
2.2.12. The role of parent involvement on achievement	11
2.2.13. The role of language on mathematics achievement.....	12
2.3. What students attribute success and failure in mathematics to?	12
2.4. Studies on teachers' views on the performance of their students	14
2.5. Misconceptions and Errors in mathematics	15
2.6. Conclusion.....	21
CHAPTER 3: THEORETICAL FRAMEWORK	23
3.1. Introduction	23
3.2. Theoretical Framework	23
3.2.1. Background.....	24
3.2.2. Teaching-Learning Process	25
3.2.3. Acquisition.....	29
3.3. Reasons for selecting the framework	29
3.4. Summary	31
CHAPTER 4: RESEARCH METHODOLOGY	32
4.1. Introduction	32
4.2. Research methods.....	32
4.3. Research paradigm	32
4.4. Research design.....	33
4.5. Ethical consideration	33
4.6. Sampling.....	34
4.6.1. Selection of college and campus	34
4.6.2. Selection of lecturer participants	34
4.6.3. Selection of classes	35
4.6.4. Selection of student participants.....	35
4.7. Data collection.....	36
4.7.1. Document analysis.....	36

4.7.2. Interviews	38
4.8. Data analysis	38
4.9. Methodological Norms.....	40
4.10. Conclusion.....	41
CHAPTER 5: DATA PRESENTATION.....	42
5.1. Introduction	42
5.2. Labelling and coding the collected data.....	42
5.3. Analysis of performance of NC(V) Level 2 mathematics students	44
5.4. Analysis of P1 and P2 (S ₁ -S ₁₂).....	45
5.5. Analysis of misconceptions and errors	46
5.6. Misconceptions and errors: Interviews with students	61
5.7. Interviews with students and lecturers: Factors linked to poor performance.....	66
5.7.1. Participants Responses- Students	67
5.7.2. Participants Responses- Lecturers	70
5.8. Similarities between students and lecturers	75
5.9. Differences between students and lecturers	75
5.10. Conclusion.....	76
CHAPTER 6: DISCUSSION OF THE FINDINGS.....	77
6.1. Introduction	77
6.2. Locating the researcher’s study in the theoretical framework	77
6.3. Analysis of misconceptions and errors	79
6.3.1. Analysis of performance of NC(V) Level 2 mathematics students.....	79
6.3.2. Analysis of NC(V) Level 2 P1 and P2 performance	79
6.3.3. Analysis of performance in Algebra: Q1 (question by question).....	80
6.3.4. Misconceptions and errors in Algebra.....	80
6.4. Factors linked to poor performance: Interviews with students and lecturers.....	85
6.4.1. Student-level factors	85
6.4.2. College-level factors.....	88
6.5. Summary	90

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS	91
7.1. Introduction	91
7.2. Answers to the research sub-questions.....	91
7.2.1. Which mathematics misconceptions and errors do these students have or make?..	91
7.2.2. To what do students attribute their poor performance in mathematics?.....	93
7.2.3. What are the lecturers' views on students' performance?	94
7.3. Answering the main research question.....	96
7.4. Recommendations	97
7.4.1. Recommendations for research purposes	97
7.4.2. Recommendations for teaching practices	97
7.5. Limitations of the study.....	98
7.6. Concluding remarks	98
REFERENCES.....	99
APPENDIX A: ETHICS CERTIFICATE	107
ANNEXTURE B: APPLICATION TO CONDUCT RESEARCH: DHET	108
APPENDIX C: LETTER OF INFORMED CONSENT FOR PRINCIPAL	113
APPENDIX D: LETTER OF INFORMED CONSENT FOR CAMPUS MANAGER	116
APPENDIX E: LETTER OF INFORMED CONSENT FOR LECTURERS	118
APPENDIX F: LETTER OF INFORMED CONSENT FOR STUDENTS	120
APPENDIX G: LETTER OF INFORMED CONSENT FOR PARENTS/GURDIANS ..	122
APPENDIX H: Interview Protocol	124
APPENDIX I: QUESTION 1 (Algebra)	125

List of Tables

Table 1.1: NC(V) Level 2 mathematics pass rates between 2011 and 2014.....	3
Table 2.1: Categories of errors Adapted from Luneta and Makonye (2010, p.161)	20
Table 2.2: Categories of misconceptions and errors.....	21
Table 4.1: Assessment for NC(V) mathematics.....	37
Table 4.2: Mark allocation of NC(V) Level 2 final examination	37

Table 4.3: Responding to secondary research questions40

Figure 5.1: Addition of unlike terms by S_3 59

Figure 5.2: Equating expressions to zero61

Figure 5.3: Failure to take out a negative common factor61

Figure 5.4: The disappearing y 63

Figure 5.5: Failure to factorise a trinomial63

Figure 5.6: Calculating x and y intercepts instead of solving simultaneously64

Figure 5.7: Misconception in elimination method65

Figure 5.8: Equating equations on the basis that they are both equal to zero65

Table 6.1: Student-level and College-level factors79

Table 7.1: Categories of misconceptions and errors91

Table 7.2: Summary of student and college factors96

List of Figures

Figure 3.1: Theoretical framework: Adapted from the Wiley-Harnischfeger Model23

Figure 3.2: How Student or college factors affect student achievement (indirectly or directly) (Adapted from Wiley and Harnischfeger model)30

Figure 5.1: Addition of unlike terms by S_3 59

Figure 5.2: Equating expressions to zero61

Figure 5.3: Failure to take out a negative common factor61

Figure 5.4: The disappearing y 63

Figure 5.5: Failure to factorise a trinomial63

Figure 5.6: Calculating x and y intercepts instead of solving simultaneously64

Figure 5.7: Misconception in elimination method65

Figure 5.8: Equating equations on the basis that they are both equal to zero65

Figure 6.1: Theoretical framework: Adapted from the Wiley-Harnischfeger Model77

Figure 6.2: How student or college factors affect student achievement (Adopted from Wiley and Harnischfeger model)78

Figure 6.3: Confusing the power of brackets83

CHAPTER 1: INTRODUCTION AND OVERVIEW

This chapter introduces the study aimed at establishing possible factors linked to poor performance of National Certificate (Vocational) (NC(V)) Level 2 students in mathematics at a Technical and Vocational Education and Training (TVET) College in Tshwane. In order to gain an in-depth understanding of the possible factors linked to poor performance in mathematics, the study investigated the misconceptions and errors that are committed by the students; what students attribute their poor performance to; as well as the lecturers' views on students' poor performance.

1.1. Background

In South Africa, the schooling system comprises primary schools, which are mainly for learners aged between 6 and 14 years, secondary schools, which are mainly for learners aged between 14 and 18 years, and the post school education. Post school education is offered at Universities, which are mainly for students who are 18 years old and above, and Technical and Vocational Education and Training (TVET) Colleges, which are mainly for students who are 16 years old and above. Universities and TVET Colleges are both situated at either public or private institutions. Different campuses of TVET Colleges may specialise in either Engineering Studies or Business Studies, while other campuses may offer both.

“TVET Colleges’ courses are vocational by nature meaning that the student receives education and training with a view towards a specific range of jobs, employment or entrepreneurial possibilities. Public TVET Colleges offer a very wide range of courses or programmes that have been developed to respond to the scarce skills required by employers. Courses offered vary in duration from short courses of a few hours to formal diploma courses of three years which are registered on the National Qualification Framework (NQF)” (<http://www.fetcolleges.co.za>).

The NQF is a set of guidelines and principles which keeps records of achievement for learners. It recognizes the knowledge and skill acquired by learners at a national level. It consists of 10 levels divided into three bands: Levels 1 to 4 are equivalent to high school Grades 9 to 12 or vocational training; Levels 5 to 7 are college diplomas and technical qualifications; Levels 7 to 10 are university degrees.

Two different programmes are offered at TVET Colleges, namely National Accredited Technical Education Diploma (NATED) (Report 191) and National Certificate (Vocational) (NC(V)). NATED consists of Engineering and Business studies. Engineering studies consist of N1-N6, which are trimester courses offered in 11 weeks, while Business studies consist of

N4-N6, which are semester courses. The admission requirement for Engineering studies is Grade 9 for N1 and Grade 12 for Business studies N4. NC(V) consists of Levels 2, 3 and 4, and Level 4 is equivalent to Grade 12. It takes a full year to complete each level and a student receive a certificate for successfully completion of each level. As it is the case with NATED, NC(V) also consists of Engineering and Business studies. The requirement for NC(V) Level 2 is Grade 9. To pass Grade 9, a learner should obtain: 50% home language; 40% additional language; 40% mathematics; 40% in any other three subjects; and 30% in any two of the subjects that are offered. Both NATED and NC(V) programmes are delivered under the auspices of the Department of Higher Education and Training and quality assured by Umalusi in respect of NC(V) Level 2-Level 4 and N1-N3; and Quality Council for Trades and Occupations, that means N4-N6.

This study focuses on the NC(V) engineering programme which is offered at TVET colleges in South Africa. NC(V) programme offers a variety of vocational study fields. “NC(V) programmes integrate theory and practice (60% practical and 40% theory of the internal assessment) and provide students with a broad range of knowledge and practical skills within specific industry fields” (<http://www.fetcolleges.co.za>). Mathematics Level 2 falls under the theoretical component.

Students may enrol for different vocational fields like Engineering and Related Design (ERD); Electrical Infrastructure and Construction (EIC); and Information Technology (IT). In order to complete each field, for an example ERD at Level 2, a student has to pass three compulsory fundamental subjects, namely Life Orientation; English or Afrikaans additional language and mathematics or mathematical literacy, and four vocational subjects; three compulsory and one elective. The four vocational subjects for ERD include three compulsory subjects, namely, Engineering Fundamentals; Engineering Systems; Engineering Technology; and one elective, which should be one of these: Automotive Repair and Maintenance, Engineering Fabrication, Fitting and Turning, Physical science, Refrigeration Principles or Welding.

In order to qualify to enrol for a subject at Level 3, a student has to pass that particular subject at Level 2, which means a student who fails mathematics at Level 2 cannot register for mathematics at Level 3; and can therefore not even receive the Level 2 certificate.

1.2. Rationale

After having taught mathematics at a high school from Grade 8 to Grade 12 for five years, the researcher joined a TVET College in 2013 where he taught the same subject to NC(V) programme students for two years before the researcher switched to NATED programmes in 2015. It was during this period that the researcher realised students were performing poorly in NC(V) mathematics. The errors that were made by NC(V) students were not comparable with those that were committed by neither NATED nor high school learners. The errors had no similarities. The researcher experience as a lecturer at NC(V) has also taught him that these students are unique as compared to learners that we find at high schools and those students doing NATED programme. The researcher also realised that there might be factors that influence the performance of the NC(V) students, which need to be taken into account when teaching them. The researcher decided to investigate some of these factors. There is a limited number of studies conducted in this area, which means there is little literature on NC(V) performance in general. This motivated the researcher to conduct this study in order to attempt to fill this gap.

1.3. Problem Statement

NC(V) programme is a relatively new programme, which was implemented for the first time in 2007. There is very limited research done in the area so far, and therefore it is still struggling to find its feet. This is evident from the performance of the NC(V) Level 2 mathematics students of Tshwane TVET Colleges between 2011 and 2014 (as accessed from Department of Higher Education and Training (DHET) data base on 25 November 2016); also displayed in Table 1.1. The average performance of the two public TVET Colleges in Tshwane for the years 2011; 2012; 2013 and 2014 is 43%; 25%; 3.9% and 34.6% respectfully, which is poor.

Table 1.1: NC(V) Level 2 mathematics pass rates between 2011 and 2014

Classification of TVET College	Percentage pass: 2011-2014			
	2011	2012	2013	2014
College A	42.7%	30%	4.7%	28.8%
College B	43.9%	19.9%	3.1%	40.3%
Average	43.3%	25%	3.9%	34.6%

From the Table above, it is evident that performance in mathematics is a cause for concern in the NC(V) programme. Poor performance of students at Level 2 in mathematics may lead to poor performance in other subjects, especially engineering subjects, since these subjects involve calculations. In many instances, students pass all subjects at Level 4 except mathematics. The reason being that they could not register for mathematics at Level 4 since they had not passed mathematics at either Level 2 or 3. This means that these students cannot graduate since it is expected of them to pass all seven subjects for them to pass each level. It is against this background that the researcher decided to conduct this study. The researcher investigated the factors that could be linked to poor performance of students in NC(V) Level 2 mathematics. The factors included misconceptions created and errors committed by students overtime; what students attributed to their poor performance; and lecturers' views on the performance of their students.

1.4. Research Questions

1.4.1. Primary Question:

What are the possible factors that might be linked to poor performance of NC(V) Level 2 Mathematics students at a TVET College in Tshwane?

1.4.2. Sub-questions:

In order to answer the primary question, the following sub-questions were formulated:

1.4.2.1. Which mathematics misconceptions and errors do these students have or make?

1.4.2.2. To what do students attribute their poor performance in mathematics?

1.4.2.3. What are the lecturers' views on students' performance?

1.5. Significance of the study

The findings of this study will inform lecturers about the factors that could impact on students' performance in mathematics. This is important since lecturers can prepare their lessons with these factors in mind. The study also reported on misconceptions and errors that students have or make in Algebra. This will inform the lecturers of the misconceptions and errors that they can expect from their students and can address in their lessons. Conducting the study at Level 2 was important since this is the entry level from high schools into the TVET Colleges. It is also important to erase any misconceptions at this level than wait to do that at higher levels.

1.6. Concept clarification

The following concepts that appear in this study were used as defined below:

1.6.1. TVET Colleges: TVET is an abbreviation for Technical and Vocational Education and Training. TVET colleges equip students with education and training, which provide students with knowledge and skills necessary for employment.

1.6.2. Errors refer to wrong action attributable to bad judgement, ignorance or inattention.

1.6.3. Misconceptions are wrong answers, which emanate from lack of knowledge or incorrect belief.

1.6.4. Attribution means identifying the source or cause of failure in mathematics.

1.6.5. Interview is the data collection instrument that was used in this study. All participating students and lecturers were interviewed using semi-structured individual interviews.

1.6.6. Lecturers referred to in this study, are lecturers at a selected TVET College campus in Tshwane, who offer mathematics to NC(V) Level 2-4.

1.6.7. Students referred to in this study are Level 2-4 students from a selected government TVET College in Tshwane, taught by the lecturers participating in the study.

1.6.8. NC(V) is an acronym for National Certificate (Vocational), which is one of the programmes offered at TVET Colleges.

1.6.9. Conjoin is a process where unlike terms are joined together.

1.7. Outline of the dissertation

Chapter 1: Introduction and Overview

This chapter presents an overview of the whole study. The background; rationale; problem statement; research questions; and significance of the study are discussed here.

Chapter 2: Literature review

This chapter discusses some of the literature related to factors that limit performance in mathematics, including the misconceptions and errors made by students.

Chapter 3: Theoretical framework

In this chapter the researcher discusses the theoretical framework based on the factors that limit performance in mathematics.

Chapter 4: Research design and methodology

This chapter discusses the research design and methodology applied in the study.

Chapter 5: Data presentation and analysis

This chapter presents the collected data. A brief description, analysis and interpretation of data is presented here.

Chapter 6: Discussion of findings

In this chapter the researcher discusses the key findings of the study.

CHAPTER 7: Conclusion and recommendation

This chapter provides answers to the research questions. The recommendations and limitations of the study are discussed in this chapter. The chapter ends with closing remarks.

1.8. Conclusion

This chapter provides the overview of the whole study. It presents the background; problem statement; rationale; significance of the study and research questions. The chapter ends with the outline of the dissertation. The following chapter reviews literature relevant to this study (national and international).

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

In this chapter, the researcher discusses literature concerned with possible factors linked to poor performance of students in mathematics, including misconceptions and errors. He begins his discussion by looking at factors that limit mathematics performance in general. The researcher also discusses what students attribute to their poor performance, followed by the discussion of teachers' views on students' performance. Finally, misconceptions and errors related to mathematics are discussed. The following subheadings, which are the main areas in this study, are discussed in the next sections:

- *Factors that could be linked to poor performance in mathematics*
- *What students attribute to their poor performance in mathematics*
- *Teachers' views on the performance of their students*
- *Misconceptions and Errors in mathematics*

2.2. Factors that could be linked to poor performance in mathematics

In a study that was reported earlier, it was stated that school-level factors have little effect on students' achievement than student-level factors (Coleman, Campbell, Hobson, McPartland, Mood, Weinfeld & York, 1966). Ensuing studies though reported that the schools account for a significant fraction of variability in academic achievement (Mohammadpour, 2012; Rumberger & Palardy, 2004; Ma & Klingner, 2000).

2.2.1. Admission requirement

The admission requirement for NC(V) Level 2 is Grade 9. This leaves room for students with Grade 10-12 to enrol for this programme. According to Mashongoane (2015, p.36) "this practice led to a diverse classroom population, often creating challenges for the lecturers in finding the correct focus for the lesson". He believes that this also leads to the demoralisation of students with higher qualifications and it is a possible cause of poor performance.

2.2.2. Socio-Economic Status

Secada (1992) define socio-economic status as an individual's relative standing in society and can be measured by things such as salary; profession; education; political influence; and prestige. Peer-pressure has been identified as one of the factors that influence academic

achievement (Coleman et al., 1966; Caldas & Bankston, 1997). According to these studies, regardless of one's own family socio-economic status, if a student attends school with, for an example classmates from families with high social status, this will significantly contribute to his or her academic achievement. Caldas and Bankston (1997, p.276) summarises this by saying, "attending school with classmates who come from higher socio-economic status backgrounds does tend to positively raise one's own academic achievement, independent of one's own socio-economic status background; race; and other factors". Tsanwani, Harding, Engelbrecht, and Maree (2014) argue that learners' perceptions of peers is a contributing factor to mathematics achievement.

Students from higher socio-economic status families are more likely to perform better than those who come from lower socio-economic status families in mathematics (Kiwanuka, Van Damme, Anumendem, Van Den Noortgate & Namusisi, 2015; Teddlie, Reynolds & Sammons, 2000). Howie (2003) also noted that socio-economic status has an effect on secondary students' performance, while Schreiber (2002) discovered that socio-economic differences happen even amongst our most advanced group of mathematics students. "Literate and well-to-do parents generally provide increased resources and educational support, while students from poor families may not find fees easily resulting in higher absenteeism and consequently, poorer performance amongst these students" (Kiwanuka et al., 2015, p.9). Conversely, Heyneman and Loxley (1983) claim that in low-income countries, socio-economic status makes slight variance in academic performance.

2.2.3. The role of intelligence in mathematics achievement

Intelligence can be defined as the ability to attain and apply knowledge. Intelligence is seen as one of the contributing factors towards mathematics achievement (Opdenakker & Van Damme, 2001). According to Opdenakker and Van Damme (2001) the more intelligent a student is, the higher his or her mathematics achievement will be at the end of the school year. On the contrary, Baştürk (2016, p.375) argue that "if a student believes that intelligence is innate, they will be hesitant to do challenging tasks because of fear of disposing themselves to other classmates, while those who believe that intelligence can be influenced and developed may be willing to take more challenging tasks since they don't believe how they deal with problems at hand have got a bearing to their overall intelligence".

2.2.4. Teaching strategies

Miheso (2002) reported that poor performance in mathematics can certainly be explained by teaching methods used in the classroom. A number of researchers (Mji & Makgato, 2006; Tshabalala & Ncube, 2016; Sa'ad, Adamu & Sadiq, 2014) agree with Miheso (2002) that teaching methods play a major role in mathematics achievement. Teachers use teaching methods that learners do not easily follow when teaching mathematics by employing teacher centred methods instead of student centred methods (Tshabalala & Ncube, 2016; Njagi, 2013). The study done by Michael (2015) reveals that some teachers claim that they use student centred methods in their classrooms as well as participatory methods aimed at improving learning. However, performance by their students does not indicate that their methods are successful, despite having attended a number of workshops and seminars.

2.2.5. Absenteeism

Teaching-learning time lost, which may be due to students' absenteeism or teachers bunking classes (or absent from work) is also noted as having a direct influence on mathematics performance (Mji & Makgato, 2006; Miheso, 2002; Tshabalala & Ncube, 2016; Njagi, 2013). Absenteeism especially from the teacher may lead to non-completion of the syllabus content over a year. Attendance on a regular basis is crucial if students are to acquire the necessary skills in mathematics (Tshabalala & Ncube, 2016).

2.2.6. Fear and negative attitude towards mathematics

Tshabalala and Ncube (2016) observed that majority of the students trust that mathematics is naturally a difficult, which means that they fear the subject. They advise that such an attitude does not help students in the pursuit to obtain knowledge on this subject. Students' positive attitudes towards mathematics are believed to be having a considerable and helpful relationship with achievement in mathematics (Botty, Taha, Shahrill & Mahidi, 2015; Mji & Makgato, 2006; Miheso, 2002; Sa'ad, Adamu & Sadiq, 2014). Botty et al. (2015) mention that teachers should help build students' positive attitudes (in and outside the classroom).

2.2.7. The role of motivation towards achievement

There is a link between motivation and mathematics achievement of secondary school students (Tella, 2007). Botty et al. (2015) emphasise that students require motivation in order to develop positive attitudes. In addition, Tella (2007, p.154) said that "highly motivated students perform

better academically than the lowly motivated students”. The scholar further states that an attitude and interest of a learner towards a particular subject is crucial, since the two constructs can motivate the student, and lead to better performance. Tella (2007) also believe that mathematics teachers are encouraged by the better interest and good attitude learners show towards mathematics, which also assist teachers in delivering the content as best as they possibly can. Tsanwani et al. (2014) argue that the application of sound teaching and learning principles promotes an atmosphere where students are inspired to achieve their full potential.

2.2.8. Mathematical Content Knowledge (MCK)

Mathematical content knowledge is the ability that teachers require to teach mathematics. There is a link between the MCK of the teachers and the performance of the learners that they teach (Wu, 2005). Teacher content knowledge is important in impacting students’ mathematics achievement (Kanyongo, Schreiber & Brown, 2007). Mji and Makgato (2006) argue that content knowledge by both students and teachers contribute towards achievement in mathematics. Tshabalala and Ncube (2016) reported that there are mathematics teachers who are not competent enough to teach mathematics, which explains why we are having such a dismal performance in mathematics.

2.2.9. Lack of resources

Shortage of teaching or learning material has also been noted as one of contributing factors towards poor performance in mathematics (Miheo, 2002; Mbugua, Kibet, Muthaa & Nkonke, 2012; Sa’ad, Adamu & Sadiq, 2014; Tshabalala & Ncube, 2016) according to studies that were conducted in Kenya, Nigeria and Zimbabwe respectively. Miheo (2002) indicates that exposure by both teacher and students to a variety of textbooks lead to better performance in mathematics. Sa’ad, Adamu and Sadiq (2014) argue that overcrowded classes and shortage of qualified mathematics teachers also contribute towards poor performance in mathematics in a study that was conducted in Nigeria. On the contrary some researchers observed that class size has no effect on mathematics achievement (Miheo, 2002; Howie, 2003), which is consistent with previous studies conducted in developing countries. Understaffing is one of the factors that contribute to poor performance in mathematics (Mbugua et al., 2012; Sa’ad, Adamu & Sadiq, 2014) according to studies that were conducted in Kenya and Nigeria respectively.

2.2.10. Mathematical background

Tshabalala and Ncube (2016) observed that poor grounding in mathematics is one of the contributing factors towards poor performance in the subject. Mathematical problems are answered in different methods and mathematics still offers an elegant solution, which is a collection of previous mathematical concepts learned (Mangulabnan, 2013). That means a student has to master the previous work before learning a new mathematical topic. Gitaari, Nyaga, Muthaa and Reche (2013) argue that poor entry marks may lead to poor performance in mathematics.

2.2.11. The role of gender on mathematics achievement

According to prior studies, gender considerably predicts mathematics achievement. Schreiber (2002) observed gender differences in the most innovative groups of mathematics students, which differed from school to school. Njagi (2013) noted that boys outperform girls considerably. He cited most mathematics teachers being males at secondary schools as a contributing factor towards boys outperforming girls in mathematics. Equally so, Kiwanuka et al. (2015) and Miheso (2002) observed girls outperforming boys in mathematics. Other researchers argue that there is very little if any gender difference in mathematics achievement (Ganley & Lubienski, 2016; Opdenaker & Van Damme, 2001; Hyde, Fennema & Lamon, 1990). In general, gender differences in mathematics performance are small, but tend to be more pronounced when the content of the assessment is less related to the material that is taught in schools (Ganley & Lubienski, 2016).

2.2.12. The role of parent involvement on achievement

Parental support may be positively linked with students' mathematics achievement through payment for extra classes; buying textbooks; encouraging their children to work hard; helping with homework and counselling (Kiwanuka et al., 2015). Parents' involvement in their children's education contributes to mathematics achievement (Sa'ad, Adamu & Sadiq, 2014; Mji & Makgato, 2006; Tshabalala & Ncube, 2016).

Kanyango et al. (2007) say that mothers' education is related to mathematics score in sub-Saharan African countries since mothers are more involved in their children's education than their fathers because they spend more time at home with their children. On the contrary

Opdenakker and Van Damme (2001) state that the father's educational level is positively related to the student's achievement.

2.2.13. The role of language on mathematics achievement

Research shows that English as medium of instruction and assessment, plays a vital role in mathematics achievement. Students attain good scores in mathematics when their proficiency in English is good and are more likely to attain poor marks in mathematics when their marks in English test are poor (Howie, 2003; Mji & Makgato, 2006). Howie (2003) further argue that those students who speak English or Afrikaans at home tend to achieve good marks in mathematics and students from homes where African languages are used, are more likely to achieve poor marks in mathematics. Makonye and Fakude (2016) discovered that English as a medium of instruction and assessment makes it difficult for the learners to understand addition and subtraction of integers. Opdenaker and Van Damme (2001) could not establish the role of language on mathematics achievement.

Even though the current study focuses on factors that could be linked to poor performance in mathematics from the students and lecturer's perspective, it was necessary to first consider studies conducted on factors that limit mathematics achievement in general before focusing on students and teachers' views. This is necessary as it will give the reader an overall view of the factors that can be linked to poor performance in mathematics, before learning to what students and teachers attribute to poor performance in mathematics. The next section discusses literature related to what students attribute to their poor performance in mathematics.

