Understanding the Differences in Marking Performance of JSC Mathematics Markers in Namibia: A Case Study

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ABSTRACT

Education reform in Namibia brought about changes to mathematics education since independence. This has put pressure on the government to provide both resources and qualified mathematics teachers to help drive the reform process in all teaching and learning activities. This included availing reliable and valid national examination results which is a measure of whether the newly introduced programmes are working or not. For the Ministry of Education this meant training more mathematics teachers and ensuring that competent and reliable teachers are appointed for marking national examination every year. The teachers' training process however, has not been going as fast as it was expected and year after year the Directorate of National Examinations and Assessment experienced problems in obtaining competent teachers for the marking of national examination.

The purpose of the study was to understand the differences in marking performances of the JSC mathematics national examination markers. Particularly the study was to create a clear and detailed understanding of different factors that could possibly affect the marking performance of different markers. In addition, the study was to investigate the effect the mathematical content knowledge of the markers has on their marking performance.

It was evident from the findings that their mathematical content knowledge had influenced their marking performance. Moreover the research findings also gave a strong indication that there are other factors that were influencing the markers marking performance. These were the markers' knowledge of the assessment and marking process, the markers' marking experience, the markers' socioeconomic background. The difference in their moderators' input has emerged as the other factors that have influenced their performance in marking and consequently contributed to the differences in their marking performances.

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Finally, my husband James Mutuku for his unyielding support and my children Mutua, Mutisya and Kioko for their support and patience throughout the period of my study.

DECLARATION OF ORIGINALITY

I ELIZABETH MUTUKU declare that this project is my own work written in my own words. Where I have drawn on the words or ideas of others, these have been acknowledged using complete references according to the department guidelines.

12/12/2008

(Signature and date)

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ACRONYMS

BETD	Basic Education Teacher Diploma
DNEA	Directorate of National Examination and Assessment
EO	Education officer
ETSIP	Education and Training Sector Improvement Programme
IGCSE	International General Certificate of Secondary Education
JS	Junior Secondary
JSC	Junior Secondary Certificate
MASTEP	Mathematics and Science teachers Education Programme
MBESC	Ministry of Basic Education, Sport and Culture
MEC	Ministry of Education and Culture
NIED	National Institute for Educational Development
MoE	Ministry of Education
NSSCO	Namibia Senior Secondary Certificate Ordinary level
NSSCH	Namibia Senior Secondary Certificate Higher level
SACMEQ	Southern African Consortium and Monitoring Education Quality
SS	Senior Secondary

CHAPTER 1: INTRODUCTION

1.1 Introduction

The purpose of this chapter is to introduce the reader to the research. The research was aimed at understanding the differences in the marking performance of JSC national examination markers in Namibia. The chapter introduces the context of the study and also the background of the research and the research site and participants.

1.2 Research context

Namibia adopted a new education system to replace the old and discriminatory South African education system after gaining her independence in 1990 (Namibia. Ministry of Education and Culture [MEC], 1993). As a result, an educational reform process faced Namibia. Therefore, her 17-year-old education system is still regarded as very new and is faced with a lot of challenges. One of the challenges is the availability of qualified teachers, especially in critical subjects like natural sciences and mathematics. The Namibian government developed teachers' education programmes to address these needs. These programmes included the Basic Education Teacher Diploma (BETD), which is described by Namibia. MEC (1993) as a uniform programme designed to prepare teachers to teach grade 1 to 10. The University of Namibia (UNAM) was tasked to train senior secondary teachers (Namibia. MEC, 1993).

In spite of the existing teacher education programmes, many Namibian mathematics teachers, especially at grade 10 level are still not proficient in mathematics. In support of this, the Southern African Consortium for Monitoring Educational Quality (SACMEQ) reports of 1992, 1997 and 2003 as cited by Namibia. Ministry of Education [MoE], (2006) rate Namibia below other Southern and Eastern African countries in terms of teachers' and learners' mathematical proficiency. This does not only affect the teachers' classroom practice, but also their level of reflection needed for the marking exercise when they are selected for national examination marking.

1.2.1 National examination marking

National examination takes up a very small percentage of time allocated in the educational activities of schools, learners, teachers and all educational stakeholders. However, Wragg (2001) emphasises the importance of national examinations by stating that they provide information on which learners or schools or even the country's education system can be judged. The data or information obtained from these examinations should therefore be accurate and of high quality. In this view, Wragg (2001) states that the accountability angle of the national examination cannot be ignored. Accountable examination results are results which are accurate, valid, reliable and of high quality (Wragg, 2001). To obtain these kinds of results National Examination and Assessment bodies require good markers.

In Namibia marking of national examination is supervised by the Directorate of National Examination and Assessment (DNEA) in the Ministry of Education.

1.3 Research background

I am an Education Officer (EO) for science and mathematics in the Directorate of National Examination and Assessment (DNEA) in the Ministry of Education. The duties of an Education Officer at DNEA includes amongst others, supervision of marking of national examinations at both Junior Secondary (JS) and Senior Secondary (SS) levels. The marking is done every year from October to December for grade 10 and 12. Different teachers from all over the country are appointed for the national examination marking. The selection of these teachers is done according to a given set of rules (Namibia. Ministry of education [MoE], 2007 a)

Despite the fact that a careful process of selecting teachers for marking is employed, experience of this process has revealed some shortcomings. For instance, during monitoring of the marking it has been discovered that there are significant differences in markers' marking performance. There are teachers who find it difficult to mark according to the prescribed and agreed mark scheme. Many of these teachers seem not to understand instructions given by their chief examiners or team leaders. Many times, they failed to make the correct and appropriate judgement of the learners' responses in the national examinations. In order not to jeopardise the quality of the marking, such teachers are asked to stop marking. This has a negative impact on the problem already faced by the DNEA, of a sufficient supply of competent teachers for marking. According to MoE (2006) the Ministry of Education plans to increase the number of Grade 12 students drastically by the year 2011. These plans could amplify the demand/supply of markers by the DNEA.