2.3. What students attribute success and failure in mathematics to?

Attribution means identifying the source or cause of failure in mathematics. Students' attributions can be clarified using the attribution theory. "Attribution theory refers to a field of study rather than to a specific scientific conception. The heart of this area of investigation includes assumptions; hypotheses; and theories regarding how laypersons arrive at answers to 'why' questions such as: 'Why did I fail my mathematics test?'" (Weiner, 2010, p.1). It is easy for a student to judge if s/he is passing or failing in mathematics than it is in other subjects due to the nature of school mathematics and this makes attribution theory to be valid in mathematics (Kloosterman, 1984). He adds that the reason students give for their performance predicts how successful they will become in future.

Sukariyah and Assaad (2015) embarked on an attribution retraining programme with the aim of helping students adopt more functional attribution and obtain improved results in mathematics. In their study, they observed that positive results where re-training achieved an enhancement in attributional style and mathematics attainment. They recommended that to enhance students' self-efficacy, teachers should be trained to use attributions that will produce mastery learning.

In mixed-ability groups, “students tend to attribute their mathematics performance to their teachers and bad luck, whereas vocational-and academic-track students are more likely to blame themselves for not doing well” (Mijs, 2016, p.150). Nokelainen, Tirri, and Merenti-Välimäki (2007) noted that mostly and averagely mathematically gifted students consider ability as more significant for achievement than effort, but mildly mathematically gifted students consider effort as leading to success. They emphasise that averagely and slightly mathematically talented students tend to attribute poor performance to absence of effort, whereas mostly mathematically gifted students attribute poor performance to lack of ability. Attributing success to effort and failure to lack of effort are the best predictors for the level of mild mathematical giftedness (Nokelainen, Tirri, & Merenti-Välimäki, 2007).

Tsawani et al. (2014) reported that students from high performing schools put more emphasis on aspects within their own control, such as doing homework, attending classes and participating in class, while students from low performing schools attach more weight on teachers' characteristics and behaviour. Students from low performing schools feel unacknowledged by their educators when it comes to efforts that they put into their school work and they are not motivated to work hard because they feel they are not treated with respect that they deserve (Tsawani et al., 2014).

Ali and Jameel (2016) and Tshabalala and Ncube (2016) argue that majority of the students agree that mathematics is naturally a very difficult subject and they fear it. Students also complain about the teaching methods that are used by their teachers, where they say their teaching methods do not make them understand the subject and they do not have the potential to teach mathematics (Ali & Jameel, 2016; Tshabalala & Ncube, 2016; Harris & Bourne, 2017).

Baştürk (2016) reported that most student teachers attribute their performance in mathematics to innate mathematical talent. According to Baştürk (2016, p.375), “the risk in this kind of

believe is that if students consider intelligence to be innate, they less likely tend to select challenging tasks due to the unwillingness of disconfirming their intelligence before others”. If a student believes that intelligence can be influenced and developed, s/he will willingly do thought-provoking questions (Baştürk, 2016). He also noted that interest in mathematics; interest in the teacher; irregularity; and bad planning are some of the factors to which student teachers attribute their performances in mathematics.

In order to answer the research question related to students’ attribution to their performance in mathematics, it was necessary to interview students to establish to what they attribute their performance in mathematics. In this study the researcher used semi-structured questions to establish factors, which students attribute to their performance in mathematics as used by Mji and Makgato (2006). In the section that follows, literature related to the teachers’ views on the performance of their students is discussed.

2.4. Studies on teachers’ views on the performance of their students

Teachers’ perceptions of learners is a contributing factor to mathematics achievement (Tsanwani et al., 2014). Teachers’ causal attributions have latent influence on learners’ own attributions through their (teachers) actions (Baştürk, 2016). Teachers should be careful about the way they describe the performance of their learners.

Ali and Jameel (2016) state that lack of practice and exercises is a main reason affecting the attainment of solid and abstract mathematical concepts according to teachers. Makeo (2013) revealed the following factors as being attributed to poor performance in mathematics by teachers:

- Shortage of professionally trained teachers
- Insufficient teaching and learning resources
- Poor teaching methods
- Absenteeism
- Negative attitude

Gender stereotype, where girls are perceived to be inferior to boys is a factor influencing student performance (Makeo, 2013). This affects participation of girls in classroom discussion and activities.

In education, the achievement gap is the disparities that occur in academic performance amongst groups of learners generally categorised by gender; ethnicity; socio-economic status; and race (Webb & Thomas, 2015). Bol and Berry (2005) discovered that secondary teachers attribute the achievement gap to motivational level; work ethics; family or parent support; and language of instruction. Teachers also attribute lack of innate talent to poor performance in mathematics (Baştürk, 2016). He emphasised that teachers who see intelligence as the main contributor towards mathematics performance, will not work harder to improve the performance of students that they consider to lack talent in mathematics.

In order to answer the research question related to the lecturers' views on their students' performance in mathematics, it was necessary to interview lecturers to establish what they think is the cause of poor performance in mathematics. In this study the researcher used semi-structured questions to establish factors, which lecturers think they limit mathematics achievement as used by Mji and Makgato (2006). In the section that follows, literature related to misconceptions and errors in mathematics is discussed.

2.5. Misconceptions and Errors in mathematics

According to Luneta and Makonye (2010, p.158), “an error is a mistake, slip, blunder or inaccuracy and a deviation from accuracy”. Misconceptions are fundamental incorrect beliefs and values in one's mind which can lead a student into making a sequence of errors (Makonye, 2012).

“Errors may occur for a variety of underlying reasons, ranging from the careless mistake (less serious) to errors resulting from misconceptions (more serious). Misconceptions are, in effect, the misunderstandings about mathematical ideas which children entertain and which usually lead to errors occurring and they are the most serious kind of errors which require urgent action on the part of the teacher” (http://ictedusrv.cumbria.ac.uk/math/pgdl/unit1/unit1/page_35.htm).

There are two types of errors, namely, *unsystematic errors* and *systematic errors*. Unsystematic errors are non-intended, non-repeated incorrect answers that students may easily correct by themselves (Luneta & Makonya, 2010). Systematic errors are repeated wrong answers that are methodologically constructed and produced over time (Luneta & Makonya, 2010).

Errors may be identified in students' work such as test; homework; classwork and assignments, while misconceptions may be concealed in correct responses (Smith, DiSessa & Roschelle, 1994). Educators should attentively listen to their students to correctly establish the reasons behind the students' responses (Luneta & Makonya, 2010; Mulungye, O'Connor & Ndethiu,

2016). In that way they will be able to help correct or clear any misconceptions that students may have, if any.

The biggest challenge with misconceptions is that students are not aware that they possess a misconception, which normally perpetuate in the classroom (Green, Piel & Flowers, 2008). According to Egodawatte (2011, p.144) “students mistakenly modify and apply a previously learned rule on an algorithm to a new problem situation and they do not realise that a misuse has occurred”. Li (2010) believe that it is quite a challenge for students to give up these wrong concepts because they are rooted in their minds. These misconceptions, according to Luneta and Makonye (2010) weaken students’ basic Algebraic skills like solving equations and factorisation, and ultimately compromise the performance of students.

Students make certain categories of errors based on identifiable misconceptions in Algebra (Mulungye, O’Connor & Ndethiu, 2016). Some of the most frequently occurring class of errors in the high school according to Mulungye, O’Connor and Ndethiu (2016) include:

$$(a + b)^2 = a^2 + b^2$$

$$3x + 3x = 6x^2$$

$$3x - (x - 5) = 2x - 5$$

$$x + y = 2xy$$

$$3x + 5 = 8x$$

For an example, expanding $(a + b)^2$ as $a^2 + b^2$ is the misconception of the power of brackets (Mulungye, O’Connor & Ndethiu, 2016). These authors suggest that teachers should use students’ mathematical ideas in order to address these errors. This is supported by Makonye and Matuku (2016) who discovered that students struggle with the correct application of distributive laws where they fail to multiply correctly.

Makonye and Khanyile (2015) investigated the effect of probing on students in respect of their errors with the purpose of comparing the difference in their performance prior probing and post probing. Probing students concerning their errors, assisted them in dispelling misconceptions that lead to committing errors such as obtaining answers using the wrong mathematical rules; careless mistakes; dropping the denominator; confusing factors; inability to recognise the common factor; failure to factorise a trinomial; and lowest common denominator (Makonye & Khanyile, 2015). They believe that if teachers can make students aware of their errors, students will be able to correct their misconceptions and improve their performance. According to

Beukes (2015), N2 students face a major challenge with respect to factorisation, especially factorisation of difference between two squares. She observed that students cannot identify and factorise a difference of two squares.

In their study of analysis of students' errors, Wijaya, Van den Heuvel-Panhuizen, Doorman, and Robitzsch (2014) identified students' difficulties in using Newman's error categories, which were connected to the modelling process described by Blum and Leiss, as well as to the Programme for International Student Assessment (PISA) stages of mathematization. The stages included:

1. "Comprehending a task" (Wijaya et al., 2014, p.577);
2. "Transforming the task into a mathematical problem" (Wijaya et al., 2014, p.577);
3. "Processing mathematical procedures" (Wijaya et al., 2014, p.577);
4. "Interpreting or encoding the solution in terms of real situation" (Wijaya et al., 2014, p.577).

Their results showed that students make most mistakes in the first two stages of the solution process. Below is a summary of their results:

- 38% of the errors were based on understanding the meaning of the context-based tasks
- 42% were errors resulting from transforming a context-based task into mathematical problem.
- mathematical processing and encoding the answers had less errors with 17% and 3% correspondingly

San Pedro, Barker and Rodrigo (2014) investigated "the relationship between students' affect and their frequency of careless errors while using an Intelligent Tutoring System for middle school mathematics". They described careless error as an error where the student's response is incorrect regardless of knowing the proficiency required to give the right response. They reported that mostly engaged students may unexpectedly be overconfident or rash, which may lead to many careless errors. Students who are confused and bored have little learning in general, meaning their errors seem to result from absence of knowledge rather than negligence (San Pedro, Barker & Rodrigo, 2014).

Kerslake (1986) reported that research evidence from Concepts in Secondary Mathematics and Science (CSMS); and from other parts of the Strategies and Errors in Secondary Mathematics

(SESM) project suggest that many children do not use formally “taught” methods in mathematics, but use, instead, their own informal methods. He concluded as follows:

- In the case of fractions, the position appears somewhat different since children rely on rote memory of previously learned techniques
- The primary cause seems to be lack of any attachment of meaning to the concept of fraction
- Fractions are not usual part of the students’ environment, and the processes on them are abruptly defined and not grounded on everyday life.

Most students are lacking in fluency in dealing with integers; fractions and algebraic conventions (O’Connor & Norton, 2016). They observed the following in their study:

- Errors included adding unlike terms; and incorrect applications of index notation and radical arithmetic.
- Some students indicate that they can factorise a quadratic equation but could not obtain the final solution due to lack of conceptual understanding regarding the null factor.

Conjoin is a process where unlike terms are joined together, for an example: $3 + x = 3x$ (Makonye and Matuku, 2016). These researchers discovered that students do not comprehend the concepts of algebraic terms and fail to make sense of the concepts like unlike terms. They say students wrap up expressions by combining unlike terms. For an example, some learners wrote $2x^2 + 3x = 5x^2$. They further observed that students conjoin unlike terms and have a tendency to take the highest exponents in the terms when they do so.

Students still struggle with some of the fundamental concepts in mathematics even at the end of their secondary schooling (Sarwadi & Shahrill, 2014). The conclusion on their study included:

- “The level of misconceptions have a significant effect on the students’ progress and achievement in high stakes tests or examinations” (Sarwadi & Shahrill, 2014, p.8).
- “Students are also not aware of having a misconception” (Sarwadi & Shahrill, 2014, p.8)
- “Fundamental mathematical misconceptions may originate in the primary stage of schooling, but, students develop even more robust misconceptions in the secondary level as a result of inattention” (Sarwadi & Shahrill, 2014, p.8).
- “Some of the students’ errors and misconceptions are as a result of inattentiveness on the part of the classroom teachers. Secondary teachers assume that students know very well most simple and fundamental concepts such as finding equivalent fractions before

doing addition and subtraction because such were taught at primary level” (Sarwadi & Shahrill, 2014, p.8).

- “Teachers should be made more aware of how misconceptions might arise and employ strategies that incorporate errors in their teaching” (Sarwadi & Shahrill, 2014, p.8).
- “Students’ written work allows teachers to detect errors and misconceptions and therefore will help teachers to plan diagnostic instruction” (Sarwadi & Shahrill, 2014, p.8).

Examples of worked solutions of the students in the study of Sarwadi and Shahrill (2014) are:

$$a) 25x^2 \div 5x^{-4} = \frac{25^2}{5^{-4}} = 5^{-2}$$

$$b) 25x^2 \div 5x^{-4} = 25x^2 \div 5x^{\frac{1}{4}} = 5x^{2\frac{1}{4}}$$

The disappearance of the unknown as illustrated in (a) due to students overgeneralising.

Number (b) shows wrong application of the law of exponents and addition of exponents when they should subtract.

Skemp (1976, p.20) describes relational understanding as “knowing both what to do and why.” Makonye and Fakude (2016) state that students have a lack of relational understanding. They argue that there is a lack of use of number line model as a strategy to show relational understanding of addition and subtraction of directed numbers. Causes of errors in learning of integers may be attributed to premature use of calculators; textbooks with insufficient examples; and poor proficiency of the students in English (Makonye & Fakude, 2016). Bohlmann, Prince and Deacon (2017, p. 8-9) in addition argue that “calculator dependence has resulted in a limited understanding of the number system hence it is important to teach the structure of the number system, especially numbers (natural, integers, rational, and so on) in relation to one another”. These researchers also discovered that learners have difficulties when dealing with subtraction.

The difference between an equation and an expression is not well distinguished by students. Essien and Setati (2006) indicated that students have little understanding of the meaning of the equal sign and this creates problems for them in Algebra. The students ignored the equal sign and changed the equation into an expression because of the confusion caused by the statement: solve with the aid of factorisation (Makonye & Matuku, 2016). Egodawatte (2011) also witnessed students violating the equality property by putting equal sign in statements that were not equal. Bohlmann, Prince and Deacon (2017) discovered that learners struggle to differentiate between an equation and an expression, and cannot correctly apply identical procedures to both sides of an equation in order to solve the equation. The meaning of equal

sign should be clearly explained to students. Egodawatte (2011) discovered that students struggle with solving simultaneous equations, especially when they used elimination method. He says that students misinterpret elimination method when solving simultaneous equations.

In her study of learning difficulties involving volumes of solids of revolution, Mofolo-Mbokane (2011) discovered that students make numerous errors when they solve problems involving evaluation of integrals and when applying different techniques of integration. Mofolo-Mbokane (2011) also reveals that students struggle a lot with the calculation of point of intersection (when solving simultaneous equations). When solving for x from the two equations, the students were unable to interpret a square root which contain a negative number. She concluded that “the nature of errors made may be as a result of the students’ lack of the mathematics register and probably because their knowledge in mathematics rules is superficial” (Mofolo-Mbokane, 2011, p. 285). She argues that students also fail to obtain the correct answer or correctly draw the graphs due to their lack of general manipulation skills.

Categories of misconceptions and errors in this study

In order to categorise misconceptions in this study, it was necessary to examine contributions by other researchers who investigated errors and misconceptions in mathematics. Makonye and Khanyile (2015) included slips as one of the categories in their study where they describe slips as careless mistakes. Luneta and Makonye (2010, p.161) used the table below to categorise errors in their study of Grade 12 learners’ errors in differentiation.

Table 2.1: Categories of errors Adapted from Luneta and Makonye (2010, p.161)

Description with examples chosen from the study
<p>Ignorance of rule restrictions or symbolism. Applying rules to the contexts they do not apply. Failure to understand the bounds where a rule applies.</p> <p>E.g. If $y = \frac{(\sqrt{x-4})}{\sqrt{x}}$, then $\frac{dy}{dx} = \frac{(x-4)^{\frac{1}{2}}}{x^{\frac{1}{2}}}$. Here the learner assumes that the square root sign covers all $x - 4$ instead of just x. The error occurs when numerator and denominator are differentiated separately. This error is due to equation balancing.</p>
<p>Incomplete application of rules</p> <p>E.g. To find the gradient of tangent of $y = x^3 + x^2 - 5x + 3$ at $x = 2$. A learner found the gradient (11) correctly then wrote the point as (2 ; 11). The thinking could not proceed from there.</p>
<p>False concepts hypothesized to form new concepts.</p> <p>E.g. To find the x and y intercepts of $f(x) = x^3 + x^2 - 5x + 3$, a learner wrote $x^3 + x^2 - 5x + 3 = 3x^2 + 3x - 5x = 0$ and ended there. The learner assumed that differentiation has to do with the intercepts. Perhaps thought turning points were intercepts! This is an example of a conceptual error.</p>

In this study, misconceptions are categorised as *false concepts; adding unlike terms; partial application of rules; and ignoring rules restrictions*. Errors were categorised as *slips*. Table 2.2 explain how these categories are used in this study.

Table 2.2: Categories of misconceptions and errors

	Category Name	Description
Misconceptions	Adding unlike terms	Unlike terms are collected and added together. These are very serious.
	False concepts	These are completely wrong answers. These are very serious as they indicate lack of knowledge.
	Partial application of rules	This is where a student partially apply the correct rule to a question. These are serious errors but indicates that the student possesses some of the knowledge required and therefore not difficult to correct as false concepts.
	Ignoring rule restrictions	This refers to ignoring the boundaries, which are applicable to a certain rule and include applying a rule to a context to which it is not applicable.
Errors	Slips	These are unintended mistakes. They are not serious as the students can easily correct by themselves or with the help of their lecturer.

In this study, misconceptions are all wrong answers, which emanate from lack of knowledge or incorrect belief by Level 2 mathematics students. Errors refer to slips or unintended mistakes committed by students during 2016 mathematics final examination. For the purpose of data analysis, all wrong answers given by students are referred to as errors.

To answer the research question based on misconceptions and errors in this study, the 2016 final examination answer books for Level 2 students were used to identify misconceptions and errors in Algebra. Misconceptions and Errors were grouped into categories, which were based on the type of misconception or error made by students as used by Luneta and Makonye (2010). Student participants were interviewed to confirm if some of the errors were slips or misconceptions and it was further established why they struggle in some of the questions. Luneta and Makonye (2010) also used interviews to find reasons behind students' errors.

2.6. Conclusion

Poor performance in Mathematics is a cause for concern throughout the world. The literature discussed here identified factors that could be linked to poor performance in mathematics, either school-level or student-level factors. The researcher also discussed literature related to students' attribution of their performance in mathematics and teachers' perceptions on the performance of their students. This will help TVET College lecturers make desirable decisions

that can enhance achievement in mathematics at classroom level since they will be aware of their students' attributions of their performance in mathematics.

It is crucial to identify misconceptions and errors in mathematics since most lecturers or teachers are not aware of mathematical misconceptions and errors of their students (Ricomini, 2005). Green, Piel and Flowers (2008) argue that students are not aware that they have any misconceptions. Furthermore, this study will equip TVET College lecturers with knowledge of the misconceptions and errors specifically applicable to their students and will therefore assist them in their daily preparations. In order to address these misconceptions, the lecturers must use the students' ideas during lessons presentation (Mulungye, O'Connor & Ndethiu 2016).

Even though the literature discussed in this chapter involved factors that can be linked to poor performance in mathematics; and misconceptions and errors, investigation was mostly conducted at primary schools, high schools and higher learning institutions. Only three investigations were conducted at TVET Colleges in South Africa, which identified a gap in this area. This study is thus an important one, as it aims to close the gap that exist at TVET Colleges.

CHAPTER 3: THEORETICAL FRAMEWORK

3.1. Introduction

*This chapter discusses the theoretical framework that was used in this study. The main research question in this study is: **What are the possible factors that might be linked to poor performance of NC(V) Level 2 Mathematics students at a TVET College in Tshwane?** In order to answer the main research question, the following research sub-questions were developed:*

- *Which mathematics misconceptions and errors do these students have or make?*
- *To what do students attribute their poor performance in mathematics?*
- *What are the lecturers' views on students' performance?*

In an attempt to answer the research questions in this study, it was important to examine school improvement or school learning models from previous studies. This was in order to evaluate how factors that could be linked to poor performance in mathematics fit in the model. For that reason, Wiley and Harnischfeger (1974) school learning model was selected.

3.2. Theoretical Framework

This study used Wiley and Harnischfeger (1974) (Figure 3.1) school learning model to investigate how misconceptions and errors; college factors and student factors fit in the model.

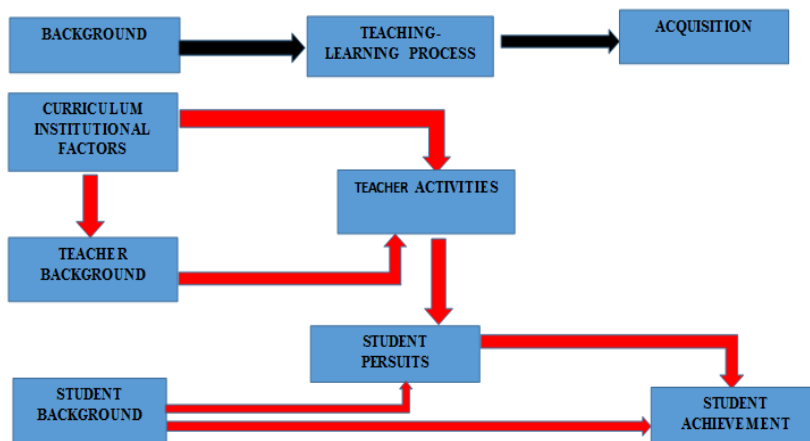


Figure 3.1: Theoretical framework: Adapted from the Wiley-Harnischfeger Model

The Wiley and Harnischfeger model consists of three main categories, namely background; teaching-learning process; and acquisition. These categories will be discussed in details in the next sections.

3.2.1. Background

In this model, background consists of “curriculum; institutional factors; and personal characteristics of teacher and students”. According to Schreiber (2002, p.275), “background factors includes such factors as courses offered; courses taken; school size; school climate; school resources; parent education level; and student attitudes”.

Student factors

Research shows that student factors have an impact on mathematics achievement (for an example, Geary, 2011; Miheso, 2002; Tshabalala & Ncube, 2016; Kiwanuka et al. 2015). Socio economic status has a direct impact on achievement; and students with parents who have higher levels of education (high socio economic status) are most likely to perform well academically (Green, Dugoni, Ingels, & Cambrun, 1995). The contribution of gender to achievement in mathematics continue to be a debatable topic, with researchers not having a consensus. Friedman (1989) observed no differences in gender performance while Dossey, Mullis, Lindquist and Chambers (1988) reported that girls out performed boys until the age of ten. At secondary school years, some research favoured girls (Miheso, 2002) and some favoured boys (Njagi, 2013); while some researchers observed no difference (Hyde, Fennema & Lamon, 1990). Attitude towards mathematics play an integral part in mathematics achievement. According to Schreiber (2002, p.275), “the general relationship between attitude and achievement is based on the concept that the better the attitude a student has toward a subject or task, the higher the achievement or performance level tends to be”.

In this study, student factors will include factors such as absenteeism; mathematical background; misconceptions and errors; and others. The misconceptions and errors are student factors; while both students and lecturers may attribute the factors that are within students’ control to poor performance. This means that the student factors will be addressed by all three research sub-questions.

Institutional factors

Research shows that school-level factors (for an example: resources, size; and culture) have an impact on achievement (Mbugua et al., 2012; Sa’ad, Adamu & Sadiq, 2014; Howie, 2003). In this study, institutional factors are referred to as college factors. These factors include all factors that are not within students’ control. This means lecturer background factors will also be referred as college factors. Examples of these factors in this study include: enrolment

requirement; teaching strategies; and others. College factors will be addressed by two research questions namely: *To what do students attribute their poor performance in mathematics? and What are the lecturers' views on students' performance?*

3.2.2. Teaching-Learning Process

Teaching-learning process consists of teacher activities and student pursuits. According to Schreiber (2002, p.274), “teaching–learning process includes such factors as in-class and out-of-school pursuits or activities (for an example, answering questions in class; working in groups; athletics; employment; or homework)”. In this model it is of utmost importance to acknowledge and refine the student's time. Wiley–Harnischfeger 1974 model is more concerned about the time that the student spends learning against total class time (Wiley & Harnischfeger, 1974). The class time consists of active responding and passive responding. In this model, active responding involves the student participating in activities like solving problems; writing; and working on a microscope. Passive responding comprises of actions such as listening to lecturers or listening to other students while they are reading (Delquadri, Greenwood & Hall, 1979). According to Greenwood, Delquadri, and Hall (1984), almost half of a student's day involves passive response and if the student responds more actively, this will increase the chances of his or her achievement. In the sections that follow, the researcher discusses the teaching and learning process assumed in the current study. The researcher further discusses how misconceptions are created over time and how errors were classified in this study.

How students acquire mathematical knowledge

Constructivism hypothesises that the construction of knowledge happens through cognition driven by mental self-regulation (Makonye, 2011). Each time a student faces occurrence that s/he is not familiar with, s/he develops anxiety and tension that may be referred to as cognitive conflict (Piaget, 2003). This situation engages the student in exploring the problem in relation to their prior understanding. According to Siegler (2007), there are three main mechanisms for the development and learning in constructivism namely: *assimilation; accommodation; and equilibration*. Assimilation is a process whereby a child actively incorporates his experience into a representation already available. Piaget explains *assimilation* as using existing schema to get meaning to new ideas. In the process of assimilation, the student may overgeneralised. *Accommodation* is when a student actively reorganise when there is too much discrepancies

between the student's current cognitive and new concept. *Equilibrium* is a state whereby a child's prevailing schemas are able to clarify what it can recognise around it (cognitive or mental balance) (Piaget, 2003). In this study teaching and learning in mathematics is viewed from a constructivist perspective (Piaget, 2003; Siegler, 2007) as it gives a clear description of how knowledge is conceived.

Students construct knowledge mainly at two levels (Cobb & Bauersfeld, 1995). The first level involves construction of knowledge through student's prior mathematical knowledge. The second one states that knowledge construction takes place through social interaction that generates contradictions. It is highly unlikely that a student cannot be satisfied with his existing knowledge, except when s/he is influenced by external forces such as reading or discussion with others. It is important to note that in a constructivist view, knowledge cannot be transferred (undigested) from the lecturer to the student. The knowledge must be re-organised and restructured by each student to give it meaning. It can therefore be said that students can acquire mathematical knowledge through construction of concepts (Sfard, 1987). In this study, Cobb and Bauersfeld's (1995) levels are seen as the main constructs in the construction of knowledge. The student needs prior knowledge to build on new knowledge and the interaction among students through robust discussions, ensure that they learn from each other.

Misconceptions in mathematics

Students are not taught misconceptions by their lecturers, but they conceive these misconceptions by themselves (Confrey & Kazak, 2006). According to Confrey and Kazak (2006, p.201), "misconceptions are the strongest pieces of evidence for the constructive nature of knowledge acquisition, because it is highly unlikely that learners have acquired them by being taught". They also highlight that if the lecturer has a misconception, he can easily pass it to the students.

In this study, the constructivist viewpoint (Confrey & Kazak, 2006; Sfard, 1987; Cobb & Bauersfeld, 1995; Piaget, 2003; Siegler, 2007) is assumed to be worthwhile as it does clarify and better envisage how students comprehend mathematical concepts as well as misconceptions. The understanding of mathematics starts with knowledge of basic facts, concepts, principles and computational procedures (Makonye, 2011). The researcher contends that misconceptions and errors happen in the cognitive realm since information is processed in the mind.

Since constructivist theories explain how students acquire mathematical knowledge (including misconceptions and errors) as discussed in the previous paragraphs, the researcher assume that Makonye's (2011) constructs of concept image and concept definition are more helpful in giving more understanding on students' misconceptions and errors. According to Makonye (2011, p. 42) "a concept image is an inner model of reality constructed by the learner as a result of experience with a particular concept and can be seen as a picture of a concept constructed by a learner to refer to an identified concept, while a concept definition can be described as words specifying the concepts as defined by the mathematics experts". Concept images may be correct, partially correct or erroneous, and they are a function of maturity and experience with the concepts. In this study, misconceptions (if any) are assumed to be occurring as a result of in-adequate knowledge acquisition.

Classification of misconceptions and errors

The classification of misconceptions and errors in this study was conducted in line with Donaldson's (1963) error classification. According to Donaldson (1963), there are three types of generic errors in mathematics that occur while students learn mathematics. The categories are *executive errors*, *structural errors* and *arbitrary errors*. The scholar believe that these three categories are the most important in teaching and learning of mathematics.

Executive errors involve the student's failure to carry out manipulations or procedures even though the student has grasped the required concepts (Makonye, 2011). An example of executive errors is procedural errors where the student fails to properly carry out an algorithm. Errors such as inability to factorise belong to this category.

Structural errors can be defined as the errors that emanate from the student's failure to grasp some principles essential to a solution or inability to appreciate the relationships involved in the problem (Makonye, 2011). These errors are comparable to conceptual errors.

Arbitrary errors are errors that occur as a result of student ignoring part of the available information while s/he acts on the rest (Makonye, 2011). They occur when a student wants questions to only fit what they are familiar with or what they know.

Factors that influence teaching and learning

Students do not spend all of their time in class, so the activities that students involve themselves in, influence performance (Schreiber, 2002). This means that different pursuits, for an example extramural or free time, may have either positive or negative impact on student's performance. Pursuits such as television; employment; and sports have been for the past years been seen as having an influence on performance (Coleman, 1961; Holland & Andre, 1987; Marsh, 1992). Marsh (1991) argue that the zero sum theory, attributed to Coleman, suggests that time spent in non-academic activities reduces academic performance by captivating important learning time. Similarly, hefty non-academic student activity load interferes with educational work, reduce the time assigned to finish homework, and the student becomes less ready to partake throughout school time (Porter, 1991). Non-academic activities may reduce the amount of time the student spends on academic activities and in the process interfere with teaching learning process (Porter, 1991). There is a link between after-school pursuits and performance (Schreiber, 2002). Students who participate in extramural activities show positive self-concept, better attitudes and better performance than students who do not participate in such activities (Holland & Andre, 1987). Gerber (1996) observed positive relationship between mathematics achievement and extracurricular activities that occur at school and outside school.

Schreiber (2002) noted four main activities that students participate in after school, which included television; homework; part-time employment and athletics. Researchers do not agree on the role played by part-time work on achievement where Singh and Ozturk (2000) observed undesirable impact, good effect (D'Amico, 1984), or none (Green & Jacquess, 1987). Research shows that television viewing lessen achievement (Comstock, 1991). According to Schreiber (2002, p.276) "television viewing displaces academic activities and reduces the amount of time available for completing homework and other academic activities, thereby reducing achievement". In their study, Cooper, Valentine, Nye and Lindsay (1999) revealed that there is an undesirable relationship between attainment and television watching (average watching time 1–2 hr per night).

It was not the intention of this study to investigate how teaching-learning process is linked to poor performance. But it was important to look at teaching-learning as it may be influenced by the factors under investigation or can emerge from the interviews with the participants.

3.2.3. Acquisition

Acquisition refers to the student's achievement. Acquisition can be explained as the relationship between captivation of time and how it can be linked with attainment (Schreiber, 2002). It is the level of attainment for the student in a particular subject, or in general. In this study, mark sheets were used to measure the performance of students in mathematics. Acquisition can be directly or indirectly affected by student or college factors. For an example if a student commit errors such as slips, this may directly affect his or her achievement as the lecturer has no control over them. Mathematical background may indirectly affect the students' achievement since it may be difficult for the student to grasp new knowledge due to lack of this background.

3.3. Reasons for selecting the framework

The reason the researcher chose Wiley and Harnischfeger (1974) model as the framework for this study is that it categorises factors that could be linked to poor performance into student-level and institutional-level factors. The idea behind this model was to help researcher in developing research questions, methodologies, analysing and interpreting the research findings. This model was used to categorise the factors that emerged from the interviews with students and lecturers into student or college level factors. The model was also considered when deciding where misconceptions and errors belong, in terms of students or college level factors. The researcher chose this model because it addresses how background factors affect teaching-learning process and the student achievement. Schreiber (2002) also used this model to investigate "institutional and student factors and their influence on advanced mathematics achievement". This model is suited to this study as the researcher will be investigating how students' background factors directly or indirectly influence student achievement; or how institutional factors directly or indirectly affect student achievement. The researcher also used Donaldson's classification of errors model to classify the misconceptions and errors provided the lens through which the misconceptions and errors that students in this study commit can be viewed.

Background factors in this study, include:

- *Students' misconceptions and errors*
- *Factors that students attribute their performance in mathematics*
- *The lecturers' perceptions of their students' performance*

Figure 3.2 shows how student or college factors affect achievement. Figure 3.2 was adapted from Figure 3.1 which is the theoretical framework of this study.

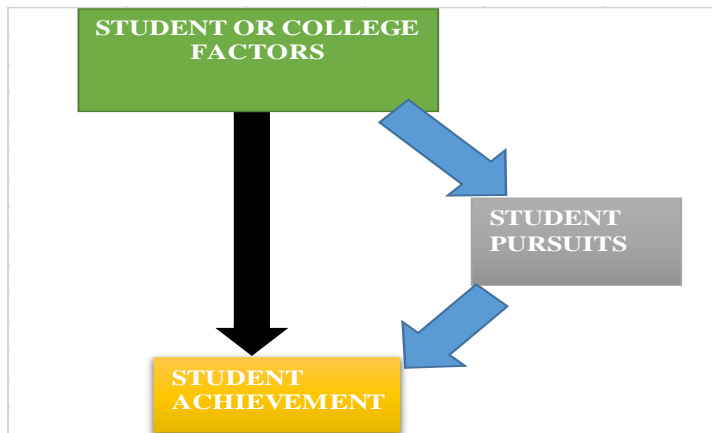


Figure 3.2: How Student or college factors affect student achievement (indirectly or directly) (Adapted from Wiley and Harnischfeger model)

Examples of student factors include misconceptions; errors; absenteeism; and mathematical background. Errors (slips) may have a direct effect on student achievement while misconceptions may affect students’ learning (student pursuits) and ultimately student achievement.

In this study the lecturer’s background factors are treated as college-level factors. Examples of college-level factors are teaching strategies; enrolment requirement; and questionable Grade 9 reports. The college factors may affect student pursuits and ultimately student achievement or directly influence achievement.

The responses from both students and lecturers in the interviews point out to Student-level and College-level factors, which may impact on students’ achievement either directly or indirectly. In this study, the researcher focused on student-level factors and college-level factors at a TVET College campus. Data was collected from students’ scripts (final examination) and individual interviews with students and lecturers.

3.4. Summary

In order to examine the factors that could be linked to poor performance of Level 2 mathematics students, it was necessary to consider school improvement or learning models. The researcher chose to use Wiley and Harnischfeger (1974) school learning model in order to examine how student factors and college factors fit in this model. Wiley and Harnischfeger (1974) model consist of background, teaching learning process and acquisition. Background factors include student-level factors and college-level factors. Student-level factors may include factors such as: socio economic status; gender; attitude; and others. College-level factors may include factors such as class size; lecturers' background; resources; and culture. It was necessary to look at these factors as the study is more concerned about finding the factors that could be linked to poor performance in mathematics. Teaching-learning process consist of teacher activities and student pursuits. Even though it was not the aim of this study to investigate teaching-learning process, it was necessary to look at literature concerning it since the factors that the study is interested in, may affect teaching-learning or teaching-learning could be part of the factors involved. Wiley-Harnischfeger 1974 model is more concerned about active learning time, or active engagement. Acquisition is influenced by the time spent learning in class.

This model was relevant as it relates to how student or college level factors play a role in teaching-learning process and ultimately affect the acquisition of the student; or how student or college factors directly affect achievement. Donaldson's (1963) error classification model was also discussed as a method that influenced the classification of misconceptions and errors in this study.

The marks sheets were used to analyse overall performance in Level 2 mathematics. Final examination answer books were used to determine which misconceptions and errors students have or make in mathematics. It was important to find out what are the factors that affect teaching-learning process from students and lecturers' point of view. The use of interviews was critical in determining these factors.

CHAPTER 4: RESEARCH METHODOLOGY

4.1. Introduction

The purpose of this study was to explore factors that could be linked to poor performance of mathematics Level 2 students at a TVET College in Tshwane. The methodology used is hereunder discussed under the following sub-topics: research methods; research paradigm; research design; ethical consideration; sampling; data collection; data analysis; and methodological norms. A conclusion at the end of this chapter will summarise the whole discussion.

4.2. Research methods

This study is qualitative in nature. Data was collected from mathematics Level 2 2016 final-examination scripts (written work) and by means of interviews with both students and lecturers. Performance and attendance of students was obtained from mark sheets and attendance registers. The researcher chose to use a qualitative method because it provides a detailed narrative descriptions and explanations of phenomena investigated (Merriam, 1998). Qualitative methods gave students an opportunity to explain the reasons for their poor performance and the errors they commit in mathematics. The participants included selected NC(V) mathematics Level 2-4 students from a public TVET College campus in Tshwane and all NC(V) mathematics lecturers at that campus.

4.3. Research paradigm

As social scientists, we are interested in the world that is not openly perceivable since it is created by each of us differently. As such, this study used an interpretivist approach, where interviews; mark sheets; attendance registers; and examination scripts were used to collect data. Thomas (2009, p.75) states that “interpretivism is interested in people and the way that they interrelate what they think about and how they form ideas about the world; how their worlds are constructed”. This approach, assisted the researcher to be objective as he was able to use his understanding to interpret the views from participants.

4.4. Research design

According to Thomas (2009, p.70), “the research design is the plan for the research, and has to take into account your expectations and your context”. Maree (2012, p.81) explains a research design as “a plan of how one intends to accomplish a particular task, and in research this plan provides a structure that informs the researcher as to which theories, methods and instruments the study is based on”.

This study aimed to investigate factors linked to poor performance. As a result, a case study design was used. A case study is an in-depth examination of a single person, group, or organisation to find the variables that influence the present performance or position of the topic of the study (Fraenkel, Wallen & Hyun, 1993). Henning, Van Rensburg and Smit (2004) argue that a case study’s aim is not just to define the case for description’s sake but to try and see patterns, connections and the dynamic that warrants inquiry. Yin (2009), emphasises that case studies may also be useful for explaining presumed casual links between variables.

4.5. Ethical consideration

Before data collection takes place, it is the responsibility of the researcher to seek permission from people in authority in the selected institutions (Maree, 2012). Ethical guidelines of the University of Pretoria (Ethics Committee of the Faculty of Education, University of Pretoria, 2008) (see Appendix A) were used as a guideline in designing consent letters (see Appendix B-G). The researcher submitted an application to conduct research to the University of Pretoria, Faculty of Education ethics committee as well as Department of Higher Education. He also sent a request to conduct a research, to the central office of the TVET College A, the campus manager and the lecturers at Campus 1. He received written approvals, which he filed for future reference.

On his first day at the campus, he met with the campus manager who introduced him to the head of department (HOD) who is responsible for mathematics in the NC(V) programme. The HOD introduced him to all mathematics lecturers in their classes. That is where he started issuing consent forms to the lecturers. All participants received informed consent letters to make them aware of their rights as participants in the study, their roles in the study and objectives of the study. Participation was voluntary and safety of the participants was kept at

heart at all times. All participants had an opportunity to withdraw their participation at any point during the study and this was clearly indicated in the consent letters.

4.6. Sampling

Purposive and convenient sampling were used to select research site and participants for this study. According to Thomas (2009, p.104) “purposive sampling involves the pursuit of the kind of person in whom the researcher is interested”. Convenient sampling is a sample that is easily accessible (Fraenkel, Wallen & Hyun, 1993). The two sampling methods complemented each other to help the researcher conduct sampling based entirely on his judgement and select participants who best represented the groups and available for the study.

4.6.1. Selection of college and campus

There are two public TVET colleges in Tshwane, namely, TVET College A and TVET College B, each with several campuses. The researcher chose to conduct his study at TVET College A. His reason for choosing TVET College A was that it has two of its campuses offering most NC(V) study fields as compared to TVET College B. TVET College A has four campuses. Campus 1 offers Engineering studies (both NC(V) and NATED) while the other three campuses offer both Business and Engineering Studies (both NATED and NC(V)). The researcher chose to conduct his study at Campus 1 because it is the biggest campus of the four campuses and offers only Engineering studies. The selected campus offers NC(V) programme where mathematics is a compulsory subject.

4.6.2. Selection of lecturer participants

There are five mathematics lecturers in the NC(V) programme at Campus 1. The researcher gave all these lecturers consent forms. All these lecturers signed and returned the consent forms indicating that they agree to participate in the study. The researcher then decided to let all mathematics lecturers at this campus participate in the study. That means he had five lecturers who participated in the interviews.

4.6.3. Selection of classes

The HOD presented the researcher with the mark sheets for Level 2 mathematics final marks for the year 2016. These mark sheets were grouped according to classes and lecturers that offered mathematics at Level 2 in 2016. The selected campus offers three vocational fields under NC(V) Engineering programme, namely, ERD (Fitting and Auto); EIC; and IT. Four lecturers offered mathematics at Level 2 in 2016, while one lecturer only offered mathematics at Level 4. The researcher selected one class from each lecturer who offered mathematics at Level 2 in 2016. Selection of classes depended on the most students in a class who returned their consent forms. The researcher ensured that all fields (IT; ERD and EIC) were represented in the study. The inclusion of all study fields in the study enabled the researcher to have a clear overview of the whole NC(V) programme.

4.6.4. Selection of student participants

A total of 150 students wrote NC(V) Level 2 mathematics final examination in 2016 while 422 students enrolled. One wonders what happened to the rest of the students (272). The retention rate is calculated as a percentage of the students passed out of the students enrolled. The retention rate in this case is 15.4% (65 students out of a total of 422 passed) which is poor.

The plan was to select six students per class (two best, two average and two poor performing students) based on 2016 final examination from the four selected classes. That means the researcher planned to select 24 students who were supposed to have their scripts analysed (misconceptions and errors) and participate in individual interviews. Few students returned their consent letters which made it difficult for the researcher to conduct sampling as planned.

The researcher decided to select three student participants per class: best, average and poor performing students from those who returned the consent forms and agreed to participate in the study. That means he selected 12 students who wrote mathematics final examination in 2016. These students consisted of four Level 2 students and eight Level 3 students. This means four students failed while eight students passed mathematics in 2016 final examinations. The scripts of the 12 students sampled were analysed for misconceptions and errors. The same students who had their scripts analysed, participated in the individual semi-structured interviews to give clarity on some of the errors that they committed and answer the research sub-question: *To what do students attribute their poor performance in mathematics?* The researcher decided to

add six Level 4 students to the 12 students (Level 2 & 3) selected students. Two best, two average and two poor performing students were selected from Level 4, based on the 2017 June examination. One of the six Level 4 students did not turn up for the interviews and the researcher ended up with 12 Level 2 & 3 students who wrote their final examination in 2016 and five Level 4 students which equal a total of 17 student participants. Level 4 students participated in the interviews only to answer the research sub-question: *To what do students attribute their poor performance in mathematics?*

4.7. Data collection

According to Teddlie and Yu (2007), the purpose of data collection in a study is to find responses to the research questions. Data collection methods used in this study were students' document analysis and interviews for both lecturers and students. In this study, triangulation was achieved by making use of mark sheets, examination answer scripts and interviews with both lecturers and students. This also helped the researcher to ensure that the results of the study are valid and reliable.

4.7.1. Document analysis

According to Bowen (2009), document analysis is a methodical technique for reviewing or assessing documents. This study used examination answer books, mark sheets, and attendance registers to analyse: errors; performance; and attendance of the students.

Assessment of Level 2 mathematics usually consists of internal (25%) and external (75%) components. The internal component is set and marked by lecturers and is conducted throughout the course of the year (see Table 4.1). All tasks are converted to 100%. The student should achieve an average of 30% in all internal assessment tasks in order to qualify to sit for the final examination. This rule was implemented for the first time in 2016 in the selected college.

The external component is set by DHET and marked internally by the lecturers and it is conducted at the end of the year (October or November). The mathematics final examination consists of Paper 1 (P1) and Paper 2 (P2) with both papers set out of 100 marks. Table 4.1 provides a summary of the assessment of mathematics at NC(V).

Table 4.1: Assessment for NC(V) mathematics

Term	Name of task	Task No.	
Term 1	Assignment No. 1	1	Internal
	Test No. 1	2	
Term 2	Assignment No. 2	3	
	Test No. 2	4	
	Midyear Exam	5	
Term 3	Practical Assignment	6	
	Trial Examination: Paper 1 and Paper 2	7	
Term 4	Final Examination: Paper 1 and Paper 2.	External	

Table 4.2 shows the sections that are covered in Paper 1 (P1) and Paper 2 (P2) with their mark allocation.

Table 4.2: Mark allocation of NC(V) Level 2 final examination

Paper 1: 100marks				Paper 2: 100marks		
Q1: Algebra (25 Marks)	Q2: Financial Mathematics (20 Marks)	Q3: Numbers (30 Marks)	Q4: Functions (25 Marks)	Q1: Data Handling (40 Marks)	Q2: Shape, Space and Measurement (30 Marks)	Q3: Trigonometry (30Marks)

The researcher began data analysis by looking at the performance of Level 2 mathematics in the whole NC(V) programme using the mark sheets that were provided to him by the HOD.

The researcher was given examination scripts for all Level 2 students. He identified the scripts of the selected participants. The researcher analysed the performance in the final examination of the 12 students who agreed to be interviewed (both P1 and P2). These are the students who wrote their final examination in October or November 2016. This means that 24 answer books were analysed at this stage.

The researcher was granted permission to make copies of Q1 of P1 (Algebra) answer books for the 12 students who wrote mathematics Level 2 final examination in 2016 by the campus manager, lecturers and the selected students (see consent letters: Appendix D, E & F) which he filed for future reference.

Misconceptions and errors in Algebra were analysed. The misconceptions and errors were noted and categorised. Some of the errors required clarification from the students. Such were noted and included in the interview questions of the individual student. The categories included *adding unlike terms; partial application of rules; false concepts; ignoring rules restrictions; and slips.*

4.7.2. Interviews

Interviews in this study involved conversation in which the researcher listened to what participants had to say in order to find out more about the factors that can be linked to poor performance in mathematics (Kvale, 1996). Interviewing was an important assessment tool because it allowed all participants to share their experiences, attitudes, and beliefs in their own words (Fraenkel, Wallen & Hyun, 1993).

4.7.3.1. Interviews with students

A total of 17 students participated in individual semi-structured interviews. Out of these students, 12 students' scripts were analysed for misconceptions and errors. The remaining five students were in Level 4. These interviews were divided into two sections for the first 12 students. The first section was aimed to clarify some of the errors that students have committed in their examination scripts. The second section included all 17 students and aimed to establish the factors that students attribute to their performances (see Appendix H). The interviews were semi-structured and each lasted between 20 to 30 minutes. The interviews were audiotaped with the consent of the participating students.

4.7.3.2. Interviews with lecturers

The participating lecturers also participated in semi-structured individual interviews which lasted between 20 and 30 minutes. These interviews were used to establish the lecturers' views on the factors that could be linked to poor performance (see Appendix H). The interviews were audiotaped with the consent of the participating lecturers.

4.8. Data analysis

The aim of qualitative data analysis is to expose developing themes, patterns, concepts, insights and understanding (Suter, 2012). All interview data were transcribed. Cohen, Manion and Morrison (2011) describe content analysis as making a summary and reporting written data; while constant comparison is an analysis strategy that allows the researcher to compare new data with existing categories and theories that have been developed to be able to accomplish perfect fit between categories and data (Cohen, Manion & Morrison, 2007). Data analysis in this study was based on Maxwell's three stages (Stage 1, 2 and 3) of Qualitative Data Analysis (Maxwell, 2012).

Stage 1: Organising and familiarising

All the mark sheets were clearly marked to indicate the students who returned their signed consent forms and those who were selected to participate in the study. Student codes were also indicated on these mark sheets. The copies of the scripts were labelled S₁-S₁₂ (Student participants) to make it easy to identify each student participant against his or her script.

The recordings were also labelled on the researchers' laptop as S₁-S₁₇ (students) or L₁-L₅ (lecturer). The researcher went through his notes, scripts and recordings several times to ensure that he has the correct labels on the right data.

The researcher coded the papers P1 for Paper 1 and P2 for Paper 2. Question numbers were coded Q1 for Question 1, Q2 for Question 2.....up to Question 4, which was coded Q4. The sub-questions were coded SQ1.1.1 for sub-question 1.1.1 or SQ1.5 for sub-question 1.5.

To make his work more organised the researcher used tables to present and analyse his data.

Stage 2: Coding and Reducing

According to Corbin and Strauss (2008, p.2) "Coding means extracting concepts from raw data and developing them in terms of their properties and dimensions."

After familiarising himself with the collected data, and considered possible meanings, the researcher was able to put interpretive conceptual labels on the data (Corbin & Strauss, 2008). Conceptualising data did not only reduce the amount of data the researcher had to work with, but at the same time provided him with a language for talking about the data. The students' misconceptions and errors were categorised. The misconceptions and errors in Algebra were analysed in a table form per category (misconception or error).

The interviews with students and lecturers established categories of factors that could be linked to poor performance in mathematics. These categories were later grouped as student-level factors or college-level factors according to Wiley and Harnischfeger's school learning model.

Stage 3: Interpreting and representing

Interpretation and representation involved writing the report on the results of the study. The research questions were answered during interpretation and representation. The categories listed in stage 2 are the answers to the researcher's research questions. The researcher answered

his research sub-questions one by one by picking up the responses from the categories that he created in stage 2. This was followed by answering the main research question, which summarised the findings of the study.

Table 4.3 represent a summary of how the research questions were addressed by the theoretical framework, methodology and data analysis. Document analysis involved 12 students. Interviews involved 17 students. Four of them were repeating Level 2 (failed Level 2 in 2016), eight were doing Level 3 (passed Level 2 in 2016) and five were doing Level 4. Five NC(V) mathematics lecturers also participated in semi-structured interviews.

Table 4.3: Responding to secondary research questions

FACTORS LINKED TO POOR PERFORMANCE IN MATHEMATICS	Research Question	Theoretical Framework	Methodology: Qualitative methods were used to answer all research questions.	Data Analysis: Steps
	Which mathematics misconceptions and errors do these students have or make?	Wiley and Hamischfeger (1974) model was used to answers all research questions	Document analysis in the form of final examination scripts and interviews with students.	Stage 1: Organising and familiarising
	To what do students attribute their poor performance in mathematics?		Interviews with students.	Stage 2: Coding and reducing
	What are the lecturers' views on students' performance?		Interviews with lecturers	Stage 3: Interpreting and representing.

4.9. Methodological Norms

Reliability and validity in a study is conceptualised as trustworthiness, rigor and quality in a qualitative paradigm (Golafshani, 2003). Triangulation may be defined to be “a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study” (Creswell & Miller, 2000, p.126). In order to achieve validity and reliability, the study applied triangulation by using mark sheets; examination scripts; class registers and interviews (students and lecturers) to collect data. This process helped the researcher to eliminate bias and increase truthfulness, which in turn ensured that every step of the inquiry was free from errors (Golafshani, 2003; Morse et al., 2002).

Verification involves inspection, indorsing, making sure, and being convinced: In qualitative research, verification refers to procedures employed when conducting research to ensure reliability and validity and, which ensure the accuracy of the results of a study (Morse, Barrett, Mayan, Olson, & Spiers, 2002). The researcher ensured that all information sources were examined, and found evidence to support categories in an attempt to ensuring accuracy. Interviews with students concerning their errors helped the researcher to correctly categorise misconceptions and errors. The inclusion of Level 2 – Level 4 students; lecturers; attendance registers; and mark sheets assisted the researcher to verify some of the responses that were provided in the interviews.

4.10. Conclusion

This chapter discussed in details the research methods, research paradigm and research design followed in the study. The researcher also discussed ethical considerations followed in this study. This was followed by sampling of the research site, classes and participants. The way data was collected and analysed was also discussed in more details. Data collection and analysis followed interpretivist perspective. To triangulate data, analysis of examination scripts and interviews with lecturers and students were conducted. The chapter concluded by looking at methodological norms.

CHAPTER 5: DATA PRESENTATION

5.1. Introduction

*This chapter presents the findings regarding misconceptions and errors of mathematics Level 2 students based on 2016 final examinations for 12 selected students. This will be followed by presentation of the findings derived from the interviews with students and lecturers of NC(V) programme at a TVET College campus in Tshwane regarding possible factors that could be linked to poor performance in mathematics. This will be in an attempt to answer the main research question: **What are the possible factors that might be linked to poor performance of NC(V) Level 2 Mathematics students at a TVET College in Tshwane?** This will be achieved by answering the following sub-questions:*

- *Which mathematics misconceptions and errors do these students have or make?*
- *To what do students attribute their poor performance in mathematics?*
- *What are the lecturers' views on students' performance?*

This chapter begins with the labelling and coding of the collected data where Table 5.1 shows how misconceptions and errors will be analysed. This is followed by analysis of performance of NC(V) Level 2 mathematics students, which is summarised in Table 5.2. Analysis of performance of the participating students is done in Table 5.3. Analysis of misconceptions and errors is done in Tables 5.4-5.8. This is followed by interviews with students about their errors. The chapter also presents the findings derived from the interviews with students and lecturers concerning factors that can be linked to poor performance in mathematics. The chapter also examines the similarities of the responses of students and lecturers concerning factors that could be linked to poor performance in mathematics, then ends by considering the differences in their responses.