Very little research has been done on the marking performance of mathematics national examination markers both in Namibia and globally. Suto,Crisp & Greatorex (2008) revealed that marking accuracy in national examination varies significantly among markers of different subjects and even amongst markers of the same subject. For example, a marker's marking accuracy in marking mathematics would differ when marking any other subject like physical science. Marking accuracy also differs amongst the markers of the same subject. Experience suggests that good mathematics markers appear to be teachers that are proficient in mathematics. A teacher proficient in mathematics should be able to think critically and engage in multiple ways of solving problems in mathematics. Ball (2003) states that mathematics teachers should master their content knowledge for the work they have do. This includes accurately evaluating learners' examination responses and giving appropriate judgement to answers given by learners.

Nevertheless, the mastery of mathematics is not a straightforward and unitary concept. According to Kilpatrick, Swafford and Findell (2001) mathematical proficiency can be seen as comprised of 5 strands:

- Conceptual understanding
- Procedural fluency
- Strategic competence
- Adaptive reasoning
- Productive disposition

These strands are inter-depended, none of them can be referred to as the most critical one but rather as Ball (2003) states that the critical point is "how and when they are interactively engaged" (p. 9). In addition, she points out that they are "coordinated in skilled mathematical reasoning and problem solving" (p. 9). Therefore, mathematical proficiency is achieved over a period of time and when engaged in different kind of activities in mathematics.

In relation to marking Suto, Crisp & Greatorex (2008) indicated that the core process of marking requires a marker to read the students' responses and utilize five cognitive strategies in order to assign a mark. They also added that the marking process is influenced by a number of factors, namely: markers' subject knowledge, markers' teaching and marking experience as well as the examining and the teaching community.

Furthermore, teachers often display different levels of proficiency for different mathematical topics and different analytical approaches to mathematics. It appears obvious that a teacher, who has not mastered a particular content topic, will not be an effective marker of questions on this specific topic. However, the relationship between mastery and marking of different topics; and the relationship between the achievement of different levels of proficiency for different strands of proficiency and the effective marking of different types of questions is not immediately apparent.

This research was aimed at investigating the issues that affects the marking performances of grade 10 national examination markers. Mathematics content knowledge of mathematics markers is seen as one of the issues affecting their performance.

1.4 Description of the research context

1.4.1 Markers

JSC mathematics teachers from different schools all over the country are appointed as national examination markers. The markers are required to have at least a 3 year teacher qualification and to have taught the subject (mathematics) for at least 3 years.

The marking is supervised by the chief marker (CM) and the assistant chief marker (ACM). The chief marker is the principle examiner (the setter of the question paper) while the assistant chief marker moderates the question paper before the examination is written. Figure 1 shows the organisation chart for 2007 JSC mathematics paper 2 national examination markers. The chart shows two chief markers on top, followed by nine team leaders each with six markers. Team leaders (TL) are teachers with outstanding marking performed for a number of years. The outstanding performance is observed by their pervious team leaders. Normally at the end of the marking session the markers are given grades by their team leaders according to their performance. The markers are graded on an alphabetical scale, where an A (A*) grade is given to the markers with an outstanding performance and potential team leaders. The poor markers, markers whose performance was unsatisfactory are awarded a D grade. When a teacher is awarded a D grade, he or she may not be reappointed for marking the following years (MoE, 2007 (a)), even if he or she applies. Markers are placed in teams using a random selection.