5.2. Labelling and coding the collected data

All the scripts were labelled and coded thematically and numerically. For instance, S₁ refers to student participant number one, S₂ to student participant number two, and continues like that until S₁₂, which refers to student participant number 12. These codes were also used to label students during the interviews. Five Level 4 students who participated only in the interviews, were labelled S₁₃-S₁₇.

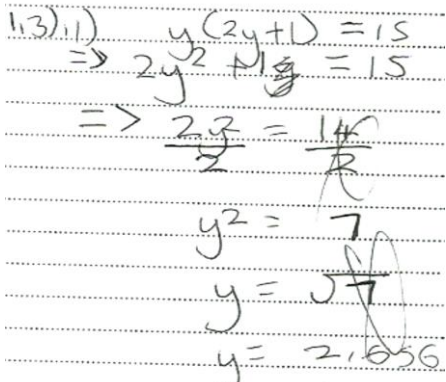
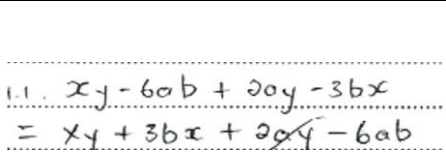
Lecturers were referred to as L₁ for lecturer participant number one, L₂ referring to lecturer participant number two, and goes on like that until L₅, which refers to lecturer participant number five. The researcher is referred to as R.

Paper 1 is referred to as P1 and Paper 2 referred to as P2. Question 1 is referred to as Q1; Question 2 as Q2; Question 3 as Q3; and Question 4 is referred to as Q4. Sub-questions are referred to as SQ; for an example Sub-Question 1.1.1 is referred to as SQ1.1.1; Sub-Question 1.5 is referred to as SQ1.5.

Table 5.1 explains how analysis of misconceptions and errors was conducted in this study. Table 5.1 consists of the name of the category; description of the error; and example of student error as found in this study, with the researcher's interpretation of the error. The categories of errors as they appear in Table 5.1 include misconceptions, which are divided into the following: *adding unlike terms, false concepts, ignoring rule restriction, and partial application of rules*; and errors, which are categorised as *slips*.

Table 5.1: Categories of misconceptions and errors

	Name	Examples as found in this study	Description and researchers' comment
MISCONCEPTIONS	Adding unlike terms	$1.1.1 \quad xy - 6ab + 2ay - 3bx$ $= 6ab - 2ay + 3bx - 2y$ $= 4by + 3by$ $= 7$	<p>Unlike terms were collected and added together. These errors are very serious. Their presence shows that there are serious challenges facing the students.</p> <p>Example: To factorise $xy - 6ab + 2ay - 3bx$ the student added unlike terms as it appears on the left.</p>
	False concepts	$1.3.1. \quad y(2y+1) = 15$ $= 36 - (20+1)$ $= 15 \quad N$	<p>These are completely wrong answers. These errors are very serious as they indicate lack of knowledge.</p> <p>Example: To solve $y(2y + 1) = 15$ the student gave the response on the left. The researcher could not establish how the student arrived at the first step.</p>
	Ignoring rule restriction	$1.5. \quad 2x - 4y = -9 \quad \text{and} \quad -3x + 5y = 16$ <p>x-intercept, $y=0$ x-intercept, $y=0$</p> $2x - 4(0) = -9 \quad -3x + 5(0) = 16$ $\frac{2x}{2} = \frac{-9}{2} \quad -\frac{3x}{3} = \frac{16}{3}$ $x = -4.5 \quad x = 5.3$	<p>This refers to ignoring the boundaries which are applicable to a certain rule and includes applying a rule to a context to which it is not applicable.</p> <p>Example: In the given example, the student was looking for x and y intercepts instead of solving the two equations simultaneously.</p>

	Partial application of rules		<p>This is where a student partially apply the correct rule to a question. These errors are serious but indicate that the student possess some of the knowledge required and therefore not difficult to correct as false concepts.</p> <p>Example: In this example, the student appears to know the correct procedure. This could be seen by the student deleted y. The challenge could be the student realised that s/he was faced with factorisation of a trinomial, which s/he could not factorise.</p>
ERRORS	Slips		<p>These are unintended mistakes. They are not serious as the students can easily correct by themselves or with their lecturer.</p> <p>Example: The example on the left shows that the student wrote $+3bx$ while it was $-3bx$ in the original question. This is categorised as a slip since the student correctly grouped the other terms.</p>

5.3. Analysis of performance of NC(V) Level 2 mathematics students

The first analysis that took place was the analysis of the performance of all NC(V) Level 2 students in their 2016 mathematics final examination. The HOD for NC(V) programme provided the researcher with the 2016 mark sheets of the NC(V) Level 2 mathematics final marks. The researcher analysed the performance and recorded the data in Table 5.2. Table 5.2 shows the number of students who enrolled; number of students who wrote; number of students who did not write; number of students who passed; and number of students who failed. It also shows the percentage of students who did write the final examination and the percentage of students who did not write the final examination calculated out of the total enrolment. The percentage of pass and fail was calculated over the total number wrote.

Table 5.2: Performance of NC(V) Level 2 mathematics students in 2016

Number Enrolled	422	Percentage
Number Did Not Write	272	64.45%
Number Wrote	150	35.55%
Number Passed	65	43.33%
Number Failed	85	56.67%

The DHET introduced a rule that requires the student to obtain 30% or more of the year mark in mathematics to qualify to sit for the final examination. This was introduced for the first time at the selected TVET College campus in 2016. The number of students who did not write the final examination was due to failure to qualify to sit for final examination because they did not

obtain a pass mark of 30% in their year mark or have dropped out during the course of the year due to factors such as socio economic status; difficulty of the course and others. The total number of students who failed to write the final examination is more than half of the students who enrolled. In percentages the number of students who failed to sit for the final examination is 64%, which is too high. Out of the students who qualified to sit for the final examination, 43% passed while 56% failed. If we consider the high number of students who failed to qualify to sit for the final examination, one would expect the pass rate to improve considerably. It was not the case here since we still have less than 50% pass. The retention rate is a point of concern here since only 15, 4% of the enrolled students in the subject managed to pass.

5.4. Analysis of P1 and P2 (S₁-S₁₂)

Mathematics final examination consists of Paper 1 and Paper 2. Both papers are set out of 100 marks. Paper 1 consists of Algebra, which is apportioned 25 marks; Financial mathematics apportioned 20 marks; Numbers apportioned 30 marks and Functions apportioned 25 marks. Paper 2 consists of Data handling allotted 40 marks; Shape, Space and Measurement allotted 30 marks and Trigonometry allotted 30 marks. These are represented in Table 5.3. The 2016 mathematics final examination scripts (P1 & P2) for S₁ – S₁₂ were analysed. The purpose of analysing these two papers was to identify in which paper students struggled the most. Furthermore to identify the question that include misconceptions and errors that could be used for analysis purposes. Table 5.3 outlines the performance of the students per question. The bold font on the marks indicates that the student has failed that question or paper. The pass mark for NC(V) Level 2 mathematics is 30%. To calculate the pass mark in each case, the researcher considered 30% of the total possible mark. Table 5.3 also shows the number of students who failed a question or paper.

Table 5.3: Performance of mathematics Level 2 students in 2016 (S₁-S₁₂)

Student Participant	P1				Total P1	P2			Total P 2	Difference between P2 and P1 (P2-P1)
	Q1:Algebra (25 Marks)	Q2:Financial Mathematics (20 Marks)	Q3:Numbers (30 Marks)	Q4:Functions (25 Marks)		Q1:Data Handling (40 Marks)	Q2: Shape, Space and Measurement (30 Marks)	Q3:Trigonometry (30Marks)		
S ₁	14	03	10	09	36	21	17	04	42	06
S ₂	04	09	19	05	37	30	26	14	70	33
S ₃	02	02	09	01	14	13	08	00	21	07
S ₄	12	09	25	16	62	30	14	09	52	-10
S ₅	05	11	21	11	48	14	13	03	30	-18

S ₆	04	11	02	02	19	26	09	00	35	16
S ₇	19	11	18	19	67	26	19	23	68	01
S ₈	15	06	23	10	54	27	13	15	55	01
S ₉	00	04	04	01	09	19	08	01	28	19
S ₁₀	00	06	05	04	15	27	16	00	43	28
S ₁₁	05	04	09	04	22	28	15	02	45	23
S ₁₂	12	09	27	04	52	24	25	02	51	-1
Total	$\frac{92}{300}$	$\frac{85}{240}$	$\frac{172}{360}$	$\frac{86}{300}$	$\frac{435}{1200}$	$\frac{285}{480}$	$\frac{183}{360}$	$\frac{73}{360}$	$\frac{587}{1200}$	
No. Failed	7	4	3	7	5	0	2	8	2	

Considering the last column of Table 5.3: the difference between the two papers, three students passed P1 better than P2; while nine students performed better in P2 than they did in P1. Secondly the total marks for P1 is 435 with an average of 36 while the total marks for P2 is 587 with an average of 49. That means P2 has a total of 152 more marks than P1 for the 12 students and a better average. This motivated the researcher to consider only P1 and check in which sections students struggled the most. This was in order for him to investigate the misconceptions and errors that are made by students in that section.

Seven students failed Q1 and Q4 of P1, which are Algebra and Functions questions respectively. To decide which question should be analysed for misconceptions and errors, the researcher considered which section depended on the other. To answer some of the sub-questions in Q4, the student requires the knowledge of solving equations, simplifying expressions, which is the knowledge applicable to Q1. This led to the decision of choosing Q1 instead of Q4. The other reason was that Q1 is more suitable to this study than Q4 as it does not have theory questions.

5.5. Analysis of misconceptions and errors

The discussion that follows is the analysis of misconceptions and errors. The answer books of 12 students were analysed (Q1 of P1). Qualitative data analysis procedure by Maxwell (2012) was considered when grouping misconceptions and errors into their categories. Misconceptions were grouped under the following categories: *adding unlike terms; partial application of rules; ignoring rule restrictions; and false concepts* while errors were categorised as *slips*.

This study is more concerned about factors that may lead to poor performance. The solutions that are included exclude fully correct answers since these have nothing to do with poor performance. That means if a student got a question correct or left a blank space, such solution will be excluded. SQ1.4 has no errors to be analysed because the students (four) who got no mark in that question left blank spaces while eight students who attempted it got full marks. This question therefore, does not form part of the discussion that follows. The misconceptions and errors will be discussed in Tables 5.4 to Table 5.8 under the categories that were discussed in Table 5.1 which include *adding unlike terms, false concepts, ignoring rule restriction, partial application of rules and slips*. Table 5.4 to Table 5.7 show the name of the categories of misconceptions while Table 5.8 shows slips. Students' solution and researchers' comments are also shown.

Table 5.4: Addition of unlike terms

Students' Solution	Researcher' Comments
S ₃ : $1.1.1 \quad xy - 6ab + 2ay - 3bx$ $= 2xay - 9abx$ $= -7xaybx$	The student added xy and $2ay$ to obtain $2xay$. The student continued to add $-6ab$ and $-3bx$ and got $-9abx$. This can be referred to as conjoining the variables because while adding unlike terms, the student joined the variables together. The conjoining of the variables continued in the last step where the student added $2xay - 9abx$ to obtain $-7xaybx$.
S ₃ : $1.1.2 \quad x^2 - xy - 2y^2$ $= x^2y - 2y^2$ $= 2x^2y^2$	In the first and second steps, the student just added unlike terms. The student conjoined the variables and took the highest exponent.
S ₂ $1.1.1 \quad xy - 6ab + 2ay - 3bx$ $= 6ab - 2ay + 3bx - 2y$ $= 4by + 3by$ $= 7$	The first step involved grouping terms with like terms together. This was done with changes to the signs, where negative sign became positive and vice versa. The next step involved addition of unlike terms, where the student eliminated the common variables (a and x) and conjoined the other variables. The variables were completely ignored in the final step
S ₉ : $1.1.2 \quad x^2 + xy - 2y^2$ $= 2x^2 + 2y^2$	The student added the first two unlike terms. That is why s/he has $2x^2$ in the final answer. The disappearance of y when the student was adding the like terms is questionable, but what is clear is that when adding terms with different degree of exponent, the student took the biggest exponent.
S ₁₀ : $1.1.2 \quad x^2 + xy - 2y^2$ $= x^2y + 2y^2$ $= 2y^2$	The student added unlike terms. In this case the student conjoined the variables in the first two terms and took the highest exponent of x . In the last step all the variables were conjoined with the constant, followed by taking the highest exponent of y .

<p>S₃:</p> $1.1.3 \quad 2x^2 - 5x - 12$ $= -3x^2 - 12$ $= -15x^2$	<p>The student added $2x^2$ and $-5x$, which are unlike terms and the answer contained the highest exponent. The student went on to add $-3x^2$ and -12 which are also unlike terms.</p>
<p>S₉:</p> $1.1.3 \quad 2x^2 - 5x - 12$ $= -3x^2 - 12$	<p>The student added the first two unlike terms to get $-3x^2$.</p>
<p>S₁₀:</p> $1.1.3 \quad 2x^2 - 5x - 12$ $= 2x^2 - 5x - 12$ $= 15x^2$	<p>The student added all three unlike terms as if they are like terms.</p>
<p>S₁:</p> $1.2.1 \quad \frac{4x^2 - 8xy^3}{-xy}$ $= \frac{4x^2 - 8xy^3}{-xy} \times \frac{-xy}{-xy}$ $= \frac{-xy(4x^2 - 8xy^3)}{-xy}$ $= \frac{-4x^2 + 8xy^3}{xy}$ $= \frac{4}{0}$	<p>The final step involved addition of unlike terms (-4 and 8) as part of the numerator and wrong division by 1. In this case, variables were ignored.</p>
<p>S₃:</p> $1.2.2 \quad \frac{4x^2 - 8xy^3}{-xy}$ $= -4x^2y^3$ $= 4x^2y^3$	<p>The first step involves the addition of unlike terms in the numerator.</p>
<p>S₆:</p> $1.2.2 \quad \frac{4x^2 - 8xy^3}{-xy}$ $= \frac{-4x^2y^3}{-xy}$ $= -4x^2y^2$	<p>In the first step, the student added unlike terms. The exponents of x were added when the student was adding unlike terms.</p>
<p>S₉:</p> $1.3.1 \quad y(2y+1) - 15$ $= y(3y) - 15$ $= 45y$	<p>The student added unlike terms inside the brackets: $2y$ and 1 to get $3y$.</p>

<p>S₁₁:</p> $1.3.1 \quad y(2y-1) = 15$ $15 = y(2y+1)$ $15 = y(2y)$ $\frac{15}{2} = y$ $5 = y$	<p>In the second step, the student added unlike terms inside the brackets.</p>
<p>S₃:</p> $1.5. \quad 2x + 4y = -9 \quad \text{and} \quad -3x + 5y = 16$ $= -2xy - 9$ $= 2 + 16$ $= 18$ $= -11$	<p>The student has added unlike terms in the first equation by conjoining the terms and ignoring the equal sign. In the last step, the student ignored the variables.</p> <p>In the second equation, the student ignored the variables and equal sign and added everything.</p>
<p>S₁₁:</p> $1.5 \quad 2x - 4y = -9 \quad \text{and} \quad -3x + 5y = 16$ $-1x^2 + 7xy = 7x^2y$ $-7yx + 14y^2 = -6y^2x$ $1x^2y$	<p>This can be seen as addition of unlike terms.</p>

Table 5.5: False concepts

Students' Solution	Researcher' Comments
<p>S₁:</p> $1.1.2. \quad x^2 + xy - 2y^2$ $x^2 - 2y^2 + x = 0$ $(x+y)(x+y-x) = 0$	<p>The first step suggests that the student is not familiar with this form of trinomials since the student correctly factorised SQ1.1.3 (see figure below).</p> $1.1.2. \quad x^2 + xy - 2y^2$ $x^2 - 2y^2 + x = 0$ $(x+y)(x+y-x) = 0$ $1.1.3. \quad 2x^2 - 5x - 12 = 0$ $(2x+3)(x-4) = 0$ <p>The student failed to recognise the trinomial.</p>
<p>S₁:</p> $1.1.1. \quad xy - bab + 2ay - 3bx$ $(a+b)(2y - b - 3x + xy) = 0$ $(a+b)(2y - b - 2x + y) = 0$ $(a+b)(3y - 2x - b) = 0$	<p>It is not clear what the student was trying to do in this instance. This is therefore categorised as false concepts.</p>
<p>S₉:</p> $1.1.1. \quad xy - bab + 2ay - 3bx$ $= 2xy - 2b$	<p>It is not clear in the student's solution what the intention was. Perhaps the student wrote the first thing that came to his or her mind. The answer ends with a + sign, which suggests that the student might have been guessing.</p>

<p>S₁₀:</p> $ \begin{aligned} &1.1.1 \quad xy - 6ab + 2ay - 3bx \\ &= 6ab - 2ay + 3bx - xy \\ &= 4by + 3bx \\ &= 7 \end{aligned} $	<p>The students' first step was to group the terms with a common factor. This was done with the swapping around of the signs. This can be seen as a false concepts.</p>
<p>S₄:</p> $ \begin{aligned} &1.1.2 \quad x^2 + xy - 2y^2 \\ &x(x+y) - 2y^2 \\ &= x(x+y) - y(2y-1) \\ &= (x+y)(2y-1) \end{aligned} $	<p>The student took out a common factor as if xy (the middle) term was divided into two terms. It looks like the student is struggling with the knowledge of factorising a trinomial. The student seems to understand factorisation as involving grouping and taking out a common factor.</p>
<p>S₁₁:</p> $ \begin{aligned} &1.1.2 \quad x^2 + xy - 2y^2 \\ &x(x+y) - 2y^2 \\ &= (x-2y^2)(x+y) \end{aligned} $	<p>The student attempted to take out the common factor of x in the first two terms and got it wrong in the process. This student shows lack of knowledge of factorising a trinomial. The student factorised as if there are grouped terms. The last step involves taking out $(x + xy)$ as if it is common in both terms. This student appears to know factorisation as involving grouping and taking out a common factor.</p>
<p>S₂:</p> $ \begin{aligned} &1.1.3 \quad 2x^2 - 5x - 12 \\ &2(x^2 - \dots) \end{aligned} $	<p>This can be seen as a wrong concept as the student was about to take out a common factor. The problem of viewing factorisation as involving grouping and taking out a common factor.</p>
<p>S₄:</p> $ \begin{aligned} &1.1.3 \quad 2x^2 - 5x - 12 \\ &2(x^2 - 6) - x(5-1) \\ &= (x^2 - 6)(5-1) \end{aligned} $	<p>This is a wrong concept. The misconception of taking factorisation as involving grouping and common factor.</p>
<p>S₅:</p> $ \begin{aligned} &1.1.3 \quad 2x^2 - 5x - 12 \\ &= x(2x - 5) - 12 \\ &= (2x - 5)(x - 12) \end{aligned} $	<p>The student tried to factorise by taking out a common factor, which was not applicable in this case. After taking out x as a common factor in the first two terms, the student then factorised by taking out a common factor as if $(2x - 5)$ is common. This is a misconception where students think factorisation is about grouping and taking out a common factor.</p>
<p>S₆:</p> $ \begin{aligned} &1.1.3 \quad 2x^2 - 5x - 12 \\ &= \frac{x}{x} (2x^2 - 5x - 12) \\ &= x(2x - 5 + 12) \end{aligned} $	<p>The student has forced taking out a common factor of x since x is not common in all the terms. These are false concepts.</p>
<p>S₁₁:</p> $ \begin{aligned} &1.1.3 \quad 2x^2 - 5x - 12 \\ &2x(x - 5x) - 12 \\ &= (2x - 12)(x - 5x) \end{aligned} $	<p>The student took out a wrong common factor in the first two terms ($2x$). In the last step the student again incorrectly took out a common factor because $(x - 5x)$ is not applicable in the second term. This is a misconception that factorisation involves grouping and taking out a common factor.</p>

<p>S₁:</p> $1.1.4 \quad a^2x^2 - b^2$ $(a+x+b)^2 = 0$ $(a+a)(x+b) = 0$	<p>These are wrong concepts. The student is applying the rules of exponents wrongly and at a wrong place. This shows lack of knowledge of factorising a difference of squares.</p>
<p>S₂:</p> $1.1.4 \quad a^2x^2 - b^2$ $(a-x)(a-x+b)(a+a)(a+x)(b+b)$	<p>The researcher could not make sense of the solution presented by the student. It is not clear how the student arrived at this solution. It shows lack of knowledge of factorising a difference of squares.</p>
<p>S₃:</p> $1.1.4 \quad a^2x^2 - b^2$ $= a^{2+1}x^{2+1} - b^{2+1}$ $= a^3x^3 - b^3$ $= a^3x^3b^3$	<p>In the first step, the student added one to the exponents of every variable. This was followed by the disappearance of the negative sign in the final answer. This is completely wrong. The student shows lack of knowledge of factorising a difference of squares.</p>
<p>S₄:</p> $1.1.4) \quad a^2x^2 - b^2$ $= (a-x)(a-x)(b-1)(b+1)$ $= (a-x)(b-1)(b+1)$	<p>The student's response shows lack of knowledge of factorisation of difference of squares. It is not clear what the student was trying to do.</p>
<p>S₆:</p> $1.1.4 \quad a^2x^2 - b^2$ $= \frac{2}{2} (a^2x^2 - b^2)$ $= \frac{2}{2} (ax - b)$	<p>The student divided each variable by 2 which is wrong since a^2 and x^2 are a single term. In the final step, 2 that divides the variables was used to divide the exponents. The method of taking out a common factor that S₆ has used here was used in the other questions that required factorisation. This shows a clear misconception.</p>
<p>S₇:</p> $1.1.4 \quad a^2x^2 - b^2$ $(ax - b)^2$	<p>This is clearly a misconception. The student may have confused multiplying out factors of a difference of two squares. The explanation that we give when we multiply out example: $(x - a)(x + a) = x^2 - y^2$ might have led the student into making such an error.</p>
<p>S₈:</p> $1.1.4 \quad a^2x^2 - b^2$ $= ax(ax - b^2)$ $= axb(ax - b)$	<p>The method followed by the student is not clear. It seems like axb was taken as a common factor, which is false. This is lack of knowledge of factorising a difference of squares.</p>
<p>S₉:</p> $1.1.4 \quad a^2x^2 - b^2$ $= ab^4x^4$	<p>This answer can be seen as a spontaneous one as it cannot be clearly established how the student arrived at that answer.</p>
<p>S₁₀:</p> $1.1.4 \quad a^2x^2 - b^2$ $(a+a)(x+x)(b+b)$	<p>The student changed a^2x^2 to $a^2 - x^2$ which is false. This shows lack of knowledge as far as factorisation is concerned.</p>

<p>S₆:</p> $ \begin{aligned} &1.2.1. (4k+y)(y^2+5ky+4k^2) \\ &= (y+y^2)(4k+5ky+4k^2) \\ &= \frac{y}{y}(y+y^2) \frac{k}{k}(4k+5ky+4k^2) \\ &= y(y)k(4+5y+4k) \end{aligned} $	<p>The student clearly have no knowledge of removing the brackets since s/he swapped the terms inside the brackets in the first step. This is completely wrong.</p>
<p>S₁₀:</p> $ \begin{aligned} &1.2.1. (4k+y)(y^2+5ky+4k^2) \\ &= (4k+4k^2+5ky)(y+y^2) \\ &= (2k^4y)(y) \\ &= (2k^4y+y^3) \end{aligned} $	<p>This is incorrect. It is not clear how the student arrived at the answer.</p>
<p>S₂:</p> $ \begin{aligned} &1.2.2. \frac{4x^2-8xy^2}{-xy} \\ &2x(2x-4xy) \div xy \end{aligned} $	<p>The negative sign in the denominator was used by the student to change the division sign into multiplication sign. That is a misconception.</p>
<p>S₃:</p> $ \begin{aligned} &1.2.2. \frac{4x^2-8xy^3}{-xy} \\ &= \frac{-4x^2y^3}{-xy} \\ &= 4x^2y^3 \end{aligned} $	<p>In the last step, the negative signs divided but the denominator disappeared. These are false concepts.</p>
<p>S₄:</p> $ \begin{aligned} &1.2.2. \frac{4x^2-8y^3}{-xy} \\ &= \frac{4x^2-8y^3}{-xy} \times \frac{-xy}{1} \\ &= 4x^2-8y^3 \\ &= 2(2x^2-4y^3) \end{aligned} $	<p>The student wanted to get rid of the denominator and did so wrongly so by multiplying by $\frac{-xy}{1}$. This is a misconception. The student is probably confusing this with rationalising the denominator.</p>
<p>S₅:</p> $ \begin{aligned} &1.2.2. \frac{4x^2-8xy^3}{-xy} \\ &= 4x^2-8xy^3 \\ &= 4x^2-8x^2y^4 \end{aligned} $	<p>The student has misconceived the rules of exponents applicable when the terms are multiplying or dividing each other. There are two terms in the numerator which rules it out. This shows a knowledge gap that exists in the student.</p>
<p>S₈:</p> $ \begin{aligned} &1.2.1. \frac{4x^2-8xy^3}{-xy} \\ &= \frac{2^2x^2-2^3xy^3}{-xy} \\ &= \frac{2^{2-3}x^{2-1}y^{3-1}}{-xy} \\ &= \frac{2^{-1}xy^2}{-xy} \\ &= \frac{x^{1-1}y^{2-1}}{-1} \\ &= \frac{x^0y^1}{-1} \end{aligned} $	<p>In this case the student wrote 4 and 8 in exponential form with the aim of adding the exponents. This is not applicable here since there are two terms in the numerator. The student did the same with the variables, which is also false.</p>
<p>S₉:</p> $ \begin{aligned} &1.2.2. \frac{4x^2-8xy^3}{-xy} \\ &\frac{4x^2-8y^3}{xy} \end{aligned} $	<p>The student only made the negative sign in the denominator disappear. This shows lack of knowledge of simplifying fractions.</p>