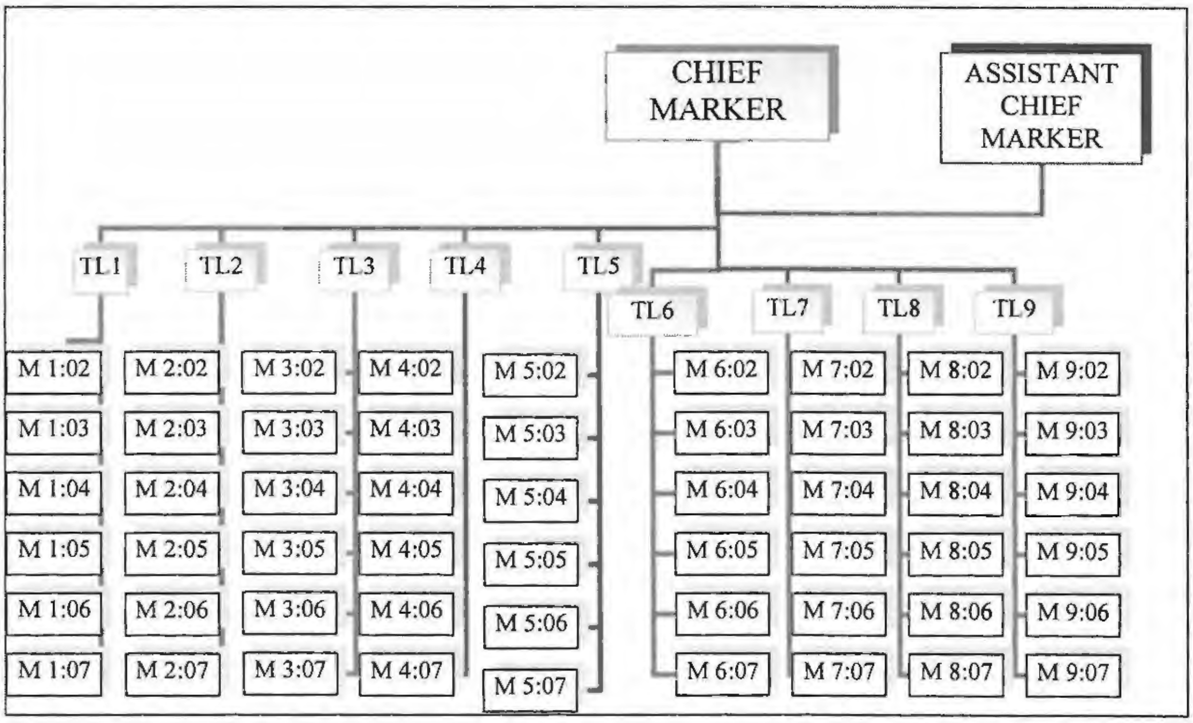


Figure 1.1: Organization chart for 2007 JSC mathematics paper 2 markers

1.4.2 The marking process

The group of appointed markers assembles for a marking session in a venue, for example Windhoek show grounds. The marking takes one week, normally starting on a Saturday and ending on the following Friday. Chief markers meet three days before the marking period starts to revise the marking scheme and do other administrative work. Two days before the markers arrive, team leaders join the chief marker to discuss and finalise the standardisation of the marking scheme and also do administrative work for their teams. The team leaders carry out some marking, in order to standardise the mark scheme and to study different ways in which learners' present answers. This marking is moderated by the chief markers.

The first day of marking is used mainly for markers' training which is done in teams by the team leader (team moderators). The team leaders together with their team of markers discuss the marking scheme to make sure all possible answers are included. This is called a standardisation meeting. The purpose of a standardisation meeting is to make sure a common understanding of the requirements of the mark scheme is found (MoE, 2007 (c)). It is essential for all the markers to attend the standardisation meeting. After a common agreement has been reached on how to apply the mark scheme, markers are requested to mark a given number of dummy scripts and discuss them in their teams with the team leader in order to eliminate all misinterpretation of the mark scheme before the 'life' scripts are marked. Further more, the markers are asked to mark 5 'life' answer scripts and give them to the moderator for moderation. The moderator moderates the scripts, discusses the errors with the respective markers in order to provide feedback and to reinforce understanding and application of the mark scheme. This process is meant to ensure that the markers do not to repeat the same mistakes as they continue marking. This process continues until a total of 20 'life' scripts are marked and moderated.

The markers are then allowed to mark a given amount of scripts per day (a daily quota). The daily quota is calculated to make sure that all markers complete marking the number of scripts assigned to them in the prescribed time. The moderators continue picking scripts at random for moderation until the marking process ends. The moderators are required to moderate at least 10% of the total scripts marked by each marker. However, the moderator can moderate up to 15% of the scripts marked by poor markers. In other words, poorly performing markers are expected to have more moderated scripts than the better performing markers. All moderated scripts are recorded in a form called a moderation record form. Each marker's moderated scripts are recorded on one moderation record form.

1.5 Research Goal

The study was aimed at understanding the differences in marking performance of the Junior Secondary Certificate (JSC) mathematics national examination markers. This included exploring the potential factors influencing the marking accuracy of the Junior Secondary Certificate (JSC) mathematics national examination markers. The specific aims were to:

1. To create a clear and detailed understanding of different factors that could possibly affect the markers' marking performance.
2. To explore the effects markers' mathematical content knowledge has on their marking performance.

1.6 Thesis overview

This section provides a summary of the study. The study contains five chapters.

Chapter one introduces the study, stating the goals and describing the context of the study.

Chapter two provides a coherent review of the available work related to the goals of the study. It discusses published information, in particular on possible factors affecting the markers' marking performance. Another important issue dealt with in this chapter is the effect of teachers' mathematical content knowledge and it influence on the markers' marking performance.

Chapter three describes the research methodology and rationale for this study.

Chapter four provides an analysis of the research findings. It also discusses the findings in the context of the literature reviewed. Finally, chapter five provides the conclusion of what emerged from the findings.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

The transformation in education both in Namibia and internationally has impacted on how we feel about teachers' knowledge for effective teaching practice (Namibia. Ministry of Basic Education and Culture [MEC], 1993). In this chapter, I will review the literature that, in a broader view looks at the factors influencing teachers' accuracy in marking. Teachers' mathematical content knowledge has been known as one of the factors influencing on their practice. This chapter will also look at the influence teachers' mathematical content knowledge has on their accuracy in marking national examination. The chapter will include the review of literature of many other factors that could possibly influence the markers' marking performance. The chapter will specifically look at the marking of mathematics in the Junior Secondary (grade 10) national examination in Namibia.

Particularly, in trying to understand the differences in marking performances amongst markers, the chapter will discuss the possible factors affecting teachers' (markers') marking accuracy. Teachers' mathematical content knowledge has been identified as a factor influencing teachers' practice in general. The chapter will therefore try to establish from the existing literature whether the teachers' mathematical content knowledge, in addition to other factors has an influence on teachers marking mathematics national examination. The chapter will also try to create an understanding of other factors that could possibly influence the markers' marking performance.

I will first refer to the reform of education in Namibia and its effect on teacher preparation programs. This chapter will emphasize the need to have mathematically proficient teachers as markers of national examinations by bringing to light the significance of assessment and examination in education. Next, this chapter will characterize the mathematics content knowledge that different researchers have identified as important for effective practice. For the most part, the chapter will look at the formulation of mathematical proficiency as given by Kilpatrick, Swafford and Findell (2001).

2.2 Namibian initiative on education reform

Before Namibia's independence in 1990, the nation was segregated in the lines of ethnic groups. Education was for the privileged few. In particular, mathematics and science education was mainly for white males (Tjikuua, 2000). The main purpose of education for black Namibians was to supply semi-skilled and unskilled labour. As a result, after independence very few Namibians were educated in mathematics and science. This forced the new government to obtain skilled labour, especially mathematics teachers from different countries.

For these reasons, the Namibian government regarded the education reform process as a matter of urgency (MEC, 1993). Two of the major changes brought about by the education reform process in Namibia were that all children were given access to schools and that the subjects of mathematics and science were made compulsory from grade 1 to 10 (Tjikuua, 2000). The other challenge to teachers was to change the teaching approach from a teacher centred to a learner centred approach.