<p>S₁₀:</p> $1.2.2 \frac{4x^2 - 8xy^2}{-xy}$ $= 4x^2 - (8xy^2 - (-xy))$ $= 2x^2 - 2xy^2 - xy$ $= 2xy$	<p>The student treated the denominator like it only affects the second term in the numerator. S/he then changed the division sign into a negative sign. This is a misconception where a student confused the rule of exponents, which says when dividing the bases that are the same, we subtract the exponents. It is not clear what the student did in the last two steps.</p>
<p>S₄:</p> $1.3.1) y + (2y + 1) = 15$ $2y + 1 = 15$ $2y = 15 - 1$ $2y = 14$ $\frac{2y}{2} = \frac{14}{2}$ $y = 7$	<p>"y", which was outside the brackets has disappeared in the first step. It is difficult to believe that this is a slip, given the fact that the student did nothing to the equation in the first step. This is therefore categorised as a false concepts.</p>
<p>S₆:</p> $1.3.1. y(2y + 1) = 15$ $= 36 - (20 + 1)$ $= 15$	<p>It is not clear how the student arrived at the second step. This is therefore classified as false concepts.</p>
<p>S₁₀:</p> $1.3.1 y(2y + 1) = 15$ $= 2y + 1 - 2 = 15 - 2$ $= 2y = 13$ $y = \frac{13}{2}$ $\therefore y = 6.5$	<p>The student has ignored y that is outside the brackets and subtracted 2 in both sides of the equation.</p>
<p>S₁₁:</p> $1.3.1 y(2y - 1) = 15$ $15 = y(2y + 1)$ $15 = y(2y)$ $\frac{15}{3} = \frac{2y}{3}$ $5 = y$	<p>The student swapped the two sides believing that the sign inside the brackets will change as s/he incorrectly copied -1 instead of +1. This is a misconception.</p>
<p>S₁₀:</p> $1.3.2 \quad 7y + 1 = 49$ $= 7y + 1 = 49 - 1$ $= 7y = 48$ $= y = \frac{48}{7} = 6.857$ $y = 4.1$	<p>In this case the student has subtracted 7 on the left hand and one on the right hand side of the equation. Second last step involves another subtraction of seven on the right hand side. It was difficult for the researcher to understand the logic behind the students' solution.</p>

Table 5.6: Ignoring rule restriction

Students' Solutions	Researcher' Comments
<p>S₁:</p> $1.1.1. xy - 6ab + 2ay - 3bx$ $(a+b)(2y-6+3x+xy) = 0$ $(a+b)(2y-6+2x+y) = 0$ $(a+b)(3y-2x-6) = 0$	<p>The student included = 0 in all the expressions that required factorisation. This is an indication of the student confusing solving equations with factorisation.</p>
<p>S₁:</p> $1.2.2. \frac{4x^2 - 8xy^3}{-xy}$ $= \frac{4x^2 - 8xy^3}{-xy} \times \frac{-xy}{-xy}$ $= \frac{-xy(4x^2 - 8xy^3)}{-xy \cdot xy}$ $= \frac{-4x^2 + 8xy^3}{xy}$ $= \frac{4}{0}$	<p>The student applied the knowledge of rationalising the denominator to simplify the fraction. This was not necessary in this case as it only helped the student to move the negative sign from the denominator to the numerator (see the third step).</p>
<p>S₁:</p> <p>1.5. $2x - 4y = -9$ and $-3x + 5y = 16$ x-intercept, $y=0$: $-3x + 5(0) = 16$ $2x - 4(0) = -9$ $-3x = 16$ $\frac{2x}{2} = \frac{-9}{2}$ $\frac{-3x}{3} = \frac{16}{3}$ $x = -4,5$ $x = 5,3$ y-intercept, $x=0$ y-intercept, $x=0$ $2(0) - 4y = -9$ $-3(0) + 5y = 16$ $-4y = -9$ $5y = 16$ $\frac{-4y}{-4} = \frac{-9}{-4}$ $\frac{5y}{5} = \frac{16}{5}$ $y = \frac{9}{4}$ $y = 3,2$ $= 2,25$</p>	<p>The student confused x and y intercepts with solving simultaneous equations. This is a serious misconception. It also means that the student cannot differentiate between the two. This is classified as ignoring the rules restrictions as the student applied the rule in the wrong context. The student was awarded two marks by mistake in this case.</p>
<p>S₅:</p> <p>1.5 $2x - 4y = -9$ and $-3x + 5y = 16$</p> $\begin{aligned} 2x - 4y + 9 &= -3x + 5y - 16 \\ 2x + 3x - 4y - 5y + 9 + 16 &= 0 \\ 5x - 9y + 25 &= 0 \end{aligned}$ <p>Let $x = 0$ Let $y = 0$ $5(0) - 9y + 25 = 0$ $5x - 9(0) + 25 = 0$ $-9y + 25 = 0$ $5x - 25 = 0$ $-9y = -25$ $5x = 25$ $\frac{-9y}{-9} = \frac{-25}{-9}$ $\frac{5x}{5} = \frac{25}{5}$ $y = \frac{25}{9}$ $x = 5$ $y = 2,778$</p>	<p>The student let $x = 0$ to find the value of y and $y = 0$ to find the value of x. The student found x and y intercepts.</p>

Table 5.7: Partial application of rules

Students' Solutions	Researcher' Comments
S ₅ : 1.1.1 $xy - 6ab + 2ay - 3bx$ $= xy - 3bx - 6ab + 2ay$ $= x(y - 3b) - 2a(3b + y)$ $= (y - 3b)(x - 2a)$	The student correctly took out a common factor in the first two grouped terms. In the second two grouped terms, the student took out the common factor of negative sign in the first term only. This is a misconception where the student does not see the negative sign as affecting both terms inside the brackets.
S ₆ : 1.1. $xy - 6ab + 2ay - 3bx$ $= xy + 3bx + 2ay - 6ab$ $= \frac{x}{x} \left(\frac{xy + 3bx}{x} \right) + \frac{a}{a} \left(\frac{2ay - 6ab}{a} \right)$ $= x(y + 3b) + a(2y - 6b)$	The student's method of taking out a common factor is a misconception. S/he confused the fact that the common factor divides the terms inside the brackets and divided also the common factor. This can also be seen in the last step where the student divided the terms inside the brackets with the common factor and the disappearance of the denominator in the common factor. This solution is grouped under partial application of rules since the student brought the denominator in the common factor and it disappeared in the final step.
S ₁₁ : 1.1.1 $xy - 6ab + 2ay - 3bx$ $xy + 2ay - 6ab - 3bx$ $y(x + 2a) - b(6a - 3x)$ $(y - b)(x + 2a)(6a - 3x)$	In this case the student correctly grouped like terms. The common factor was correctly taken out in the first two terms. In the last pair, the student took out the negative sign in the first term only. Three was also common but not considered. This is grouped under partial application of rules.
S ₂ : 1.1.2 $x^2 + xy - 2y^2$ $(x - y)(x - y)$ $(x - y) \otimes y(x + y)$	The student managed to get the first factor correct, but struggled to get the second one. The step that the student deleted was more promising. This is grouped under partial application due to the incompleteness of the solution especially the deleted one.
S ₈ : 1.1.3 $2x^2 - 5x + 12$ $= (2x - 7)(x + 5)$	Wrong factors. The student had the correct idea. The only problem was execution.
S ₁₁ : 1.1.4 $a^2x^2 - b^2$ $a(a)x(x) - b(b)$ $(ax - b)(ax - b)$	The student got the first factor right. The presentation of the answer made it difficult for the marker to see exactly what was the student trying to do. The inclusion of brackets for a , x and b after the first brackets in the final step made the answer to be completely wrong since a , x and b required to be in one bracket with a positive sign for it to be correct.
S ₂ : 1.2.1. $(4k + y)(y^2 + 5ky + 4k^2)$ $(4ky^2 + 20k^2y + 16k^3)(y^2 + y)$	The student had a misconception. The student correctly multiplied the first term of the binomial with the trinomial but put the answer inside the brackets. This gave the student problems when it was the turn of the second term in the binomial to multiply the trinomial.

<p>S₇:</p> $ \begin{array}{r} 1.3.2 \quad 4x^2 - 8xy^3 \\ \underline{-2x} \\ 4x(x-2y^3) \\ \underline{-2x} \\ 4x(-2y^3) \\ \underline{-1} \\ -4(2y^3) \\ \dots -8y^3 \end{array} $	<p>The student correctly identified the common factor of $4x$ but incorrectly divided xy into $x - 2y^3$.</p>
<p>S₁₂:</p> $ \begin{array}{l} 1.3.1.1) \quad y(2y+1) = 15 \\ \Rightarrow 2y^2 + 1y = 15 \\ \Rightarrow \frac{2y^2}{2} = \frac{14}{2} \\ y^2 = 7 \\ y = \sqrt{7} \\ y = -\sqrt{7} \end{array} $	<p>In the first step the student correctly multiplied y inside the brackets. The student later deleted y in the second term. The student might have realised that s/he has to deal with an unfamiliar equation.</p>
<p>S₀:</p> $ \begin{array}{l} 1.3.2 \quad 7^{3+1} = 49 \\ 7^{3+1} = 49 \\ 7^2 = 49 \end{array} $	<p>The student shows that s/he can solve this equation by inspection. The problem is the presentation of the solution (7^{y^2}). This is categorised as partial application of rules because the student is not sure how to present a solution while solving the equation by inspection.</p>
<p>S₄:</p> $ \begin{array}{l} 1.5) \quad 2x - 4y = -9 \\ \quad \quad -3x + 5y = 16 \\ \\ \begin{array}{r} 2x - 4y = -9 \dots \textcircled{1} \quad \times \quad 5 \\ -3x + 5y = 16 \dots \textcircled{2} \quad \times \quad 4 \\ \hline 10x - 20y = -45 \\ -12x + 20y = 64 \\ \hline \text{Subtract } \textcircled{2} \text{ from } \textcircled{1} \\ \hline 2x = 0 + \frac{19}{2} \\ x = \frac{19}{2} \\ \\ 10x - 20y = -45 \\ 10\left(\frac{19}{2}\right) - 20y = -45 \\ 95 - 20y = -45 \end{array} \end{array} $	<p>The student in this case correctly multiplied equations (1) and (2) by 5 and 4 respectively. This was followed by addition of the two equations. The student claim to be subtracting (2) from (1) but the answer shows that the student added the two equations. This is a misconception. The student assume that we always subtract the two equations when we want to eliminate one variable.</p> <p>To solve for x, the student divided the right hand side by 2 in one step and divided the left hand side by 2 in the next step. This is a serious error as it shows lack of appreciation of mathematical argument. This is categorised as partial application of rules because the idea is correct.</p>

Table 5.8: Slips

Students' Solutions	Researcher' Comments
<p>S₆:</p> $ \begin{array}{l} 1.1. \quad xy - 6ab + 2ay - 3bx \\ = xy + 3bx + 2ay - 6ab \\ = \frac{x}{x} \left(\frac{xy + 3bx}{x} \right) + \frac{a}{a} \left(\frac{2ay - 6ab}{a} \right) \\ = x(y + 3b) + a(2y - 6b) \end{array} $	<p>The student here correctly grouped terms with a common factor besides missing the negative sign in the second term ($+3bx$ instead of $-3bx$). This could be seen as a slip as the student grouped the last pair of terms correctly.</p>

<p>S₅:</p> <p>1.1.4 $a^2x^2 - b^2$</p> <p>$= ax(ax) - b(b)$</p> <p>$= (ax - b)(ax - b)$</p>	<p>The student failed to put a positive sign in either of the brackets. This may be a slip from the side of the student which is not serious. The student may correct this himself or herself or with the help of the lecturer.</p>
<p>S₁₂:</p> <p>1.2.2) $4x^2 - 8xy^3$</p> <p>$-xy^3$</p> <p>$= -4x(x - 2y^3)$</p> <p>$-xy^3$</p> <p>$= -4(x - 2y^3)$</p> <p>$-xy^3$</p>	<p>The student correctly identified the common factor of $4x$. The problem is the negative sign, which can be seen as a slip. The student might have been overshadowed by the negative sign in the denominator. Beyond that, everything was correct. Out of two marks the student deserve at least one mark, but perhaps the negative sign might have distracted the marker to see the logic in the rest of the solution.</p>
<p>S₈:</p> <p>1.3.1. $y(2y + 1) = 15$</p> <p>$3y + y = 15$</p> <p>$\frac{4y}{4} = \frac{15}{4}$</p> <p>$y = \frac{15}{4}$</p>	<p>In the first step, the student added instead of multiplying y and $2y$. The student indicated that s/he is aware of the distributive law considering the drawings on top of brackets. This is therefore seen as a lapse in concentration from the side of the student.</p>
<p>S₄:</p> <p>1.5) $2x - 4y = -9$</p> <p>$-3x + 5y = 16$</p> <p>$2x - 4y = -9 \dots \dots \textcircled{1} \quad \times \quad 5$</p> <p>$-3x + 5y = 16 \dots \dots \textcircled{2} \quad \times \quad 4$</p> <p>$10x - 20y = -45$</p> <p>$-12x + 20y = 64$</p> <p>Subtract $\textcircled{2}$ from $\textcircled{1}$</p> <p>$2x = 0 + \frac{19}{2}$</p> <p>$x = \frac{19}{2}$</p> <p>$10x - 20y = -45$</p> <p>$10(\frac{19}{2}) - 20y = -45$</p> <p>$95 - 20y = -45$</p>	<p>The student wrote $2x$ instead of $-2x$ after adding the two equations (step 5). This is seen as a mistake.</p>

From Table 5.4, it can be seen that addition of unlike terms instead of factorisation was a point of concern. The first issue concerning addition of unlike terms was conjoining the variables when adding unlike terms (S₃). The second one was eliminating the variable that is common when subtracting variables (S₁₀). Addition of unlike terms which can be seen from S₃; S₉ and S₁₀ who conjoined the variables and took the highest exponent when the variables were the same is another point of concern. It can be said that students have a tendency of adding everything together irrespective of the question's requirements and without considering the like terms. See Figure 5.1 which displays how S₃ approached factorisation.

1.1.1 $xy - 6ab + 2ay - 3bx$
 ~~$= xy - 6ab + 2ay - 3bx$~~
 ~~$= 2ax +$~~
 ~~$= 2x$~~

1.1.1 $xy - 6ab + 2ay - 3bx$
 ~~$= 2xay - 9abx$~~
 ~~$= -7xaybx$~~

1.1.2 $x^2 - xy - 2y^2$
 ~~$= x^2y - 2y^2$~~
 ~~$= 2x^2y^2$~~

1.1.3 $2x^2 - 5x - 12$
 ~~$= -3x^2 - 12$~~
 ~~$= -15x^2$~~

1.1.4 $a^2x^2 - b^2$
 ~~$= a^2 + 1x^2 + 1 - b^2 + 1$~~
 ~~$= a^3x^3 - b^3$~~
 ~~$= a^3x^3b^3$~~

Figure 5.1: Addition of unlike terms by S₃

In Tables 5.4-5.8, it was shown that factorisation is a major challenge to these students. Some students know factorisation as involving grouping terms. They are not familiar with factorisation of a trinomial and difference of squares. This was visible in the students' responses. Each time they factorised, they attempted to take out a common factor. Those who could recognise a trinomial, they are not familiar with different forms of trinomials, i.e.: where there are two different variables in a trinomial or when the variable that is squared has a coefficient greater than 1.

Simplifying fractions proved to be a serious challenge to the students. In this question, all students obtained zero each. The biggest challenge was failure by the students to recognise a common factor. Only two students realised what the trick was. The first student who correctly identified the common factor, wrongly divided after the common factor. The second student included a negative sign in the common factor, which could be viewed as a slip. Other errors included the incorrect application of rules of exponents.

Solving the equation $y(2y + 1) = 15$ was also a challenge to the students. The performance in this question was very poor. Only two students managed to obtain full marks each. This question required the application of factorisation of a trinomials which proved to be a challenge to them. The two students who answered SQ1.1.3 correctly also answered SQ1.3.1 correctly. It can therefore be concluded that the performance in this question was more influenced by the students' failure to factorise trinomials.

Solving simultaneous equations proved to be a serious challenge to these students. Two students managed to score full marks (4marks) each while two students managed to score two marks each. The remaining eight students scored zero each. S₁ calculated x and y intercepts instead of solving for x and y simultaneously. S₅ equated the two equations on the basis that they are both equal to zero. This was after transposing the constants so that both equations are equal to zero. S₅ went on to let $x = 0$ in order to find y and let $y = 0$ to find x just like S₁ did. Again we saw in this question students adding unlike terms. One student tried to solve the two equations using inspection, which proved to be a difficult task.

The errors that were committed in Algebra (Q1) are 75 in total. Table 5.9 present the summary of the categories of errors that were committed in Q1.

Table 5.9: Categories of misconceptions and errors committed in Algebra

Misconception or Error	Category	Number
Misconceptions	False Concepts	39
	Adding Unlike Terms	15
	Partial Application of Rules	12
	Ignoring Rules Restrictions	04
Errors	Slips	05
	Total	75

Table 5.9 shows that **false concepts** dominated the other categories with 39 out of 75 errors. This category shows that most of the errors emanate from lack of knowledge. The dominance of false concepts means that there is a lot that has to be done. Another category, which contained more errors was **addition of unlike terms** with 15 errors. This is also very serious as it indicates that students lack conceptual understanding. **Partial application of rules** consists of 12 errors. This category shows that the student has some knowledge that is required to answer the question. Partial application of rules category is serious in the context of achieving the marks allocated to that question, but they are not difficult to correct as compared

to false concepts and adding unlike terms. **Slips** were five in number and these are the simplest to correct and students may correct them themselves or with the assistance from their lecturers. The last category was **ignorance of rules restrictions** with a total of four errors. This category is serious and indicates confusion from the students' side. Ignorance of rules restrictions shows that students do not know exactly how to approach a particular question or when to apply a particular rule.

5.6. Misconceptions and errors: Interviews with students

The following discussion is based on the interviews with students concerning the misconceptions and errors that they committed in Algebra (Q1) of P1. The first 12 students ($S_1 - S_{12}$) participated in these interviews. The students were shown the misconceptions and errors that they committed in their final examination.

Factorisation:

Students had to factorise the following expressions.

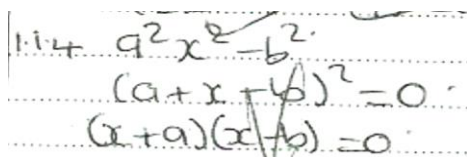
1.1.1. $xy - 6ab + 2ay - 3bx$

1.1.2. $x^2 + xy - 2y^2$

1.1.3. $2x^2 - 5x - 12$

1.1.4. $a^2x^2 - b^2$

R: *Why did you equate the expressions to zero, while there were no equal signs in the original questions? Example:*

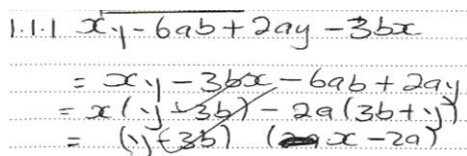


1.1.4 $a^2x^2 - b^2$
 $(a+x+b)^2 = 0$
 $(a+a)(x+b) = 0$

Figure 5.2: Equating expressions to zero

S_1 : *We always put equal to zero in mathematics. That is the reason I equated them to zero. Many problems in mathematics have equal to zero at the end.*

R: *After grouping $xy - 3bx - 6ab + 2ay$ you did take out common factors as follows:*



1.1.1 $xy - 6ab + 2ay - 3bx$
 $= x(y - 3bx) - 6ab + 2ay$
 $= x(y - 3bx) - 2a(3b + y)$
 $= (y - 3bx)(2ax - 2a)$

Figure 5.3: Failure to take out a negative common factor

Considering $-2a$ as a common factor why did you take out negative sign as a common factor only in the first term?

S₅: That is the correct answer. It is done that way.

Most of the students struggled with factorisation. There were four sub-questions involving factorisation. The following question was asked to those who struggled the most in factorisation:

R: Do you know how to factorise?

S₂: I did not know how to factorise when we wrote final examination last year. It is still tough, but I think I am improving.

S₆: I struggle with factorisation because I did mathematical literacy at high school.

S₈: Yes, Grouping.

S₉: I do not know how to factorise.

S₁₀: No. the only thing that I remember is that when they say factorise, you have to get the minimum. Example 9: Cut to 3, which is 3; 6; 9.

S₁₁: I have a problem knowing exactly what I should do when asked questions like factorise. Lecturers should explain what terms like factorisation and simplification mean. The lecturers assume that we know what all these terms mean because this is the knowledge that was done in the previous classes.

The responses from students show how difficult students find factorisation. During the analysis of students answer books, it emerged that some of the students know factorisation as involving taking out a common factor. S₈ confirmed this when s/he said factorisation means grouping. Students approach factorisation of a trinomial as if it is factorisation by grouping. Factorisation of a difference of squares is also a challenge to these students.

Simplifying: $\frac{4x^2 - 8xy^3}{-xy}$

The students' responses to this question were a clear indication of how students struggle with fractions. There is no student who obtained a mark on this question from the 12 students. This made the researcher wonders if they were taught fractions in class. The interviews revealed otherwise as the students indicated that they did fractions in class. It is clear that the students did not understand this section.

R: Why did you struggle to simplify the fraction?

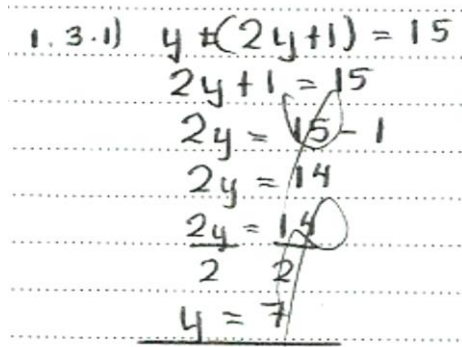
S₁: Fractions are always a problem to me. I cannot divide, add or subtract fractions. When I see fractions, my mind just go blank.

S₇: Fractions are a bit confusing. Even though we did them in class, when we get to the examination room it is something else.

The students could not recognise a common factor in the given fraction, which made it difficult for them to simplify it.

Solving for y: $y(2y + 1) = 15$

R: To solve the equation $y(2y + 1) = 15$, your "y" outside the brackets disappeared and you ended up solving a linear equation:



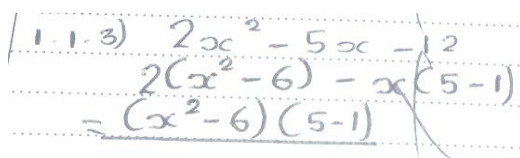
$$\begin{array}{l}
 1.3.1) \quad y(2y+1) = 15 \\
 2y+1 = 15 \\
 2y = 15-1 \\
 2y = 14 \\
 \frac{2y}{2} = \frac{14}{2} \\
 y = 7
 \end{array}$$

Figure 5.4: The disappearing y

Where did y outside the brackets go?

S₄: It was a mistake, it was supposed to be $2y^2 + y = 15$.

The student may claim it to be a mistake but in the first step the student did nothing to the equation except to make y disappear. The student may have tried to avoid factorising a trinomial with y^2 having a coefficient of 2. The same student failed to factorise SQ1.1.3 (see Figure 5.5), which is similar to this equation.



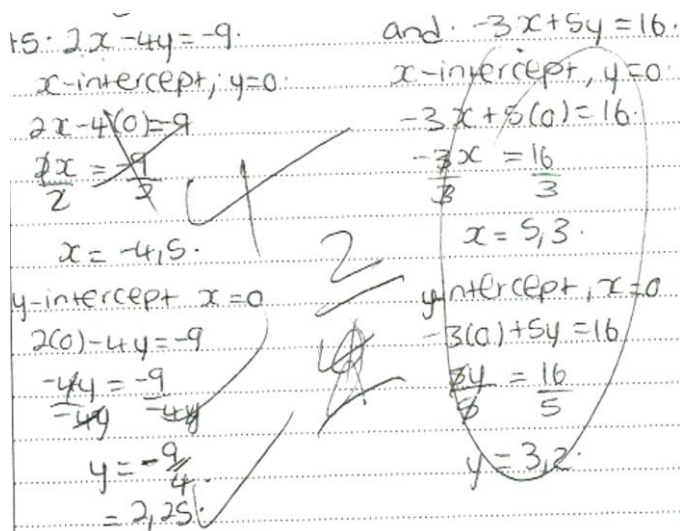
$$\begin{array}{l}
 1.1.3) \quad 2x^2 - 5x - 12 \\
 2(x^2 - 6) - x(5-1) \\
 = (x^2 - 6)(5-1)
 \end{array}$$

Figure 5.5: Failure to factorise a trinomial

Solving simultaneous linear equations: $2x - 4y = -9$ and $-3x + 5y = 16$

Solving simultaneous equations was a challenge for these students. In this question, two students scored maximum marks (4marks) each, the other two scored two marks each, while eight scored zero mark each. The following are some of the interviews with the students:

R: When you responded to this question, this is what you did:



$15. 2x - 4y = -9$ and $-3x + 5y = 16$
 $x\text{-intercept, } y=0$ $x\text{-intercept, } y=0$
 $2x - 4(0) = -9$ $-3x + 5(0) = 16$
 $\frac{2x}{2} = \frac{-9}{2}$ $\frac{-3x}{3} = \frac{16}{3}$
 $x = -4.5$ $x = 5.3$
 $y\text{-intercept } x=0$ $y\text{-intercept, } x=0$
 $2(0) - 4y = -9$ $-3(0) + 5y = 16$
 $-4y = -9$ $\frac{5y}{5} = \frac{16}{5}$
 $\frac{-4y}{-4} = \frac{-9}{-4}$ $y = 3.2$
 $y = -\frac{9}{4}$
 $= -2.25$

Figure 5.6: Calculating x and y intercepts instead of solving simultaneously

In this question you were expected to solve for x and y. This is how you approached the question (showing student his or her response). May you kindly explain this approach? Especially when you mention x-intercept and y-intercept.

S₁: Is that me who did that? Simultaneous equations are a big challenge to me. I struggle a lot with simultaneous equations. I just get stuck. Another reason is that I just do not want to leave empty spaces when I am in the exam room.

R: This is how you approached solving simultaneous equations:

$$\begin{aligned}
 1.5) \quad & 2x - 4y = -9 \\
 & -3x + 5y = 16
 \end{aligned}$$

$$\begin{array}{rcl}
 2x - 4y = -9 & \dots & \textcircled{1} \quad \times \quad 5 \\
 -3x + 5y = 16 & \dots & \textcircled{2} \quad \times \quad 4
 \end{array}$$

$$\begin{array}{r}
 10x - 20y = -45 \\
 -12x + 20y = 64 \\
 \hline
 \text{Subtract } \textcircled{2} \text{ from } \textcircled{1}
 \end{array}$$

$$2x = 0 + \frac{19}{2}$$

$$\underline{x = \frac{19}{2}}$$

$$\begin{array}{r}
 10x - 20y = -45 \\
 10\left(\frac{19}{2}\right) - 20y = -45
 \end{array}$$

$$95 - 20y = -45$$

Figure 5.7: Misconception in elimination method

You indicated that subtract (2) from (1), but you ended up adding the two equations. Why?