Since mathematics became compulsory in all junior secondary schools and the increase in access to schools for most Namibians has increased, the need for training mathematics teachers at all levels of basic education became a burning issue. Therefore, mathematics teacher education in Namibia has received considerable attention over the past years. The government has developed teacher educational programmes to address the needs of teachers. Different colleges of education in the country trained new primary school and junior secondary school teachers and the University of Namibia was tasked to train senior secondary school teachers (MEC, 1993). In addition, there was also a greater need to retrain old teachers to help them understand the newly introduced philosophies of learner-centeredness. The major focus of these initiatives has been to train teachers on how to help learners to construct mathematical knowledge through a learner-centred paradigm, which involves using a range of learning activities and quality instruction (Namibia. Ministry of Education [MoE], 2006 a).

The assessment and evaluation of education in Namibia was also reformed. In the past, examination was mainly used as a measure of success for individuals and programmes (MEC, 1993). In the reform, the role of examinations was rethought and a shift of emphasis from "success versus failure to an orientation that focussed on encouraging and recording achievement" (MEC, 1993. p.124) was made. This demanded the inclusion of assessment and examinations in the teachers' instructional practices. The new form of criterion-based assessment was introduced. The Ministry of Education also introduced two national examinations (MEC, 1993)

- The Junior Secondary Certificate (JSC) at grade 10
- The International General Certificate of Secondary Education (IGCSE) administered by the University of Cambridge at grade 12. (The IGCSE has now been localised as the Namibian Senior Secondary Certificate (NSSC)).

The implementation of all these changes demanded well-trained teachers in content of specific subjects, especially in mathematics. It also demanded the Namibian government to provide adequate resources to all schools, especially to previously disadvantaged school and/ schools with poor socioeconomic backgrounds.

I agree with Battista (1994) when she stated that teachers are viewed as essential agents of change in the education reform effort presently under way in education around the world. Therefore, they are expected to play a major role in changing mathematics teaching and learning and more general instructional practices. However, despite a lot of effort by the Namibian government in developing mathematical content knowledge for teachers, it has been revealed by the Southern African Consortium for Monitoring Educational Quality (SACMEQ) reports of 1992, 1997 and 2003 as cited in MoE, (2006) that Namibia still trails behind other Southern and Eastern African countries in terms of teachers' and learners' mathematical proficiency.

The education reform process in Namibia is continuous; not only because of the transition from the colonial government to the present but for the new government continuously assesses and evaluates its programme. Through its Education and Training Sector Improvement Programme (ETSIP), the Ministry of Education highlights that the mastery of content knowledge and pedagogical skills by teachers during their teachers' preparation programme is essential and important for effective teaching (Namibia. Ministry of Education [MoE], 2006). The Mathematics and Science Teachers Extension Programme (MASTEP) was also initiated in Namibia in 2003 with the aim to enhance science and mathematics teachers' subject content knowledge for Junior Secondary teachers. This was done with an understanding that the structures and curriculum of some teacher preparation programmes did not prepare teachers well in subject content (Namibia. Ministry of Basic Education Sport and Culture [MBESC], 2002).

2.3. Assessment: National examination

Webb (1992) defined assessment as the "comprehensive accounting of a student's or a group of students' knowledge (p.1)". In this context, Webb is of the opinion that assessment is a tool used by schools and teachers to measure their accountability and effectiveness. I agree with Wragg (2001) when he stated that assessment is a very important component of every education system. Accurate assessment of students' academic abilities has been identified as one of the most crucial variables related to effective instructional planning and positive student outcomes (Fuchs & Fuchs, 1986; Shinn & Bamonto, 1998)

Although national examinations takes up just a small percentage of the time used for assessment in school, the information obtained from it can be used for a wide range of reasons. In particular, national examination results can be used to provide information on which a learner, a school or even the whole country can be judged (Wragg, 2001).

Assessment is carried out for various reasons, including informing teachers in the classroom of the abilities of their learners, providing feedback to learners on what concepts they understand better and providing them encouragement and motivation for further studies. Assessment is also used for diagnostic and selection purposes (Wragg, 2001; Webb, 1992; Shepard, 2001; MEC, 1993).

National examination is an important component of assessment, which is also used for several purposes. In Namibia, like many other countries in the world, national examination results are used for certification and selection purposes (MEC 1993, Wragg, 2001, MoE, 2006). For example, learners can only proceed from grade 10 to grade 11 in Namibia, if they performed well in their grade 10 national examinations. Learners who do not qualify for selection to grade 11 are certified to give them a chance to compete in the job market. Therefore, as Webb (1992) stated, the national examinations are putting a lot of pressure on both learners and teachers to better their performance - now more than ever before.

As mentioned before Wragg (2001) emphasised the importance of national examinations by stating that they also provide information on which learners, or schools, or even the country's education system can be judged. Additionally, national examination results inform policy makers in government and other stakeholders in education systems around the world whether or not education programmes are effective (Webb, 1992). National examination results should therefore be accurate, *valid, reliable* and of high quality (Wragg, 2001).

2.3.1 Validity and reliability of examinations

The purposes of assessment will not be fulfilled if strong emphasis is not put on its validity and reliability. Crisp (2008) suggested that validity and reliability assure the confidence we have in the assessment results. Wragg (2001) called validity and reliability the principles of examinations. Although taken as interrelated, these terms have different meaning. Validity refers to whether the examination measures what it is suppose to measure, while reliability refers to the consistency of the examination and all its activities (Crisp, 2008). She added that an examination couldn't be reliable if it is not valid. I therefore feel that other efforts and activities of assessment will be useless without the consideration of validity and reliability.

Correct assessment of students' academic abilities has been acknowledged as one of the most crucial variables related to successful instructional development and positive student outcomes (Fuchs & Fuchs, 1986; Shinn, 1998). I agree with Martens & Witt, (2004) who argued that without a valid and reliable assessment of students' academic skills, instructional decision-making is unlikely to encourage academic competence. The issues of validity and more especially reliability are highly affected by markers' judgment (Wragg, 2001; Crisp, 2008). This research therefore looks at understanding possible influences on the judgment making of markers and thus possibly on the reliability of the examination results. One particular influence is the content knowledge of the markers.

A number of assessment measures are available for measuring the global academic achievement of students. Less formal approaches are more commonly used in classroom settings while formal approaches are used for external (national) examinations (Deno, 1992). Shepard (2001) suggested that external assessment is formal and equivalently controlled to ensure comparability across the schools.

Many countries including Namibia ensure consistency and fairness in examinations that are used for selection and monitoring purposes by conducting a single (national) examination. As stated by Shepard (2001), the national examination should be uniformly administered and should also target a single specific instructional goal. Teachers should be made aware of such goals. According to Wragg (2001) the most important factors that should be uniformly controlled to ensure the validity and consistency of external examination results are firstly *the tested content*, which may be controlled by using a single curriculum, *the setting of test items*, *consistency in marking learners' responses* in the examination and *the fairness in the grading activity*. The grading activity estimates and decides which learners are more suitable for higher and lower ability groups and is used as a selection criterion (Wragg, 2001). The two factors: *consistency in marking learners' responses* in the examination and *the fairness in the grading activity* will investigated in this research.

2.3.2 Examination setting and marking

2. 3.2.1 Examination setting

Examination is an integral part of teaching and learning; therefore, it is imperative for every teacher to have a clear understanding of the purpose of examination (Wragg, 2001; Webb 1992). I agree with Namibia. Ministry of Education Sport and Culture [MESC] (2001) when stating that every teacher should be able to clearly set examination items that are valid and reliable and should also be able to understand what the examination is expected to achieve.

To ensure consistent assessment, the examination items must be constructed to an appropriate quality (MESC, 2001; Wragg, 2001). Experience shows that judging the quality of items can be complicated but, as a starting point, teachers should consider the difficulty level of the items. In general, a good assessment ought to be at about the difficulty level of the average learner (MESC, 2001). Also, consider how well the assessment differentiates between the learners. To provide maximum information, the assessment ought to separate the learners as much as possible (MESC, 2001).

2.3.2.2 Examination marking

Wragg (2001) defines marking assessment as a way of setting boundaries by assigning grades and categorizing the learners' assessment responses as being right or wrong. Teachers perform the marking of assessment and therefore it is part of the teacher's practice (Kilpatrick, Swafford and Findell, 2001).

In a review of the literature, Hoge & Coladarci (1989) combined the results of empirical studies conducted over a number of years. Their findings suggested a sensible to strong connection between teacher judgments and student achievement. Given the significant role of teacher judgment in assessing students' academic achievement, a number of studies have examined the accuracy of these perceptions (Hoge & Coladarci, 1989). In their study Suto,Crisp & Greatorex (2008) indicated that the core process of marking requires a marker to read the students' responses and utilise five cognitive strategies in order to assign a mark. The five cognitive strategies highlighted by Suto, Crisp & Greatorex (2008) are matching and no response, scrutinising, evaluating and scanning. They also added that the marking process is influenced by a number of factors namely;

- Markers' subject knowledge,
- Markers' teaching and marking experience
- The examining and the teaching community.
- Marking task demands
- Specific question and mark scheme features and
- Candidate response features

Experience shows that when a candidate's response includes features that are different from the mark scheme features of a specific question, although giving the same interpretation; some markers may not make the correct judgment. In another study Nadas & Suto (2008) have found that a marker's subject knowledge, teaching and marking experience has a great influence on a marker's self-confidence during the marking process.

There are therefore many factors that influence the way teachers' judge and mark the learners' responses in the national examination. Wragg (2001) has also highlighted that when teachers are marking assessment they are influenced by "their mental set about particular learners" (p.23). In particular, he further emphasised that the level of teachers' mathematical knowledge is a major influencing factor of teachers' judgment of learners' responses.

I believe that the accuracy and the validity of information obtained from assessment depend critically on how accurate the judgment of the marker is. In addition Kilpatrick, Swafford and Findell (2001) emphasised that the more accurate the information obtained from the assessment process and well coordinated to the curriculum goals, the better it serves its purpose. Therefore, teachers' ability to make accurate judgments of learners' responses and the clear interpretation of assessment result is crucial for effective teaching and learning.

Marking assessment tasks is an important part of teachers' practice, including national examination marking. In their study Suto, Crisp & Greatorex (2008) have summarised that the learners' response features and mark scheme features have a great influence on the affective reaction of a marker. Thus, marking assessment requires a very high level of reflection on the learners' response and the teachers' actions towards those responses is vital. In other words, for teachers to give meaning to procedures, they should understand the concepts underlying procedures. They should then be able to see that a certain procedure is correct, relate it to other procedures that they already understand and use the concepts and procedures in making judgments (Ball, 1989; Fennema & Franke, 1992; Shulman, 1986).

Wragg (2001) stated that in some instances the marking of mathematics assessment is straightforward. However, he added that this could only be true for simple calculations. When more complicated questions are involved, these might result in different features in learners' responses than the features reflected by the mark scheme. The marking of such questions can no longer be regarded as straightforward since, according to Suto, Crisp & Greatorex (2008), the difference in features between the mark scheme and the learners' response influence the markers' judgement.

From experience, I have found that good mathematics markers appear to be teachers that are proficient in mathematics. A teacher proficient in mathematics should be able to think critically and engage in multiple ways of solving problems in mathematics. Ball (2003) stated that mathematics teachers should master their content knowledge for the work they have to do. This includes accurately evaluating learners' examination responses and giving appropriate judgement to answers given by learners.