S4: When we use elimination method, we always subtract the two equations. That is why I said (1)-(2). But if I continued to subtract I would not have eliminated y. That is the reason why I added the two equations.

R: You approached simultaneous equations by transposing the constant terms to the left hand side so that the right hand side is equal to zero. Then you equated the two equations on the basis that they are both equal to zero. You continued to let x equal to zero to find y. Finally you let y equal to zero to find x. May you kindly make me understand the reasons for these method?

S5: No, I cannot.

$$\begin{aligned}
 1.5 \quad & 2x - 4y = -9 \text{ and } -3x + 5y = 16 \\
 & \# 2x - 4y + 9 = -3x + 5y - 16 \\
 & 2x + 3x - 4y - 5y + 9 + 16 = 0 \\
 & 5x - 9y + 25 = 0
 \end{aligned}$$

$$\begin{array}{l}
 \text{Let } x = 0 \\
 5(0) - 9y + 25 = 0 \\
 -9y + 25 = 0 \\
 -9y = -25 \\
 -9 \quad -9 \\
 \hline
 y = \frac{25}{9} \\
 y = 2,77\bar{8}
 \end{array}$$

$$\begin{array}{l}
 \text{Let } y = 0 \\
 5x - 9(0) + 25 = 0 \\
 5x - 25 = 0 \\
 5x = 25 \\
 \frac{5x}{5} = \frac{25}{5} \\
 \therefore x = 5
 \end{array}$$

Figure 5.8: Equating equations on the basis that they are both equal to zero

The performance in solving simultaneous equations was poor. The following are responses to the question by the researcher:

R: *Do you understand simultaneous equations?*

S₂: *I just have light on simultaneous equations. I can do a maximum of three steps.*

S₃: *I do not have a clue when it comes to simultaneous equations.*

S₇: *Simultaneous equations are very tough for me. They really give me tough time.*

S₉: *I normally get lost when I answer questions on simultaneous equations.*

S₁₁: *I struggle a lot when it comes to simultaneous equations.*

The students revealed how much they struggle with simultaneous equations. They see simultaneous equations as a very difficult section.

The interviews assisted in the triangulation of the analysis of misconceptions and errors. This was important as some of the suspected misconceptions were confirmed while others were correctly grouped as slips. Most of the students agreed that factorisation, simplification of fractions and simultaneous equations were a big challenge to them. Some of the students confused solving simultaneous equations and finding x and y intercepts. The frustration was evident during the interviews when some of the students could not recall how and why they gave the responses that appear in their answer books.

5.7. Interviews with students and lecturers: Factors linked to poor performance

The discussion that follows is based on the discussed theoretical framework. Factors that limit performance in mathematics that emerged from the interviews are now presented. This was in an effort to answer two research sub-questions:

- To what students attribute their poor performance in mathematics? and
- What are the lecturers' views on students' performance?

5.7.1. Participants Responses- Students

The discussion that follows is a summary of the interviews conducted with students. The students were S₁-S₁₇.

The categories: *Self-blame; doing mathematical literacy at high school; fear and negative attitude towards mathematics; lack of practice; failure to do homework or classwork; poor background; lecturer or teaching approach; absenteeism; quality of tutors; peer pressure*, emerged during interviews in response to the research sub-question 2: **To what do students attribute their poor performance in mathematics?**

One main question was asked to all students in the effort to establish factors that students attribute their poor performance in mathematics.

R: *To what do you attribute your performance in mathematics and why?*

5.7.1.1. Self-blame

Eleven students believe that they only have themselves to blame for performing poorly in mathematics. They agree that their lecturers are doing everything in their power to help them pass. Below are some of their responses.

S₆: *Lecturers do everything right to help us pass mathematics. They give us homework, extra-work and also volunteer to give us extra classes.*

S₁₃: *Our lecturer use different approaches to tackle problems and is always available in class to assist us. Some students are only there to copy the answers, which the lecturer always advice against. Our lecturer motivates us to do well.*

5.7.1.2. Poor background and mathematical literacy instead of pure mathematics at high school

Students stressed the fact that their choice of doing mathematical literacy at high school instead of pure mathematics has disadvantaged them. They believe that they lack basic knowledge in mathematics because they did not do mathematics at high school. Some explanations included:

S₁₁: *I did mathematical literacy at high school. It is difficult for me to cope with pure mathematics. I do regret doing mathematical literacy at high school.*

S₉: *I never expected to do pure mathematics when I enrolled for IT. I expected to do core subjects only. I try to study mathematics very hard but nothing make sense because of my mathematical background.*

S₄: *I believe that mathematics is about building on the previous knowledge. What you have learned in the previous class or chapter makes the foundation of more new information to follow.*

Students believe that lack of sound mathematical background or foundation is a major contributor of poor performance in mathematics. Most of these students believe that mathematical literacy deprived them the opportunity to acquire the necessary background to pass mathematics.

5.7.1.3. Fear and negative attitude towards mathematics

NC(V) students agree that mathematics is difficult and they fear it. Some of the feelings of the students surrounding this included:

S₂: *Mathematics is difficult. Last year we were taught things that are very difficult. Even though I managed to pass last year, this year we are taught even more difficult stuff and we must apply last years' knowledge. I think it is even worse this year.*

S₁₇: *I define myself as a person who enjoys using his hands and not a numbers person. I just don't like mathematics.*

S₁₅: *The perception that mathematics is a difficult subject plays a role in the poor performance in the subject. We just have a negative attitude towards mathematics.*

5.7.1.4. Lack of practice

Students agree that they don't give themselves enough time to practice mathematics and this is their downfall in the subject. The following are examples that they gave:

S₅: *I believe that practice is the only key to pass mathematics. You can only excel in mathematics when you give yourself enough time to practice.*

S₇: *I think the students don't give themselves enough time to study mathematics, they give up easily. They don't try again when they fail to solve a problem.*

S₈: *I used to pass mathematics in the past but since I stopped practicing it, I am no longer passing it. Even if you can get the best lecturer in mathematics, if you don't practice you are destined to fail.*

S₂: *I don't have time for mathematics. I would rather do other subjects than practicing mathematics.*

5.7.1.5. Failure to do homework or classwork

Most of the students agree that they don't do their homework and classwork regularly. As it is also the case when it comes to practising mathematics. Students mentioned that they do not have time to do mathematics homework. Some gave excuses such as they are overloaded, and the difficulty of mathematics as their reasons for not doing their homework or classwork. Some of their explanations included:

S₅: Students say that this is college level and homework are not important.

S₉: I do my homework or classwork sometimes. I can only do homework or classwork for topics on P2 if I understand the topic. I understand topics that are on P2 since most of the sections are applicable to mathematical literacy which I did at high school.

S₁₂: I do not do homework. I am not the only one as majority of us do not do it.

5.7.1.6. Lecturer or teaching approach

Even though most students said that they only have themselves to blame as discussed earlier, four students blamed their lecturers for their poor performance. This is what some of them said:

S₄: There is no clear understanding between me and my lecturer. There is no joy in class as the lecturer does not make learning interesting. The lecturer sometimes just come to class and says do exercise on page "x" without showing us how it should be done.

S₇: Our lecturer is too fast, does not teach, just look at the problem and just think we all understand. Our lecturer does not explain step by step. If you ask for clarity from our lecturer, the next explanation will be more confusing than the previous one.

S₈: I do not connect with my lecturer as compared to last years' lecturer. The current lecturer is responsible for my sudden drop in mathematics performance this year.

5.7.1.7. Absenteeism

Absenteeism was one of the most mentioned contributor of poor performance in mathematics by the students. They believe that their absenteeism impact negatively on their performance. In support of this statement, the students said:

S₅: Attendance at our college is very poor. When you abscond, the lecturer may continue with other students and complete a chapter or start another one in your absence. There is nothing that you will understand on your return.

S₁₂: *Attendance is poor and nobody is pushing for it to improve. I do not come to school on Fridays. I am not the only one who do not come to school on Fridays, most of us do not come. Our weekend begins on Thursday.*

5.7.1.8. Quality of tutors

The students have expressed their appreciation to the efforts made by the college, especially towards examinations. They explained how the college organises tutors to help them with extra lessons. However, students are not happy with the quality of the tutors. They say they cannot attend these classes because the tutors are not good enough. This is what some of them had to say:

S₄: *Extra classes should not be offered by tutors who are just previous students. We require experienced lecturers to offer these additional classes.*

S₁₂: *They should organise competent people who are sure about their story to offer these extra lessons. They might have completed Level 4, but they are not in a good position to help us pass. That is the reason why we do not attend those classes.*

5.7.1.9. Peer pressure

Students also mentioned peer pressure as a factor that can influence performance, either positively or negatively. Students also see the value in making study groups and mentioned that any student that is not involved in study groups is destined to fail. They noted the following:

S₁₅: *Mathematics is not a subject which you can just work alone. You have to involve yourself in study groups in order to become successful.*

S₁₂: *If my friends are playful, I will also be playful and we are all likely to fail.*

S₉: *I am good in P2 and I met a classmate who is good in P1. We learn from each other as I teach him or her P2 and s/he teaches me P1. This helps us to succeed in our studies.*

5.7.2. Participants Responses- Lecturers

The discussion that follows is a summary of the interviews conducted with lecturers.

The aim was to answer the research sub-question 3: **What are the lecturers' views on students' performance?** The categories that emerged were:

Quality of students; Teaching strategies; Mathematical Content Knowledge (MCK); Socio-Economic Status; Lack of subject meetings or workshops; Enrolment deadline; Absenteeism;

Late coming; Negative Attitude towards mathematics; Failure to do homework or classwork or assignments. The main question that was asked in the pursuit of these factors was:

R: Which factors do you think could be linked to poor performance by NC(V) Level 2 mathematics students?

5.7.2.1. Quality of students

All lecturers complained about the quality of students that they receive at NC(V) programme. They feel the selection criteria of students has a huge impact on performance of mathematics. The lecturers claim to have students who come from special schools. Below is what some of them had to say:

L₁: We receive students from special schools where they were not doing mathematics in class.

L₂: We have students coming from special schools whilst we are not trained to deal with students with learning disabilities. Marketing strategies for our college does not attract the students who have what it takes to pass mathematics.

Lecturers are in agreement when it comes to the issue of students who bring Grade 9 reports as their entry qualification. They say that because the reports are not verified, there is a possibility of students bringing faked reports. The following is what they said about this issue:

L₄: Some of the students appears not to have passed Grade 6. I am not sure because I cannot prove it, but I can tell by their actions in class.

L₁: There are students who cannot read or write in our classes and we have to teach such students mathematics. It is questionable if indeed they have passed Grade 9. English lecturers also complain about students who cannot even construct a sentence.

Mathematical background was also noted by the lecturers as one of the limiting factors in mathematics achievement. The lack of mathematical background was linked to students who did mathematical literacy at high school, students coming from special schools and doubtful Grade 9 reports. The following are what some of the lecturers had to say:

L₁: We receive students without the necessary background to pass mathematics at Level 2.

L₃: Some students never expected to do mathematics at such a high level when they came to the college.

The minimum requirement for NC(V) as discussed in chapter 1 is Grade 9. That means students who have passed Grade 10-12 may also enrol for Level 2. This is seen by lecturers as a big challenge since they have to deal with a group of students whose academic backgrounds varies greatly, in one class. The following is how some of them feel:

L₂: There is a mixture of students who passed Grade 9, 10, 11 and 12 in one class. In this pool of students, some have done mathematics until Grade 12, while some have done mathematical literacy. We also have those whose Grade 9 is questionable and those who come from special schools. It is really difficult to teach such a class and expect quality results.

In conclusion under quality of students the following emerged: *Students from special schools; Mathematical background; Questionable Grade 9 reports; Mixture of students with different mathematical background.*

5.7.2.2. Socio-Economic Status

Lecturers indicated how socio-economic status of their students affect their performance. This is what some of them said:

L₁: We have students who are without parents in our classes and their performance is negatively affected by this status. We try to investigate some of our students when we suspect that something is not right. It is not always possible to pick up some of these issues on time as we often realise this when it is too late.

L₃: Some of these students do not come from proper homes and this is visible in their school work which shows lack of parental monitoring at home.

5.7.2.3. Absenteeism and late coming

Lecturers say absenteeism is one of the biggest contributors to the poor performance of their students. Some of them said that:

L₂: Absenteeism is a big issue at our campus. Even the implementation of the policy which says a student must attend 80% of the classes in order to qualify to write the exams did not help much to address the issue. Our students just do not care.

L₄: Our students just do not care. When it come to the issue of attendance, it is very bad, just look at my students' register. It looks so terrible.

L₄ showed the researcher an attendance register that he summarised in Table 5.10. Table 5.10 shows a summary of attendance for the academic week that began on 28 August 2017 and ended on 01 September 2017. This table shows the number of students attended on a particular

day (Monday to Friday) and the percentage attendance for the day. Table 5.10 shows the total attendance of the week and the average attendance for the week. The total number of students for this class as it appears on the register is **41**.

Table 5.10: A summary of attendance: 28-08-2017 to 01-09-2017

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Total
Students Present	05	12	11	11	05	44
% attendance	12%	29%	27%	27%	12%	21%

In Table 5.10, there were five students present on Monday; 12 students on Tuesday; 11 students on Wednesday and Thursday; and five students on Friday. The average attendance was nine students out of a possible 44. This attendance is very low. Such an attendance cannot yield quality results at the end of the year.

Late coming was also noted as a contributing factor to poor performance on the part of students, by the participating lecturers. On the issue of late coming, some lecturers said:

L₃: Some students would come to class 10 minutes before the end of the period. That is a clear indication that the student just want to sign the register. They do not care about attending their classes.

L₂: First period is always affected by late coming since most students rely on a train as a mode of transport and trains are not reliable.

5.7.2.4. Failure to do homework or classwork or assignments

The participating lecturers also indicated that students do not do their homework, classwork and assignments. They indicated that students fail to submit even assignments, which contribute towards their year mark. Some lecturers said:

L₃: A few students do their homework. You will fight a losing battle if you want to push them to do their homework. About 3 out of 40 students do their homework in my class.

L₄: Most students submit Task 1 (assignment 1) towards the end of Term 3. I have just received assignment 1 for certain students this week and still yet to mark it. We always force our students to submit assignments. I am still waiting for a practical group work, which was due weeks ago.

5.7.2.5. Enrolment deadline

Enrolment for NC(V) programme takes place until the beginning of second term according to the lecturers. The student attendance registers also indicate that there are students who enrolled in March. According to these lecturers, enrolling students until second quarter disrupt the smooth running of the classes since the teaching-learning starts at the beginning of February. On this issue, some lecturers said:

L₁: Algebra and Functions are the most failed sections in P1. These two sections are completed while the enrolment is still ongoing.

L₄: At the beginning of the year, students are grouped according to their field of study while the registrations are ongoing. This continues until around March. Students get confused not knowing where they should attend or submit their assignments. When the students are finally allocated to their correct classes and lecturers, you find out that teaching Algebra and Functions has been completed.

The lecturers described the enrolment deadline as having a huge impact on performance in mathematics. It is believed if performance can improve in *Algebra and Functions*, the performance in the subject will improve.

5.7.2.6. Lack of subject meetings or workshops

The lecturers claim that there is a shortage of subject meetings and workshops, which can capacitate them. They emphasised the need to learn from each other on how to approach certain sections. They believe that workshops and subject meetings could help address some of the gaps that exist among some of the lecturers. The lecturers said:

L₁: We require in-service training in the form of workshops or subject meetings to share how to teach certain sections. There are knowledge gaps amongst ourselves which could be closed by such workshops or meetings.

*L₂: We require in-service training at college level. We must identify lecturers who are good in certain sections to teach other lecturers within the college.
On the issue of class visits, we only receive feedback based on administrative issues only. The class visits may also be used to help us improve our teaching. Those who conduct class visits should also concentrate on lesson presentations and provide feedback on where can we improve our teaching strategies.*

5.7.2.7. Fear and negative attitude towards mathematics

Students have a negative attitude towards mathematics. They also have fear for the subject according to the lecturers. Some of their views included:

L₂: Most students never expected to do mathematics again after opting for mathematical literacy at high school. They do not have hope that they can make it at this level after leaving it some years ago.

L₅: These students have convinced themselves that mathematics is difficult. They just have a negative attitude towards mathematics.

L₄: Some students misbehave in class. They would try and disturb those who are serious and willing to do their job. They will even try and disrupt my lesson. That is the attitude they have towards mathematics.

5.8. Similarities between students and lecturers

Under student-level factors, the participants agreed on the following categories:

- High level of absenteeism
- Fear and negative attitude towards mathematics
- Failure to do homework and classwork
- Lack of mathematical background mainly because of the choice of mathematical literacy at high school level

Under the college-level factors, the participants agreed on:

- Teaching strategies, which are not learner-centred.

5.9. Differences between students and lecturers

The differences that are discussed here are based on factors that were mentioned by either of the two groups (group of lecturers and group of students) but not by both groups. However, it does not necessarily mean that the two groups do not agree on them.

Students

Under student-level factors, students mentioned the following factors, which were not mentioned by lecturers:

- Students blamed themselves for their poor performances in mathematics.
- They agree that mathematics requires practice, which is something they do not do.

- Forming groups with their peers is a factor that they believe students should engage in, for them to pass mathematics.

Under college-level factors, students mentioned the following factor, which was not mentioned by lecturers: Quality of tutors

Lecturers

Under student-level factors, lecturers mentioned the following factors, which were not mentioned by students:

- Students from special schools.
- There are students who cannot read or write in their classes.
- Late coming by the students.
- Socio-Economic Status

Under college-level factors, lecturers mentioned the following factors, which were not mentioned by students:

- Enrolment which continues until the beginning of the second term.
- Minimum entry requirement of Grade 9, leaves room for students who passed Grade 10, 11 and 12 to enrol for the NC(V) programme. This creates a mixture of students with different mathematical backgrounds in one class. It then becomes difficult to prepare for such a class.
- The legitimacy of Grade 9 reports is questionable according to these lecturers.

5.10. Conclusion

This chapter presented the data that was collected from mark sheets, registers, examination answer books and interviews (students and lecturers). The misconceptions were categorised into *false concepts; adding unlike terms; partial application of rules; and ignoring rule restrictions*. Errors were categorised as *slips*. The interviews also revealed factors that could be linked to poor performance in mathematics. These factors were divided into student level and college level factors. The next chapter discusses and analyses the data presented in this chapter in terms of theoretical framework discussed in Chapter 3.

CHAPTER 6: DISCUSSION OF THE FINDINGS

6.1. Introduction

In this chapter; the findings that were presented and interpreted in the previous chapter are discussed in terms of the theoretical framework that was presented in Chapter 3. The chapter addresses the main research question: What are the possible factors that might be linked to poor performance of NC(V) Level 2 Mathematics students at a TVET College in Tshwane?

To achieve this objective, the following research sub-questions will be answered:

- *Which mathematics misconceptions and errors do these students have or make?*
- *To what do students attribute their poor performance in mathematics?*
- *What are the lecturers' views on students' performance?*

The findings are hereunder discussed under the following sub-heading:

- ❖ *Locating the researcher's study in the theoretical framework*
- ❖ *Analysis of misconceptions and errors*
 - *Analysis of performance of NC(V) Level 2 mathematics students*
 - *Analysis of NC(V) Level 2 P1 and P2 performance of the students.*
 - *Misconceptions and errors in Algebra.*
- ❖ *Factors that could be linked to poor performance in mathematics.*
 - *Student level factors*
 - *College level factors*

6.2. Locating the researcher's study in the theoretical framework

This study investigates how misconceptions and errors; college factors and student factors errors fit in the Wiley and Harnischfeger (1974) school learning model (Figure 6.1).

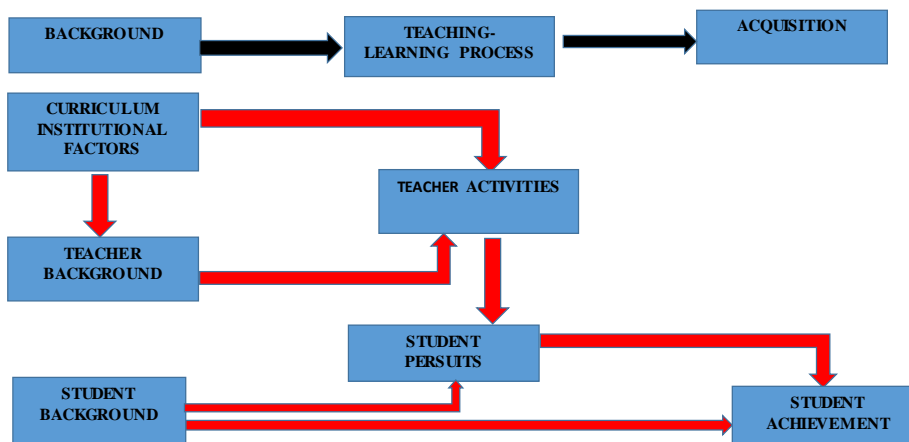


Figure 6.1: Theoretical framework: Adapted from the Wiley-Harnischfeger Model

In this study, the researcher investigates how misconceptions and errors; college factors and student factors fit in the Wiley and Harnischfeger model. Figure 6.2 illustrates how the findings of this study fit into the theoretical framework in an attempt to answer the research questions.

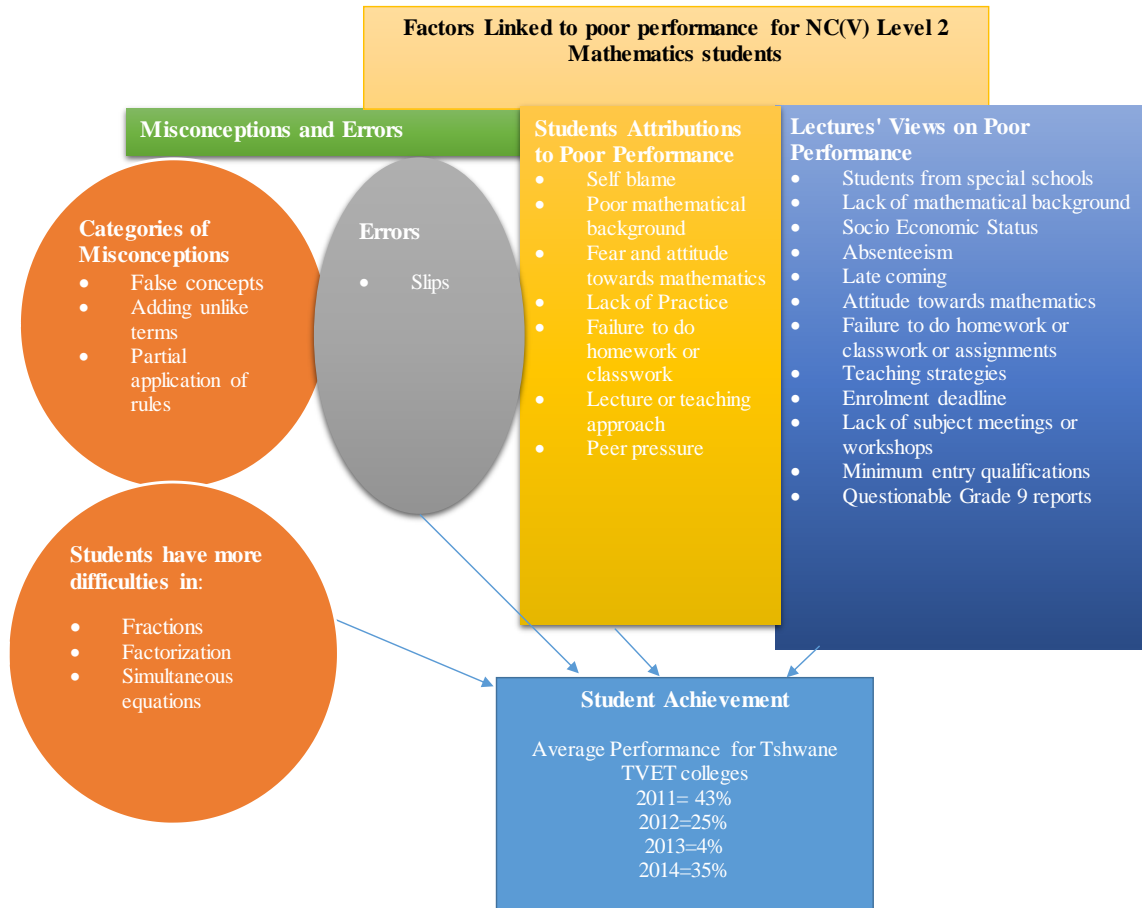


Figure 6.2: How student or college factors affect student achievement (Adopted from Wiley and Harnischfeger model)

The study was mainly concerned with factors that affect performance. The students’ attributions and lecturers’ views consist of student-level and college-level factors, but were not separated in Figure 6.2. These factors are now separated in Table 6.1. The aim is to show which factors are more dominant in accordance with Wiley and Harnischfeger model. The factors in Table 6.1 include factors from both students and lecturers. All errors and misconceptions are viewed as student-level factors and are therefore excluded from Table 6.1.

Table 6.1: Student-level and College-level factors

Student-level factors	College-level factors
Students from special schools	Teaching strategies
Lack of mathematical background	Enrolment deadline
Socio-Economic Status	Lack of subject meetings or workshops
Absenteeism	Minimum entry qualifications
Late coming	Questionable Grade 9 reports
Fear and negative attitude towards mathematics	
Failure to do homework or classwork or assignment	
Self-blame	
Lack of practice	
Peer pressure	

6.3. Analysis of misconceptions and errors

Before the researcher examines the misconceptions and errors, it was necessary to first discuss mathematics performance of Level 2 students in the whole NC(V) programme at selected TVET College campus, for the year ending 2016. This was followed by analysis of performance for the selected students in P1 and P2. Lastly the researcher examined the misconceptions and errors in Algebra by 12 selected students.