2.3.3 National Examination marking in Namibia

As mentioned earlier, the Directorate of National Examination and Assessments (DNEA) supervise the marking of national examinations in Namibia (Namibia. Ministry of Education [MoE] 2007 a). Teachers from different parts of the country are selected as markers. These selections are done according to a set of rules. These rules include; the teacher should have being teaching that grade for at least three years, he or she should have a three years teacher's qualification and their appointment should be approved by their school principal (Namibia. Ministry of Education [MoE, 2007 b).

During the marking exercise, markers are separated in teams, each team with its team leader. The whole group is again controlled by the overall group leader called a chief marker. Experience shows that team leaders are selected based on their continuously good performance in marking for a number of years and the chief markers are the examiners (setters) for the examination paper written. Chief markers are responsible for monitoring the whole marking process. Apart from making sure that a clear marking scheme is available, chief markers together with the team leader markers have to make sure that markers are properly trained on how to apply the mark scheme. They also continuously monitor the marking process by moderating the scripts marked by other markers at random (MoE 2007(a)). Having a clear mark scheme and a proper moderation system enhances reliability and fairness. The reflection on the different solutions to problems further enhances the validity and reliability of examination.

The teachers' selection process for marking employed by the DNEA seems to be carefully and strict. However, my experience over the past few years has revealed some shortcomings. For example, during monitoring of the marking it has been discovered that there are teachers who find it difficult to mark according to the prescribed mark scheme. Many of these teachers fail to make the correct and appropriate judgement of the learners' responses in the national examinations. Many times, they seem not to understand instructions given by their chief examiners or team leader markers. In order not to jeopardise the quality of the marking, such teachers are not allowed to continue marking (MoE 2007(a)).

2.3.3.1 Common errors and issues in marking performance

Errors in marking examination commonly occur because of misinterpretation on how to apply the mark scheme (MEC, 2001). Lack of concentration has also been known to cause several errors in marking. Njabili (1993) stated that markers may lack concentration because of stress, exhaustion and sidetracked by anything else during marking. She further recommended that marking should not be done under mental stress.

Consistence in the application of the mark scheme is known to be the biggest issue that may lead to a number of errors in the marking (MEC, 2001). Some errors however, could happen in mechanical procedure such as adding marks within a question and or the total of a learner's answer sheet. Such errors are always minimised if not eliminated. Every marker's work is supposed to be checked for addition by a partner marker for mechanical errors, like adding errors.

2.3.3.2 Difficult questions for marking

According to the Namibia. Ministry of Education [MoE] (2007 d) the most difficult questions to mark in mathematics are questions that are classified as 'follow through' questions. These are questions with many sections example (a), (b) and (c). If an error in learners' response occurs in the first section of the question and such (wrong) answer was to be used in the next section for calculations and it is used correctly to obtain another answer correctly, such answer has to be marked correct although it is not the one shown in the mark scheme. For example assume that the question has two sections (a) and (b), where the answer to section (a) should be used in the calculations in section (b) but unfortunately the learner's answer to section (a) is wrong. If the learner uses (a)'s wrong answer to do the calculation in (b) correctly and get a different answer, this answer should be marked as a correct answer.

2.3.3.3. Monitoring markers

Markers in a team are monitored by their team leader markers. The team leaders have a responsibility to ensure that each marker in their team is applying the agreed mark scheme accurately. Furthermore, the team leader has to ensure that "the markers have a well founded and a common understanding of the requirements of the mark scheme and can apply it reliably and consistently" (Namibia. Ministry of Education [MOE], 2007 d). This is done during the standardisation meeting.

It is important that on each occasion were moderating occurs, the marker is informed of any deviation from the accepted marking criterion and in some case markers are urged to remark the scripts that were marked together with the moderated scripts. They are also informed of the errors they made in order not to repeat the same errors.

2.4. The complexity of good mathematics content knowledge

In the last few decades, a number of research studies were done in an attempt to find out whether teachers' content knowledge has an impact on their practice. The results of these studies have remained surprisingly disappointing (Kilpatrick, Swafford and Findell, 2001; Ball, 2003). These studies have failed to find concrete evidence that shows teachers' mathematical content knowledge has a direct influence on the effectiveness of their practice. The above conclusion can be attributed to many contributing factors. The two common factors were that researchers relied on the data obtained from standard test results and teachers' qualifications in comparison with students' performance (Kilpatrick, Swafford and Findell, 2001).

However, many of these studies found out that teachers with relatively low level of content knowledge needed to study more mathematics to be able to do effective teaching. Teachers will find it difficult to explain concepts they do not understand well themselves. For example, Mewborn (2001) states,

> "a secondary school teacher held an equation concept of functions, expected the graphs of the functions to be smooth and continuous, and were unable to provide an explanation for the univalence requirement of the functions"(p.31).

Since this research project is to focus on the marking of national examination, the same can be said about a teacher (marker) who does not understand a concept well. This marker will find it difficult to make a correct judgment, especially if the student's work differs from what is appearing in the mark scheme generated

Some studies have attempted to compare the content knowledge for elementary and secondary school teachers. According to Ball (1990), the mathematical knowledge of the elementary teacher is relatively weaker than that of a secondary school teacher. However, this does not mean that all secondary school teachers have mathematical knowledge sufficient for effective teaching practice. But as she also stated, although secondary school teachers had studied advance courses in their teacher preparation course, it did not allow them to expand their understanding in Algebra, or Geometry and even Arithmetic. Teachers need to know more than the fact that a certain sum is correct or incorrect; they need to know ways of getting the correct answer (Ball, 1990). The above however, is difficult to generalise in developing countries like Namibia where many of the Junior Secondary teachers are grade twelve graduates who are trained mainly on teaching methodology with an assumption that they have mastered the grade 12 mathematics content (MEC, 1993). This results from the greater demand of teachers in the country in the field of mathematics and since the mastery of mathematics is assumed many colleges of education found themselves taking student teachers in the mathematics field just so that they can fill the yearly intake quarters (MoE, 2006). Some colleges find themselves taking students who do not meet the college entry requirements because those that meet these requirements are very few.