6.3.1. Analysis of performance of NC(V) Level 2 mathematics students

The analysis of performance of all NC(V) Level 2 mathematics students in the year 2016 revealed unexpected statistics. It was revealed in Table 5.2 that 272 students (64%) out of a total of 422 did not write their final examination, which may be due to the fact that they did not qualify to sit for the final examination (did not obtain 39% in their year mark); socio-economic status; level too high and others. That means out of 422 students only 150 students wrote the final examination. From 150 students who wrote the final examination, only 65 students passed. This translates into 43,33%, which is not-acceptable considering the number of students who failed to write the final examination. The retention rate is a point of concern since it stands at 15,4%. These statistics indicate that there are challenges, which require urgent attention.

6.3.2. Analysis of NC(V) Level 2 P1 and P2 performance

Analysis of students' performance in P1 and P2 revealed that students perform relatively well in P2 (49% average). On the contrary students perform poorly in P1 (36%) on average (see Table 5.3). Analysis of P1 alone, revealed that students struggle the most in Q1 and Q4 (Algebra and Functions respectively). The researcher decided to analyse misconceptions and

errors in Q1 only. This decision was influenced by the fact that some of the questions in Q4 depend on the knowledge that is tested in Q1, for an example, calculation of the equation of a graph involves the knowledge of simplifying expressions and solving equations, which is applicable to Q1.

6.3.3. Analysis of performance in Algebra: Q1 (question by question)

Students performed poorly in SQ1.2.2 (simplifying a fraction) where all students obtained zero each. It was followed by SQ1.1.3 (factorising a trinomial) and SQ1.3.1 (solving a quadratic equation) with only two same students getting them correct. The third worst performing questions were SQ1.1.2 and SQ1.1.4 (factorising: trinomial and difference of squares respectfully) and SQ1.5 (solving simultaneous equations) with eight students scoring zero marks in all three questions.

6.3.4. Misconceptions and errors in Algebra

The misconceptions and errors that the students make in Algebra were grouped under categories as displayed in Table 5.1. For the purpose of this discussion, the categories in Table 5.1 were sub-divided into more specific sub-categories. The aim of sub-dividing these categories is to give the reader a clearer picture of the misconceptions and errors that the students commit in mathematics. The sub-categories include: *addition of unlike terms; failure to factorise a trinomial or difference of two squares; failure to simplify a fraction; students' difficulties in solving simultaneous equations; failure to correctly apply the distributive laws; misinterpretation of the power of brackets; applying learned rule or an algorithm to a new problem situation; equating expressions to zero; negative sign ignored in the second term when taking out a common factor in two terms; division of the common factor; incorrect mathematical argument.*

Addition of unlike terms

Addition of unlike terms was a problem to these students. Addition of unlike terms was responsible for 15 errors of the total of 75. Eight of these errors occurred when students were supposed to factorise. Students add unlike terms when simplifying expressions or when solving equations as observed by O'Connor and Norton (2016), which is consistent with the results of this study.

When there is a subtraction sign, students would eliminate the variable that is common. They also conjoin different variables that are added. If the variables are the same but have different exponents, they tend to take the highest exponent. The same results were reported by Makonye and Matuku (2016) who reported that learners have a tendency to wrap up algebraic expressions by joining unlike terms, e.g. $2x^2 + 3x = 5x^2$.

The students view operation signs between terms as an invitation to add or subtract terms. Students also have a misconception that the final answer in mathematics should consist of a single term. These findings are the same as the findings by Mulungye, O'Connor and Ndethiu (2016) who discovered that students see the operator sign between unlike terms as an incitement to do something and should not be in the final answer.

Failure to factorise a trinomial or difference of two squares

Students struggle to factorise a trinomial or a difference of two squares. There were two questions testing factorisation of a trinomial. Eight students failed to obtain a single mark in the first trinomial while ten students failed to obtain a single mark in the second one. There are students who understand factorisation to be involving grouping only. When these students are given a trinomial to factorise, they group the terms with a common factor and take out a common factor for the two terms. They then take what is in the brackets to be a common factor. S₄; S₅; S₁₁ did this while S₂ was attempting to do the same. Makonye and Khanyile (2015) discovered similar results in their study where they reported that students are unable to factorise a trinomial.

Students also struggle with factorisation of a difference of two squares. There was one question testing knowledge of a difference of two squares. Eight students got no mark. Beukes (2014) reported the same results as in this study and reported that students have misconception of factorisation of a difference of two squares.

Failure to simplify a fraction

Students find it difficult to simplify fractions. None of the students managed to score a mark in fractions. The biggest challenge was their inability to identify the common factor. Two students managed to identify a common factor but made other errors in the process. According to Makonye and Khanyile (2015, p.66) "in the pre-test, some students could not recognise the

common factor where they were supposed to factorise before simplifying”, which are the same results as discovered in this study.

Students’ difficulties in solving simultaneous equations

Students find it hard to solve simultaneous equations. Only two students managed to obtain four full marks, two of them got two marks and the other eight students got no mark. Students in general harbour negative attitude towards simultaneous equations. They believe that when you use elimination method, you always subtract the equations. Students find it tough in general to use elimination method. Those who managed to get full marks on this question used substitution method. Same as in this study, Egodawatte (2011) observed that students misinterpret elimination method when they solve systems of equations and were willing to avoid using elimination method and instead use substitution method.

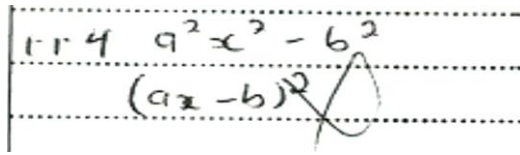
Failure to correctly apply the distributive laws

Eight students correctly multiplied a binomial by a trinomial. On the contrary only three students applied distributive laws correctly in the equation: $y(2y + 1) = 15$. The researcher did find this hard to believe since it is more challenging to multiply binomial by trinomial than to remove the brackets in this equation. Maybe the students are used to solving linear equations and not quadratic equations. This is explained by some of the students’ responses where a student deleted y after multiplying out where y was correct. Another reason may be that students wanted to avoid factorising a trinomial, which proved to be a challenge to these students. This study concurs with Makonye and Matuku (2016) who observed that learners fail to apply the distributive laws where they failed to correctly multiply to remove the brackets. Some errors committed by students in this question included cases where a student added y and $2y$ to get $3y$ instead of multiplying the two. In one of the students’ responses, the “ y ” that is outside the brackets disappeared.

A notable error in the multiplication of binomial by trinomial was when one student used the first term in the binomial to correctly multiply the trinomial but put the product in brackets. This confused the student who did not know what the next step should be.

Misinterpretation of the power of brackets

On the question of factorising a difference of two squares, the student factorised like this:



$$a^2x^2 - b^2$$

$$(ax - b)^2$$

Figure 6.3: Confusing the power of brackets

The student may have confused this situation with multiplying out factors of a difference of two squares. The explanation that we give when we multiply out for an example: $(x - a)(x + a) = x^2 - y^2$ might have led the student into making such an error. Same findings were discovered by Mulungye, O'Connor and Ndethiu (2016), who discovered that students expand $(a + b)^2$ as $a^2 + b^2$, which can be seen as the misinterpretation of the power of brackets evolving from incorrect application of the distributive law.

Applying learned rule or an algorithm to a new problem situation

Students apply previously learned rules or algorithm to new situations. Three students committed this error. Two students calculated x and y intercepts when they were supposed to solve for x and y simultaneously. One of them started by transposing the constant terms in order to make the two equations equal to zero. This was followed by equating the two equations on the basis that they are both equal to zero. This was followed by finding x and y intercepts. There are two misconceptions that this student showed. The first misconception occurred when the student equated the two equations on the basis that they are equal to zero. This is a misunderstanding emanating from making one variable the subject of the formula followed by equating the two equations on the basis that they are both equal to the same variable. The second misconception was finding x and y intercepts instead of solving x and y simultaneously, which was the same as the other student.

Another error included a situation where the student was simplifying a fraction but ended up multiplying the fraction by the denominator over the denominator like in the case of rationalising the denominator i.e.: $\frac{4x^2 - 8xy^3}{-xy} \times \frac{-xy}{-xy}$. The student only managed to remove the negative sign in the denominator, which was far from simplifying the given fraction. According to Egodawatte (2011, p.144), “students mistakenly modify and apply a previously learned rule

or an algorithm to a new problem situation”, which is the same as the results of this study. He adds that when this happens, students do not realise that a misuse has happened.

Equating expressions to zero

One student equated four expressions that required factorisation to zero. This is a misconception emanating from solving equations. It shows lack of differentiation between expression and equations. During the interviews the student said all mathematics questions contain equal to zero. The results of this study oppose the findings of Makonye and Matuku (2016) who discovered that students changed the equation to an expression when asked to solve the equation by factorisation.

Negative sign ignored in the second term when taking out a common factor in two terms

Two students made this error. When the students took out a common factor in two terms where the common factor was negative, students failed to recognise that the negative sign must affect both terms. They only took it out in the first term. This misconception was confirmed in the interviews. It is important to explain this using reversibility, where students will see that the factors will not multiply back.

Division of the common factor

One student factorised all four questions in a similar manner. This student correctly identified the common factor between two terms, put it outside the brackets and the two terms inside the brackets. The student then divided the common factor and the terms inside the brackets by the common factor. In the next step, the denominator of the common factor disappeared. This misconception comes from the misunderstanding of the explanation of the process of taking out a common factor. The explanation that says when you take out a common factor in two terms, you divide the terms that you are taking out a common factor from by the common factor.

Incorrect mathematical argument

There is a student who illustrated incorrect mathematical argument when solving algebraic equations. In an equation the student divided one side in one step and divided the other side in the next step instead of dividing both sides in the same step. This shows lack of appreciation of mathematical argument.

Categories of misconceptions and errors in this study

It was revealed in Table 5.9 that the most dominant category of misconceptions or errors made by the students are **false concepts** with 39 errors out of the total of 75 errors committed. These are serious errors and their domination is a point of concern for the lecturer. It was followed by **addition of unlike terms** with 15 out of 75 errors committed. These errors are also serious. The third category was **partial application of rules** with 12 out of 75 errors. Partial application of rules are also serious errors but not difficult to correct than false concepts and addition of unlike terms because students indicate that they have some knowledge necessary to answer the question. **Slips** (five errors) are just careless mistakes and not too serious as other errors because the students can correct them themselves or with the help of the lecturer. **Ignorance of rules restriction** was last with four errors. These errors are also serious as they indicate confusion from the side of the student.

Since slips and ignorance of rules are few (9 in total), these errors cannot influence the performance given the total number between them. It can be concluded that false concepts (39 errors), partial application of rules (12 errors) and adding unlike terms (15 errors) with a total of 66 out of 75 errors influence the performance in mathematics. Students fail Algebra because they have misconceptions.

6.4. Factors linked to poor performance: Interviews with students and lecturers

The interviews with both students and lecturers revealed factors that could be linked to poor performance in mathematics. The categories that emerged from students and lecturers' interviews will hereunder be discussed under student and college level factors.

6.4.1. Student-level factors

Students blaming themselves

Students at the most blame themselves for their poor performances. From the 17 students, 13 indicated that lecturers cannot be blamed for their poor performance. These students indicated that the college is doing the best it could to assist them pass mathematics. According to them the problem lies with themselves. Same results were reported by Mijs (2016) who discovered that students who are involved in vocational education are most likely to take the blame for their poor performance in mathematics.

Poor mathematical background

Students accept that they do not have a sound grounding in mathematics. Mathematical literacy was considered to be one of the biggest contributing factors to their lack of mathematical background. Those who did mathematical literacy regret their choices they made at secondary school.

Lecturers also agree that students lack necessary background to pass mathematics. These results concur with the results of Tshabalala and Ncube (2016) who observed that poor grounding in mathematics is one of the contributing factors towards poor performance in the subject.

Students from special schools

Lecturers mentioned that they have students who come from special schools in their classes. Their biggest challenge is that they are not equipped with the necessary skills to teach these students.

Fear and negative attitude towards mathematics

Most students also believe that mathematics is a difficult subject and they as a result fear it. Some of these students never expected to do mathematics when they enrolled for the NC(V) programme. They were surprised to learn that they had to do mathematics not mathematical literacy as one of the subjects. In general, the attitude of the students towards mathematics is negative.

Lecturers agree that students have a negative attitude towards mathematics. They emphasised that students who abandoned mathematics at high school level get traumatised when they have to do the subject again. This study concurs with Tshabalala and Ncube (2016) who observed that majority of the students believe that mathematics is naturally a difficult subject, which means that they fear the subject.

Lack of practice

Students are aware that they need to practice mathematics in order to pass it. Despite this awareness, they still do not practice. They just do not have time for mathematics. Same as this study, Ali and Jameel (2016) state that lack of practice and exercises is a main reason affecting the development of solid and abstract mathematical concepts negatively.

Failure to do homework or classwork or assignment

Homework and classwork form an integral part in the preparation of students for their assessments. Students admitted that they do not do their homework and classwork regularly. Again students show that they are aware of the importance of playing their roles in respect of these activities. Students do not do homework and classwork according to the lecturers. They say that students are also pushed to submit their assignments, which contribute towards their year mark. The findings of this study agree with Cooper (1989) who reported that high school students who were regularly given homework in their classes, performed 75% better than students who were never given homework

Absenteeism and late coming

Absenteeism is one of the major challenges that face the entire NC(V) programme according to students and lecturers. The attendance register from L₄ as summarised in Table 5.10 fully supports what students and lecturers claim. Table 5.10 shows a summary of attendance for the week that ended on 01-09-2017. The average percentage attendance for that particular week was 21%, which is very poor. The researcher's findings are consistent with Tshabalala and Ncube, (2016) who discovered that regular class attendance is crucial if students are to acquire the necessary skills in mathematics. Lecturers also identified late coming as a contributing factor to poor performance of students.

Socio-Economic Status

According to lecturers it is important to understand the socio-economic status of the students given the nature of the students who enrol for NC(V) programme. They believe that understanding the students may assist them in identifying those of them who require special attention. Lecturers, however, also concede that it may not always be possible given their workload. The researcher's results concur with Kiwanuka et al. (2015) who discovered that students from higher socio-economic status families are more likely to perform better than those who come from lower socio-economic status families in mathematics.

Peer pressure

Working as a group is a strategy that students view as a valuable tool to pass mathematics. They believe that a student who does not participate in study groups is destined to fail. They also believe that a peer group that a student associates with can either make that particular student pass or fail, depending on whether the group is playful or serious about school work.

Same results were corroborated by Coleman et al. (1966) that peer-pressure has been identified as one of the factors that influence academic achievement. According to these studies, regardless of one's own family socio-economic status, if a student attends school with, for an example, classmates from families with high social status, this will significantly contribute positively to his or her academic performance.

6.4.2. College-level factors

Grade 9 reports

The lecturers complained about students who enrol for NC(V) programme with Grade 9 reports. Lecturers are concerned about the legitimacy of these reports as they are not verified. One of the reasons why lecturers suspect the legitimacy of these Grade 9 reports is that some of these students who are carriers of these reports can neither read nor write.

The requirement for NC(V) Level 2, which is a minimum of Grade 9, leaves a room for students who passed Grade 10, 11 and 12 to enrol for this programme. This mixture of students who possess different mathematical backgrounds make it difficult for the lecturers to cater for the needs of each and every student in class. Similar to this study, Mashongoane (2015) observed that entry requirement of Grade 9 means that many students are admitted to NC(V) Level 2 with Grade 9-12 and this creates a diversity of population into the classroom. He further indicates that this causes problems for the lecturers who struggle to get the right balance in their lessons.

Teaching strategies

Even though most of the students have themselves to blame for their poor performance, there were those who had other ideas. Four students believe that their lecturers are to blame for their poor performances. They mentioned that teaching strategies of their lecturers are not able to help them understand. Out of the four students, three were from the same lecturer and their responses were common. The fourth student who blamed the lecturer was a Level 4 student. The responses from this student were not convincing enough to believe that the lecturer could be at fault. It can be concluded that there is one lecturer who employs strategies, which are not student-centred. This study agrees with Njagi (2013) who discovered that teachers use teaching methods that learners do not easily follow when teaching mathematics by employing teacher-centred methods instead of student-centred methods.

Quality of tutors

According to students the college organises students who have passed Level 4 to assist other students in key subjects like mathematics. Students expressed their appreciations for the efforts of the college, however they complain about the quality of the tutors. They are not encouraged to attend these classes because they do not trust that these tutors have what it takes to help them pass. They would rather have their own lecturers presenting these extra lessons as compared to the former (or current) students. The extra classes that students alluded to are just additional classes organised by the college. They fall outside the normal school hours. Even though the purpose of these classes is to improve performance of students, they were not taken into account for the purpose of this study since they fall outside normal schooling time.

Enrolment deadline

Enrolment takes place until the beginning of term 2 according to lecturers. The attendance register that was shown to the researcher by L₄ shows that one of the students enrolled on the 09th of March 2017 while teaching and learning started at the beginning of February. It also emerged from the lecturers that during registrations up until the end of the term, students are grouped temporarily according to their respective fields of study (for an example, IT, ERD). This means that students are allocated to lecturers temporarily. During this period, temporary registers are used where students have to write their names down. The lecturers assert it is very difficult to control students during this period. Algebra and Functions are offered during this period and this could be the reason why students perform poorly in these sections, said the lecturers. These findings agree with Wiley and Harnischfeger (1974) that there is a relationship between lost time and acquisition in mathematics. This means that the time that some of the students loose due to non-attendance of classes will have a negative influence on their achievement.

Lack of workshops or subject meetings

According to lecturers, there is a need for workshops or subject meetings, which are supposed to help them share knowledge concerning how to teach certain sections. They agree that there are knowledge gaps, which could be addressed by such workshops. The researcher's findings confirm the findings of Wu (2005), who says that there is a link between the MCK of the teachers and the performance of the learners that they teach.

6.5. Summary

The study that was conducted earlier indicated that school-level factors have little effect on students' achievement than student-level factors (Coleman et al., 1966), which is consistent with the researcher's results. Some other studies reported that schools account for a significant fraction of variability in academic achievement (Mohammadpour, 2012; Rumberger & Palardy, 2004; Ma & Klinger, 2000). In this study, it was proved that student-level factors dominate college related factors. The responses from participants put more emphasis on student-level factors than they put on college-level factors. It must also be noted that this study was carried out at a TVET College campus in South Africa where there is a limited number of studies conducted in general (<http://www.saqa.org.za>).

This study exposed the challenges that confront TVET Colleges, which are unique as compared to other institutions of learning. It was proved that students make serious errors like false concepts and addition of unlike terms. It was also established that students struggle with factorisation especially trinomials and difference of squares. This study proved that students cannot simplify fractions. Solving simultaneous equations also proved to be a challenge to these students.

It was revealed in this study that there are students who come from special schools, but lecturers are not equipped with the necessary skills to teach these students. The study also exposed that entry qualification of Grade 9 for NC(V) creates a mixture of students with different mathematical background. The Grade 9 reports are questioned by the lecturers who teach these students since they are not verified. The absenteeism, which is too high also proved to be a contributing factor to poor performance. Students who do not do their homework and assignments also proved to be contributing a setback in mathematics achievement. Students blame themselves for their poor performance in mathematics. The study also reveals that registration takes too long to complete. This results in students missing about two months of their teaching and learning time, which may be seen as a possible cause of poor performance.

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

7.1. Introduction

This chapter provides answers to the research questions. This will be followed by the recommendations and limitations of the study. The chapter ends with concluding remarks.

*The main question of the study is: **What are the possible factors that might be linked to poor performance of NC(V) Level 2 Mathematics students at a TVET College in Tshwane?***

The following research questions were used to address the main question of this study:

- *Which mathematics misconceptions and errors do these students have or make?*
- *To what do students attribute their poor performance in mathematics?*
- *What are the lecturers' views on students' performance?*

7.2. Answers to the research sub-questions

7.2.1. Which mathematics misconceptions and errors do these students have or make?

To answer this research question, the final examination scripts of the students were analysed for misconceptions and errors in Algebra (Q1). The misconceptions were categorised as **adding unlike terms; false concepts; ignoring rule restriction; and partial application of rules** while errors were categorised as **slips**. This is shown in Table 7.1. Interviews were used to get explanations from the students on some of their errors and difficulties that they find in Algebra.

Table 7.1: Categories of misconceptions and errors

	Category Name	Description
Misconceptions	Adding unlike terms	Unlike terms were collected and added together. These are very serious.
	False concepts	These are completely wrong answers. These are very serious as they indicate lack of knowledge.
	Partial application of rules	This is where a student partially applies the correct rule to a question. These are serious errors but indicates that the student possesses some of the knowledge required and therefore not difficult to correct as false concepts.
	Ignoring rule restrictions	This refers to ignoring the boundaries, which are applicable to a certain rule and includes applying a rule to a context to which it is not applicable.
Errors	Slips	These are unintended mistakes. They are not serious as the students can easily correct by themselves or with the help of their lecturer.

Before analysis of misconceptions and errors took place, the performance of students in P1 and P2 was analysed. It revealed that students perform relatively well in P2 than they do perform in P1.

Students perform poorly in mathematics because they have misconceptions. The misconceptions include: *false concepts; adding unlike terms; and partial application of rules*. False concepts identified were 39, addition of unlike terms were 15 and partial application of rules were 12. These errors dominated other errors and are therefore seen as possible factors that could be linked to poor performance.

Out of a total of 75 errors, slips were five and ignoring rule restrictions were four. This is a total of nine errors all together. Given their total number, these categories could not have an impact on performance of students. These categories were therefore excluded from factors that influence performance in mathematics.

Sections in which students performed poorly

Students make more errors in fractions because they are unable to recognise the common factor. In rare cases when they do recognise a common factor, they commit division errors. These findings support the findings by Makonye and Khanyile (2015), which state that students struggle to recognise a common factor when simplifying fractions.

Students also commit more errors in factorisation. Most students understand factorisation to be involving grouping and taking out a common factor. They cannot factorise a trinomial or difference of squares.

Students commit a lot of errors in solving simultaneous equations because they believe simultaneous equations are difficult to solve. This attitude prevents students from acquiring knowledge of solving simultaneous equations.

Misconceptions and errors that students make

- Students add unlike terms: Students conjoin unlike terms and take the highest exponent. When there is a subtraction sign, they eliminate the common variable. They see the operating sign as a cue to do something and the final answer should contain only one term or number.

- When students take out a common factor which contains a negative sign, they only take out the negative sign in the first term.
- Students understand elimination method to be involving subtraction of equations and not addition.
- They also find the x and y intercepts instead of solving x and y simultaneously when solving systems of linear equations.
- Students also equate two equations on the basis that they are equal to zero, which result in combining the two equations into one equation.
- Students also misinterpreted the power of the brackets, i.e. $a^2x^2 - b^2 = (ax - b)^2$.
- Students equate expressions to zero.
- When students solve algebraic equations, they divide the left hand side in one step and divide the right hand side in the next step.

7.2.2. To what do students attribute their poor performance in mathematics?

To answer this research question, it was necessary to interview students to get an understanding of the factors that they believe contribute to their poor performance.

Students have themselves to blame for their poor performance. This is consistent with research findings by Mijs (2016), which state that students who are involved in vocational education are most likely to take the blame for their poor performance in mathematics.

Students perceive themselves as having a lack of mathematical background to pass mathematics. The choice of mathematical literacy at high school was seen as a contributing factor towards their lack of mathematical background. These findings are in line with the findings by Tshabalala and Ncube (2016), which reveal that poor grounding in mathematics is one of the contributing factors towards poor performance in mathematics.

Another factor that these students mentioned was their fear and negative attitude towards mathematics. Students also mentioned that they did not expect to do pure mathematics when they enrolled at the college. These findings are in line with the findings by Tshabalala and Ncube (2016), which showed that the majority of students believe that mathematics is naturally a difficult subject, which means that they fear the subject.

Students do not practice mathematics. They also do not do their homework and classwork. These findings are in line with the findings of Ali and Jameel (2016) who discovered that lack of practice and exercises are the main contributing factors towards poor performance in mathematics.

Students were in agreement with respect to the problem of high absenteeism. They see this factor as having a negative impact on their performance. These findings support the findings by Tshabalala and Ncube (2016), which revealed that participants believe that the absence of students from school affect their mathematics performance.

Students also feel that some of their lecturers use teaching strategies that are lecturer-centred. This is consistent with the findings by Miheso (2002), which say that poor performance in mathematics can certainly be explained by teaching methods used in the classroom.

7.2.3. What are the lecturers' views on students' performance?

To answer this research question, NC(V) mathematics lecturers were interviewed.

Lecturers complained about the quality of students as the main contributing factor to poor performance in mathematics. The quality of students includes the following factors:

- Students from special schools: Lecturers claim that they have students who come from special schools in their classes, while they are not trained to deal with such students.
- Minimum entry qualifications of Grade 9: They say this creates a mixture of students with different mathematical backgrounds because students who passed Grade 10, 11 and 12 may also enrol for the NC(V) programme.
- Legitimacy of the Grade 9 reports is questionable according to lecturers.
- Students who cannot read or write: Lecturers also stated that they have students who cannot read or write in their classes.
- Students lack mathematical background, which can enable them to pass mathematics at NC(V) Level 2.

Tshabalala and Ncube (2016) also discovered that poor background in mathematics is one of the contributing factors towards poor performance. These results are also in support of the results of the study by Mashongoane (2015) that students enter NC(V) Level 2 with mixed qualifications, e.g. Grade 9-12, which creates a diversified population in the classroom and in turn cause problems for the lecturers who struggle to get the right balance during their lessons.

Absenteeism is very high according to the lecturers. Table 5.10 shows how serious the situation is. The average percentage attendance for the week was 21%, which is too low if we anticipate quality results. Late coming was also quoted as having a negative impact on performance in mathematics. These findings are in line with the findings by Tshabalala and Ncube (2016), which revealed that participants believe that the absence of students from school affect their mathematics performance.

Students' negative attitude towards mathematics is another reason for poor performance according to these lecturers. These findings are in line with the findings of Tshabalala and Ncube (2016), which say majority of the students believe that mathematics is naturally a difficult subject, which means that they fear the subject.

Failure to do homework or classwork or assignments was another point of concern. The students show little interest in doing these tasks as they have to be pushed to submit assignments, which contribute towards their year mark. These findings concur with the findings of Ali and Jameel (2016) who exposed that lack of practice and exercises are central points in the reasons affecting mathematics achievement.

Lower socio-economic status was also quoted as having negative impact on students' performance. Research also indicates that students from higher socio-economic status families are more likely to perform better than those who come from lower socio-economic status families in mathematics (Kiwauka et al., 2015; Teddlie, Reynolds & Sammons, 2000).

Enrolment continues until the beginning of Term 2 according to lecturers. During this period, students are grouped temporarily according to their fields of study (e.g. Information Technology; Engineering and Related Design). Teaching-learning continues during this period until the students are grouped according to their specific lecturers. This creates confusion for both students and lecturers. The manual registers are used during that time for each student to write his or her name down, which are difficult to control. Algebra and Functions are taught during this period and students perform poorly in these sections.