Nevertheless, Kilpatrick, Swafford and Findell (2001) did find some evidence that shows a positive relationship between teachers' mathematical subject content knowledge and student performance in advanced topics of mathematics. It however, does not follow that the more advanced qualifications a teacher has in mathematics the better his or her student achievement in mathematics is (Kilpatrick, Swafford and Findell, 2001). The evaluation of these studies about what constitutes knowledge required for teaching, reveals that characterizing teachers' content knowledge in mathematics is not easy, let alone trying to understand how it relates to effective teaching and learning (Fennema & Franke, 1992). According to Webb (1992 and MEC (1993) assessment is part and parcel of teaching and learning; therefore the above can also be said to hold for assessment.

Ball (1990) strongly feels that teachers' effective practice is driven from his or her ability to understand the subject content knowledge. I believe the teachers' effective practice mentioned by Ball includes the marking of examination. With a good understanding of the subject content knowledge, Ball (1990) is of opinion that the teacher will be able to carry out the task of teaching successfully. This includes the marking of student responses in the examination. In addition, she argues that although it is easy to understand that mathematical content knowledge is needed for teachers to carry out their tasks effectively, it is however difficult to understand the nature of the content knowledge needed (Ball, 2003). She highlighted a number of questions that should be put into consideration when referring to content knowledge for effective teaching practice;

> What do teachers need to know of mathematics in order to teach it? What are the mathematical questions and problems that teachers face in their daily works? What is involved in using mathematical knowledge in context of teaching (p. 17).

The same question can be asked as far as marking of mathematics examinations are concerned.

Many studies done by authors such as Fenstermacher (1986); Shulman (1986); Munby, Russell & Martin (2001) and have shown that effective practice of teachers in mathematics depends largely on the level of a teachers' content knowledge as a whole. Shulman (1986) described the mathematical content knowledge as the pedagogical knowledge plus mathematics subject matter knowledge and curricula content knowledge. Subject matter content knowledge was characterized as more than the information a teacher knows. Shulman indicated that teachers needed to know about both the content of their subject and the structure of their subject, that is, how the content fits together. They needed to know "what" is true, "why" it is true, and why it is worth knowing in the first place (Shulman, 1986).

Pedagogical content knowledge was "the particular form of content knowledge that embodies the aspects of content most germane to its teachability" (Shulman, 1986, p. 9). In other words, good teachers not only know their content but also know things about the content that makes effective teaching practice possible (Shulman, 1987). According to Shulman, (1986) subject content knowledge includes a variety of illustrations available for specific topics; understanding the basic difficulties that are a part of these topics; being aware of the variety of conceptions; preconceptions and misconceptions related to specific topics and knowing and using strategies that would be helpful in overcoming these misconceptions. Curricular content knowledge, Schulman's third category, is also very important for teachers' practice. Brink (2008) refers to the knowledge of curriculum as knowledge specific to the curriculum used in the classroom and how it compares to other curricula. Teachers, particularly examination markers, need to be aware of what the curriculum expects students to know.

Shulman's study inspired researchers' interest in the issue of teachers' subject matter knowledge. It also changed the focus of investigation. Rather than measuring teachers' subject matter knowledge, researchers are attempting to document or assess teachers' level of understanding and how it relates to teaching practice (Shulman, 1986). Recent studies have been interpretive. There is agreement among researchers on the importance of the role teachers' subject matter knowledge plays in a teacher's practice. However, the specifics about how much or exactly what teachers need to know, is a different matter and seen as very complex (Fennema & Franke, 1992).

According to Webb (1992), assessment is an integral part of teaching practices. He further stated that integrating assessment into teaching and learning places a very big challenge on teachers. He says for teachers to be involved in assessment "not only must they have a thorough knowledge of content structure, learning and teaching" (p.678) but also should learn how to base their teaching practice on assessment results. Fennema and Franke (1992) regarded assessment to be the most complex activity teachers are involved in and requires even more complex knowledge from the teachers either in setting assessment or in marking learners' assessment responses.

Kilpatrick, Swafford and Findell (2001) described the mathematical content knowledge necessary for effective teaching practice as *mathematical proficiency* and highlighted five strands that define mathematical proficiency as: *conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition.* They feel that teachers' pedagogical understanding reflects their mathematical conceptions. In addition, Shulman (1986) was of the opinion that teachers need to experience mathematics in ways that allow for rich understandings of the conceptual underpinnings of the content.

Although some writers tend to split teachers' knowledge into different components, I however agree with Kilpatrick, Swafford and Findell (2001) when they said that it is important to note that the different components of teachers' knowledge are interdependent. In particular, Kilpatrick, Swafford and Findell's (2001) mathematical proficiency, which will be the core idea for this research, clearly indicates the interdependence of its components.

2.4.1 Mathematical Proficiency

Mathematical proficiency as described by Kilpatrick, Swafford and Findell (2001), is based on the idea of performing at some level of competency in mathematics. It is represented by five inter-depended strands, which are interwoven. The teaching and learning of mathematics is viewed as a product of interrelation between teachers, students and mathematics in an appropriate context (Kilpatrick, Swafford and Findell, 2001). The interaction between teacher, mathematics and context can clearly be illustrated in Figure 1 below, which was adopted form Kilpatrick, Swafford and Findell (2001, p. 371). The bigger (outer) circle indicates that a teacher, mathematics and students have to interact in a specified context. The double pointed arrows indicate the interactions between different components of smaller circles within the bigger circle. For marking however, a marker is expected to have such a figure in mind to help them make accurate judgment. As indicated by Webb (1992) assessment with all its activities incorporates a number of features. These features include;

- teachers' knowledge of subject content
- teachers' knowledge of learners and how learners learn
- teachers' knowledge about assessment activities themselves. In my opinion the knowledge about assessment activities should be developed from the teachers respective schools.