Teaching strategies where lecturers use lecturer-centred methods were also seen as contributing factors towards poor performance. These findings are consistent with the findings by Tshabalala and Ncube (2016) and Njagi (2013), which state that teachers use teaching methods that learners do not easily follow when teaching mathematics since they apply teacher-centred methods instead of learner-centred methods.

Lecturers also mentioned lack of MCK from the lecturers as having an impact on the performance of students. Lecturers believe that these factors could be addressed by workshops or subject meetings, which are currently lacking. These findings support the findings by Wu (2005), which say there is a link between the MCK of the teachers and the performance of the

learners that they teach. The findings of this study are also in agreement with the findings of Kanongo (2007), which say the teacher content knowledge is important in impacting students' mathematics achievement.

7.3. Answering the main research question

The main question was: **What are the possible factors that might be linked to poor performance of NC(V) Level 2 Mathematics students at a TVET College in Tshwane?**

The objective of research sub-questions was to help answer the main question. These questions were answered in 7.2. The section that follows provides a summary of the answers in 7.2 in an attempt to answer the main question.

The factors that contribute to poor performance in mathematics consist of:

- misconceptions and errors that the students make and the sections in which they make most errors in Algebra, and
- Student or college level factors.

Students' misconceptions and errors in Algebra.

The students perform poorly in mathematics because they have misconceptions in Algebra. The misconceptions are: false concepts; addition of unlike terms; partial application of rules. Students make more errors in fractions; factorisation; and in simultaneous equations.

Student and college level factors

Table 7.2 provides a summary of factors that emerged from interviews with participants.

Table 7.2: Summary of student and college factors

Student level Factors	College level Factors
Absenteeism	Teaching strategies
Students from special schools	Enrolment deadline
Lack of mathematical background	Lack of subject meetings or workshops
Socio-Economic Status	Minimum entry requirement of Grade 9
Late coming	Questionable Grade 9 reports
Fear and negative attitude towards mathematics	
Failure to do homework or classwork or assignments	
Self-blame	
Lack of practice	
Peer pressure	

7.4. Recommendations

Based on the findings of this study, it was noted that there are many challenges at TVET Colleges, especially in NC(V) programme. These findings explain why the performance is as poor as it was mentioned in the opening remarks.

7.4.1. Recommendations for research purposes

Little research has been conducted into the factors that affect performance in mathematics at TVET Colleges in South Africa. The same can be said about the misconceptions and errors in mathematics for NC(V) students. There is limited literature as far as TVET Colleges is concerned. More studies are required to close this gap. In the context of this study, the researcher makes the following recommendations for future studies:

- A study to determine the impact of having students who have passed Grade 9; 10; 11 and 12 in one mathematics class.
- A study to examine the motivation level of students when they transit from high school to TVET Colleges.
- A study that will develop instruments to enable TVET Colleges to select students who will successfully pass mathematics.
- A study that will determine the completion and retention rate at this programme given the challenges that it faces, e.g.: the number of students who fail to qualify to sit for their final examination while others drop out during the course of the year.
- A study that will determine if mathematical literacy can be offered as an alternative to mathematics for NC(V) engineering programmes.

7.4.2. Recommendations for teaching practices

TVET Colleges should develop or introduce instruments, which will measure the readiness of the students to enrol for mathematics in the NC(V) programme. This will assist TVET College lecturers in selecting students who are capable of passing mathematics throughout the NC(V) programme.

TVET Colleges should develop monitoring tools for attendance on a daily basis. Measures to ensure that the attendance policy is available and adhered to, should be put in place. Monitoring of class attendance should start from the first day of teaching and learning. Enrolment by the students should have a time frame not exceeding one month.

TVET Colleges should organise workshops that will help capacitate lecturers with mathematics content knowledge. Subject meetings should be held regularly across the TVET Colleges.

These meetings should aim to address the knowledge gaps that lecturers may have and allow lecturers to share teaching strategies.

The reasons for choosing students who passed Level 4, to facilitate extra lessons should be clearly stated. The students should be motivated to attend these classes.

Students should be motivated to take their studies seriously. The lecturers can be helpful in this regard.

7.5. Limitations of the study

This study was conducted at a single TVET College campus. Only seventeen students and five lecturers participated in the study. These factors make it impossible to generalise the results.

The examination was written ten months before the interviews took place. Some of the misconceptions might have been erased from the minds during this period and some students might have forgotten some of the details concerning what they wrote in that examination.

7.6. Concluding remarks

This study has helped the researcher gain knowledge regarding challenges that the TVET Colleges are facing in respect of performance in mathematics. The researcher has also learned how to identify misconceptions or errors and to apply this knowledge in his day to day lesson presentation. The researcher has learned the art of finding answers from participants through this study. Going through several articles to find more information has helped the researcher learn how to analyse published articles from other researchers.

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APPENDIX A: ETHICS CERTIFICATE



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

RESEARCH ETHICS COMMITTEE

CLEARANCE CERTIFICATE

CLEARANCE NUMBER: **SM 17/06/02**

DEGREE AND PROJECT

M.Ed

Factors linked to poor performance for NC (V) Level 2 mathematics students

INVESTIGATOR

Mr Mbazima Ngoveni

DEPARTMENT

Science, Mathematics and Technology Education

APPROVAL TO COMMENCE STUDY

2 August 2017

DATE OF CLEARANCE CERTIFICATE

23 March 2018

CHAIRPERSON OF ETHICS COMMITTEE: Prof Liesel Ebersöhn

CC

Ms Bronwynne Swarts

Dr Batseba Mofolo-Mbokane

This Ethics Clearance Certificate should be read in conjunction with the Integrated Declaration Form (D08) which specifies details regarding:

- Compliance with approved research protocol,
- No significant changes,
- Informed consent/assent,
- Adverse experience or undue risk,
- Registered title, and
- Data storage requirements.

ANNEXTURE B: APPLICATION TO CONDUCT RESEARCH: DHET



**higher education
& training**

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

DHET 004: APPENDIX 1:

APPLICATION FORM FOR STUDENTS TO CONDUCT RESEARCH IN PUBLIC COLLEGES

1. APPLICANT INFORMATION

1.1.	Title (Dr /Mr /Mrs /Ms)	Mr	
1.2	Name and surname	Mbazima Amos Ngoveni	
1.3	Postal address	P O BOX 1830 Rosslyn 0200	
1.4	Contact details	Tel	
		Cell	0828877829
		Fax	0862626093
		Email	mbazimangoveni@yahoo.com
1.5	Name of institution where enrolled	University of Pretoria	
1.6	Field of study	Education	
1.7	Qualification registered for	Please tick relevant option:	
		Doctoral Degree (PhD)	<input type="checkbox"/>
		Master's Degree	<input checked="" type="checkbox"/>
		Other (please specify)	<input type="checkbox"/>

2. DETAILS OF THE STUDY

2.1	Title of the study
Possible factors linked to poor performance for NC(V) Level 2 Mathematics students: A case of one TVET College in Tshwane.	

2.2	Purpose of the study
The purpose of this study is to establish the possible factors linked to poor performance of NC(V) Level 2 students in mathematics at TVET Colleges in Tshwane.	

3. PARTICIPANTS AND TYPE/S OF ACTIVITIES TO BE UNDERTAKEN IN THE COLLEGE

Please indicate the types of research activities you are planning to undertake in the College, as well as the categories of persons who are expected to participate in your study (for example, lecturers, students, College Principals, Deputy Principals, Campus Heads, Support Staff, Heads of Departments), including the number of participants for each activity.			
3.1	Complete questionnaires	Expected participants (e.g. students, lecturers, College Principal)	Number of participants
		a)	
		b)	
		c)	
		d)	
		e)	
3.2	Participate in individual interviews	Expected participants	Number of participants
		a) Students	24
		b) Lecturers 4-6	

4. SUPPORT NEEDED FROM THE COLLEGE

Please indicate the type of support required from the College (Please tick relevant option/s)			
Type of support		Yes	No
4.1	The College will be required to identify participants and provide their contact details to the researcher.		
4.2	The College will be required to distribute questionnaires/instruments to participants on behalf of the researcher.		
4.3	The College will be required to provide official documents. Please specify the documents required below	√	
	NC(V) Level 2 Mathematics final examination for the year 2016		
4.4	The College will be required to provide data (only if this data is not available from the DHET). Please specify the data fields required, below	√	
	2016 mathematics Level 2 Final results per class for the year 2016		
4.5	Other, please specify below		√

5. DOCUMENTS TO BE ATTACHED TO THE APPLICATION


The following 2 (two) documents must be attached as a prerequisite for approval to undertake research in the College	
5.1	Ethics Clearance Certificate issued by a University Ethics Committee
5.2	Research proposal approved by a University

6. DECLARATION BY THE APPLICANT

I undertake to use the information that I acquire through my research, in a balanced and a responsible manner. I furthermore take note of, and agree to adhere to the following conditions:

- a) I will schedule my research activities in consultation with the said College/s and participants in order not to interrupt the programme of the said College/s.
- b) I agree that involvement by participants in my research study is voluntary, and that participants have a right to decline to participate in my research study.
- c) I will obtain signed consent forms from participants prior to any engagement with them.
- d) I will obtain written parental consent of students under 18 years of age, if they are expected to participate in my research.
- e) I will inform participants about the use of recording devices such as tape-recorders and cameras, and participants will be free to reject them if they wish.
- f) I will honour the right of participants to privacy, anonymity, confidentiality and respect for human dignity at all times. Participants will not be identifiable in any way from the results of my research, unless written consent is obtained otherwise.
- g) I will not include the names of the said College/s or research participants in my research report, without the written consent of each of the said individuals and/or College/s.
- h) I will send the draft research report to research participants before finalisation, in order to validate the accuracy of the information in the report.
- i) I will not use the resources of the said College/s in which I am conducting research (such as stationery, photocopies, faxes, and telephones), for my research study.
- j) Should I require data for this study, I will first request data directly from the Department of Higher Education and Training. I will request data from the College/s only if the DHET does not have the required data.
- k) I will include a disclaimer in any report, publication or presentation arising from my research, that the findings and recommendations of the study do not represent the views of the said College/s or the Department of Higher Education and Training.
- l) I will provide a summary of my research report to the Head of the College/s in which I undertook my research, for information purposes.

I declare that all statements made in this application are true and accurate. I accept the conditions associated with the granting of approval to conduct research and undertake to abide by them.

SIGNATURE	
DATE	03 August 2017

FOR OFFICIAL USE

DECISION BY HEAD OF COLLEGE

Please tick relevant decision and provide conditions/reasons where applicable		
Decision		Please tick relevant option below
1	Application approved	
2	Application approved subject to certain conditions. <i>Specify conditions below</i>	
3	Application not approved. Provide reasons for non-approval below	
NAME OF COLLEGE		
NAME AND SURNAME OF HEAD OF COLLEGE		
SIGNATURE		
DATE		

APPENDIX C: LETTER OF INFORMED CONSENT FOR PRINCIPAL



UNIVERSITY OF PRETORIA
FACULTY OF EDUCATION
DEPARTMENT OF SCIENCE, MATHEMATICS
AND TECHNOLOGY EDUCATION
Groenkloof Campus
PRETORIA
0002
Republic of South Africa
12 June 2017

The Principal

.....
.....

Dear Sir

REQUEST TO PARTICIPATE IN A RESEARCH PROJECT

I am a student at the University of Pretoria currently doing Master's Degree in the Department of Science, Mathematics and Technology Education under the supervision of Dr B. Mofolo-Mbokane. I hereby request you to give permission for this study to be conducted at the TVET College campus I will identify.

The topic for my study is: **FACTORS LINKED TO POOR PERFORMANCE FOR NC(V) LEVEL 2 MATHEMATICS STUDENTS**

The aim of this study is to investigate factors that might be linked to poor performance of NC(V) Level 2 mathematics students. The outcomes of the study may provide solutions to current performance of students in mathematics.

Final examination answer books (P1 and P2) will be checked with the objective of finding out which misconceptions do students have and which errors they make. This will be followed by semi-structured interviews with the students which will last 20-30 minutes. The aim of these interviews will be to find reasons behind students' misconceptions. These interviews will also be used to investigate to what students attribute their performance in mathematics. Interviews will be audiotaped.

The participating lecturers will participate in semi-structured interviews, which will take 20-30 minutes. The objective of these interviews will be to get the lecturers' perspective on some of the responses received from the student participants and get the lecturers' views on the students' errors and misconceptions. These interviews will also be used to establish the lecturers' perspective on the performance of the students. Interviews will be tape-recorded.

I hereby request permission to conduct my study on NC(V) mathematics students and lecturers at your TVET College campus. I will select four classes at the selected campus. I will further select two best, two average and two low performing students in this study, based on the final examination results for the year 2016. I further request permission to make photocopies of the final examination answer books of the selected students.

All the interviews will take place after college hours to ensure minimum disruption of the teaching-learning activities. Consent forms will be given to the concerned students, parent/guardian (where necessary), campus manager and lecturers involved. Participants may withdraw at any stage during the research without any consequences. Documents used in document analysis (copies of examination answer books) and tape recordings from interviews will be stored in the Science, Mathematics and Technology Education department in terms of the policy requirements of the University of Pretoria, after data analysis.

Kind regards

Mbazima Amos Ngoveni
 University of Pretoria Masters student

Ngoveni MA (Student)

Dr B.L.K. Mofolo-Mbokane (Supervisor)

For any questions please feel free to contact either myself or my supervisor.

Student	Supervisor
Ngoveni M.A	Dr. Mofolo-Mbokane, B
Cell-phone: 082 8877829	Contact number: 012 420 3088
e-mail: mbazimangoeni@yahoo.com	e-mail: Batseba.Mofolo-Mbokane@up.ac.za

I _____, grant permission that the selected campus, as determined by the researcher, cooperate by participating in the above-mentioned research. I am aware that the findings of this research will be used to promote teaching and learning and will be published. I am furthermore aware that identities of all participants, TVET College and campus will be protected and they will therefore remain anonymous.

Signed Date

APPENDIX D: LETTER OF INFORMED CONSENT FOR CAMPUS MANAGER



UNIVERSITY OF PRETORIA
FACULTY OF EDUCATION
DEPARTMENT OF SCIENCE, MATHEMATICS
AND TECHNOLOGY EDUCATION
Groenkloof Campus
PRETORIA
0002
Republic of South Africa
12 June 2017

The Campus Manager

Dear Sir

REQUEST TO PARTICIPATE IN A RESEARCH PROJECT

I am a student at University of Pretoria currently doing Master's Degree in the Department of Science, Mathematics and Technology Education under the supervision of Dr B. Mofolo-Mbokane. I hereby request you to give permission for this study to be conducted at your campus.

The topic for my study is: **FACTORS LINKED TO POOR PERFORMANCE FOR NC(V) LEVEL 2 MATHEMATICS STUDENTS**

The aim of this study is to investigate factors that might be linked to poor performance of NC(V) Level 2 mathematics students. The outcomes of the study may provide solutions to current performance of students in mathematics.

Final examination answer books (P1 and P2) will be checked with the objective of finding out which misconceptions do students have and which errors they make. This will be followed by semi-structured interviews with the students, which will last 20-30 minutes. The aim of these interviews will be to find reasons behind students' misconceptions. These interviews will also be used to investigate to what students attribute their performance in mathematics.

The participating lecturers will participate in semi-structured interviews which will take 20-30 minutes. The objective of these interviews will be to get the lecturers' perspective on some of the responses received from the student participants and get the lecturers' views on the

students' errors and misconceptions. These interviews will also be used to establish the lecturers' perspective on the performance of the students.

I will select four classes at the chosen campus. I will further select two best, two average and two low performing students in this study based on the final examination results of the year 2016. I further request permission to make photocopies of the final examination answer books of the selected students.

All the interviews will take place after college hours to ensure minimum disruption of the teaching-learning activities. Consent forms will be given to the concerned students, parent/guardian (where necessary) and lecturers involved through your office. Participants may withdraw at any stage during the research without any consequences. After completing the study, documents used in document analysis (copies of examination answer books) and tape recordings from interviews will be stored in the Science, Mathematics and Technology Education department in terms of the policy requirements of the University of Pretoria.

Kind regards

Mbazima Amos Ngoveni
 University of Pretoria Masters student

 Ngoveni MA (Student)

 Dr B.L.K. Mofolo-Mbokane (Supervisor)

For any questions please feel free to contact either myself or my supervisor.

Student	Supervisor
Ngoveni M.A	Dr. Mofolo-Mbokane, B
Cell-phone: 082 8877829	Contact number: 012 420 3088
e-mail: mbazimangoveni@yahoo.com	e-mail: Batseba.Mofolo-Mbokane@up.ac.za

I, grant permission that the above-mentioned TVET campus participates voluntarily in this research. I am aware that the findings of this research will be used to promote teaching and learning and will be published. I am furthermore aware that the identity of the campus and participants will be protected.

Signed

Date

APPENDIX E: LETTER OF INFORMED CONSENT FOR LECTURERS



UNIVERSITY OF PRETORIA
FACULTY OF EDUCATION
DEPARTMENT OF SCIENCE, MATHEMATICS
AND TECHNOLOGY EDUCATION
Groenkloof Campus
PRETORIA
0002
Republic of South Africa
12 June 2017

Dear Lecturer

REQUEST TO PARTICIPATE IN A RESEARCH PROJECT

I am a student at the University of Pretoria currently doing Master's Degree in the Department of Science, Mathematics and Technology Education under the supervision of Dr B. Mofolo-Mbokane. I hereby request you to participate in my research project.

The topic for my study is: **FACTORS LINKED TO POOR PERFORMANCE FOR NC(V) LEVEL 2 MATHEMATICS STUDENTS**

The aim of this study is to investigate factors that might be linked to poor performance of NC(V) Level 2 mathematics students. The outcomes of the study may provide solutions to current performance of students in NC(V) mathematics.

Final examination answer books (P1 and P2) will be checked with the objective of finding out which misconceptions do students have and which errors they make. This will be followed by interviews with the students. The aim of these interviews will be to find out from students what the reasons behind their misconceptions are. These interviews will also be used to investigate to what students attribute their successes and failures in mathematics.

The participating lecturers will be interviewed. The objective of these interviews will be to get the lecturers' perspective on some of the responses received from the student participants and get the lecturers' views on the students' errors and misconceptions. These interviews will also be used to establish the lecturers' perspective on the performance of the students in mathematics. Both the students and lecturers' interviews will be tape-recorded. All the

interviews will take place after college hours to ensure minimum disruption of the teaching-learning activities.

Participation of students and lecturers in this study is completely voluntary and their names will not be revealed. Participants may withdraw at any stage during the research without any consequences. Their identity will remain confidential at all times. After completing the study, documents used in document analysis (copies of examination answer books) and tape recordings from interviews will be stored in the Science, Mathematics and Technology Education department in terms of the policy requirements of the University of Pretoria.

Yours Sincerely

Mbazima Amos Ngoveni

Ngoveni MA (Student)

Dr B.L.K. Mofolo-Mbokane (Supervisor)

I _____ volunteer to participate in this research by participating in an individual interview process. I am aware that the findings of this research will be used to promote teaching and learning and will be published. I am also aware that my identity will remain anonymous.

Signed: _____ Date: _____

For any questions please feel free to contact either myself or my supervisor.

Student	Supervisor
Ngoveni M.A	Dr. Mofolo-Mbokane, B
Cell-phone: 082 8877829	Tel: 012 420 3088
e-mail: mbazimangoveni@yahoo.com	e-mail: Batseba.Mofolo-Mbokane@up.ac.za

APPENDIX F: LETTER OF INFORMED CONSENT FOR STUDENTS



UNIVERSITY OF PRETORIA
FACULTY OF EDUCATION
DEPARTMENT OF SCIENCE, MATHEMATICS
AND TECHNOLOGY EDUCATION
Groenkloof Campus
PRETORIA
0002
Republic of South Africa
12 June 2017

Dear Student

REQUEST TO PARTICIPATE IN A RESEARCH PROJECT

I am a student at the University of Pretoria currently doing Master's Degree in the Department of Science, Mathematics and Technology Education under the supervision of Dr B. Mofolo-Mbokane. I hereby request your assent to take part in this study by giving me permission to access your mathematics final examination answer books for the year 2016 and participate in individual interviews.

The topic for my study is: **FACTORS LINKED TO POOR PERFORMANCE FOR NC(V) LEVEL 2 MATHEMATICS STUDENTS**

The aim of this study is to investigate factors that might be linked to poor performance of NC(V) Level 2 mathematics students. The outcomes of the study may provide solutions to current performance of students in mathematics.

If you agree to participate in this study, I will make copies of your 2016 final examination answer books, P1 and P2. The aim will be to see which errors are made by NC(V) mathematics Level 2 students and which misconceptions they have. You will also be expected to participate in semi-structured interviews, which will take between 20-30 minutes. These interviews will aim to clarify some of the answers in your answer books. This interviews will be tape-recorded. All the interviews will take place after college hours to ensure minimum disruption of the teaching-learning activities. Your mathematics lecturer has also been requested to participate in the study.

Your participation in this study is completely voluntary and your name will not be revealed. Your identity will remain confidential at all times. Participants may withdraw at any stage during the research without any consequences. Documents used in document analysis (copies of examination answer books) and tape recordings from interviews will be stored in the Science, Mathematics and Technology Education department in terms of the policy requirements of the University of Pretoria, after data collection.

Yours Sincerely

Mbazima Amos Ngoveni

Ngoveni MA (Student)

Dr B.L.K. Mofolo-Mbokane (Supervisor)

I _____ volunteer to participate in this research by participating in an individual interview process.

I _____ also give permission that my mathematics examination answer books (2016) may be used by the researcher to collect data. I am aware that the findings of this research will be used to promote teaching and learning and will be published. I am also aware that my identity will remain anonymous.

My mathematics final mark at Level 2 in 2016 was _____%

Signed: _____ Date: _____

For any questions please feel free to contact either myself or my supervisor.

Student	Supervisor
Ngoveni M.A	Dr. Mofolo-Mbokane, B
Cell-phone: 082 8877829	Tel: 012 420 3088
e-mail: mbazimangoveni@yahoo.com	e-mail: Batseba.Mofolo-Mbokane@up.ac.za

APPENDIX G: LETTER OF INFORMED CONSENT FOR PARENTS/GURDIANS



UNIVERSITY OF PRETORIA
FACULTY OF EDUCATION
DEPARTMENT OF SCIENCE, MATHEMATICS
AND TECHNOLOGY EDUCATION
Groenkloof Campus
PRETORIA
0002
Republic of South Africa
12 June 2017

Dear Parent(s)/Guardian(s):

REQUEST FOR YOU TO GRANT YOUR CHILD PERMISSION TO PARTICIPATE IN THE RESEARCH PROJECT

I am a student at the University of Pretoria currently, doing Master's Degree in the Department of Science, Mathematics and Technology Education under the supervision of Dr B. Mofolo-Mbokane. I hereby request you to grant your child, who is in NC(V) Level 2/3, permission to participate in my research project.

The topic for my study is: **FACTORS LINKED TO POOR PERFORMANCE FOR NC(V) LEVEL 2 MATHEMATICS STUDENTS**

The aim of this study is to investigate factors that might be linked to poor performance of NC(V) Level 2 mathematics students. The outcomes of the study may provide solutions to current performance of students in NC(V) mathematics.

Final examination answer books (P1 and P 2) will be checked with the objective of examining which misconceptions do students have and which errors they make. This will be followed by interviews with the students. The aim of these interviews will be to find out from students what the reasons behind their misconceptions are. These interviews will also be used to investigate what students attribute their successes and failures in mathematics to. The interviews will be tape-recorded. All the interviews will take place after college hours to ensure minimum disruption of the teaching-learning activities.

Your consent is completely voluntary and your child's name will not be mentioned. The students' identities will remain confidential at all times. Participants may withdraw at any stage during the research without any consequences. I do not anticipate any harm in this study. The collected data will only be used for the purpose of this research. Documents used in document analysis (copies of examination answer books) and tape recordings from interviews will be stored in the Science, Mathematics and Technology Education department, in terms of the policy requirements of the University of Pretoria, after data analysis.

Yours Sincerely

Mbazima Amos Ngoveni

 Ngoveni MA (Student)

 Dr B.L.K. Mofolo-Mbokane (Supervisor)

I _____ give permission for my child
 _____ to participate in this research.

I _____ also give permission that my child may be interviewed and his/her mathematics final examination answer books for the year 2016 may be used in this study. I am aware that the findings of this research will be used to promote teaching and learning and will be published. I am aware that my child will remain anonymous.

Signed: _____ Date: _____

For any questions please feel free to contact either myself or my supervisor.

Student	Supervisor
Ngoveni M.A	Dr. Mofolo-Mbokane, B
Cell-phone: 082 8877829	Tel: 012 420 3088
e-mail: mbazimangoveni@yahoo.com	e-mail: Batseba.Mofolo-Mbokane@up.ac.za

APPENDIX H: Interview Protocol

Individual Interviews

Interviews with students: structured question

Administration only:
Name of TVET College and campus: _____
Student Code: _____
2016 Final exam mark in mathematics: _____

1. To what do you attribute your performance in mathematics and why?

Interviews with lecturers: structured questions

Administration only:
Name of TVET College and campus: _____
Lecturer Code: _____

1. Which factors do you think could be linked to poor performance by NC(V) Level 2 mathematics students?

APPENDIX I: QUESTION 1 (Algebra)

1.1. Factorise the following:

1.1.1. $xy - 6ab + 2ay - 3bx$ (3)

1.1.2. $x^2 + xy - 2y^2$ (2)

1.1.3. $2x^2 - 5x - 12$ (2)

1.1.4. $a^2x^2 - b^2$ (2)

1.2. Simplify the following:

1.2.1. $(4k + y)(y^2 + 5ky + 4k^2)$ (3)

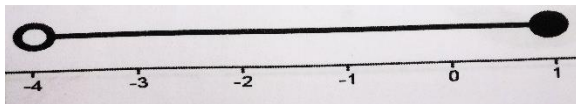
1.2.2. $\frac{4x^2 - 8xy^3}{-xy}$ (2)

1.3. Solve for y in the following:

1.3.1. $y(2y + 1) = 15$ (3)

1.3.2. $7^{y+1} = 49$ (2)

1.4. Write an equality to describe the number line below:



(2)

1.5. Solve the following system of linear equations algebraically.

$2x - 4y = -9$ and $-3x + 5y = 16$ (4)

[25]