Therefore, teachers involved in any assessment activity, like marking, have to be aware of the interrelations that are represented by Figure 1.

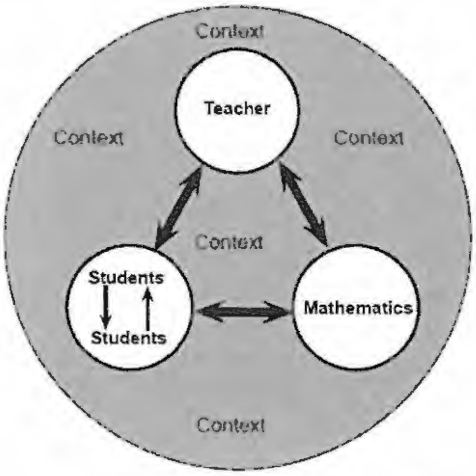


Figure 2.1: Kilpatrick, Swafford and Findell, 2001's interaction between mathematics teachers, mathematics knowledge and students in the right context needed for mathematical proficiency.

It sounds obvious that to be able to teach effectively, a teacher has to sufficiently master the subject content knowledge and at the same time have to acquire sufficient pedagogical content knowledge that help all students to develop proficiency. For instance, Kilpatrick, Swafford and Findell (2001) stated, " Choosing content, deciding how to present it and determining how much time to allocate to it are ways in which learning is affected by how the teacher interacts with the content." (p. 333).

In addition, teachers need to believe that learners are able to learn, it is teachers' expectation that guides them in choosing appropriate assessment tasks (example tests, home works, quizzes and even examination items). Likewise, teachers with high expectation of their students tend to work harder to allow their learners to meet their expectation (Boaler, 1997). Furthermore, I am agreeing with Kilpatrick, Swafford and Findell (2001) when suggesting that teachers would be successful in their practice if they know how to interpret and use information obtained from students' work. For example, they would be successful markers if they know how to interpret learners' responses to examination questions when the features in the response are not the same as the one highlighted by the mark scheme.

Teachers' interpretation of their students work is guided by their own understanding of the mathematical content knowledge. Fennema and Franke (1992) are of an opinion that a teacher will also do more teaching that is effective if they learn to pay more attention to students' work because students' work can reveal what students can and cannot do. Paying attention to students' work help the teacher as a marker to make accurate judgment of student responses in the examination.

An assessment activity in mathematics, which includes marking of national examination, demands from teachers to be proficient in mathematics since effective forms of teachers' practice attend to all five strands of mathematical proficiency (Kilpatrick, Swafford and Findell, 2001).

The strands are said to be inter-depended and none of them can be referred to as the most critical one but rather as stated by Ball (2003) that the critical point is "how and when they are interactively engaged" and are "coordinated in skilled mathematical reasoning and problem solving" (p. 9). Therefore, mathematical proficiency is complex and achieved over a period of time.

2.4.1.1 Conceptual understanding

Kilpatrick, Swafford and Findell (2001) defined conceptual understanding as an understanding that "refers to an integrated and functional grasp of mathematical ideas. Conceptual understanding involves the relations, logic, and sense making of a mathematical concept. For a teacher, it involves making connections between the mathematical subject knowledge and using it intelligently with an understanding of pedagogical and knowledge of students and context (Kilpatrick, Swafford and Findell, 2001).

If a teacher understands mathematical content knowledge and how students develop their mathematical knowledge and a collection of pedagogical concepts with regard how mathematics can be taught and learned this teacher is said to have conceptual understanding (Kilpatrick, Swafford and Findell, 2001).

2.4.1.2 Procedural fluency

Procedural fluency refers to knowledge of procedures and knowledge of when and how to use them properly. Kilpatrick, Swafford and Findell, (2001) define procedural fluency "as a skill in performing procedures flexibly, accurately, efficiently and appropriately" (p.162). In terms of numbers, procedural fluency is especially needed to support conceptual understanding of place value and the meanings of rational numbers (Ball, 2003). It also supports the analysis of similarities and differences between methods of calculating. It does not only include written procedures, but also fluency in mental methods for finding certain sums, differences, products or quotients. Kilpatrick, Swafford and Findell (2001) argued that the use of calculators should not threaten the computation skills but being fluent in the methods that to use calculators, computers, or manipulative of counting materials such as blocks, counters or beads also reflect procedural fluency.

Kilpatrick, Swafford and Findell (2001) consider procedural fluency for a teacher as the knowledge that does not only include fluency in procedures but also the fluency in performing instructional practice. Teachers with procedural fluency are able to readily draw upon their knowledge when interacting with mathematics content, student and the teaching context. A teacher's procedural fluency depends on his/her conceptual understanding. It is important for computational procedures to be efficient, to be used accurately and to result in correct answers or routine, but they should be developed through understanding. Fluency in performing instructional routine helps teachers to immediately detect and react to situations arising in their practice more accurately, efficiently and appropriately (Carpenter, 1988). A teacher with procedural fluency should therefore be able to flexibly and accurately decide whether a student's response to a specific question is fully or partially correct.

2.4.1.3 Strategic competence

According to Kilpatrick, Swafford and Findell (2001) strategic competence refers to the ability to construct mathematical problems, represent them, and solve them. Carpenter

(1988) stated that teaching is a problem solving business, thus teachers have to be able to construct problems, whether mathematical or otherwise of any other kind in the teaching environment, represent them and solve them. Teachers face a lot of situations where many times they first have to discover what the problem is and find ways to solve the problem. For example, Kilpatrick, Swafford and Findell (2001) suggested that for teachers to be able to give appropriate solutions to students' questions and situations they need to figure out what the students know. To represent a problem accurately, teachers must first understand the situation and they need a conceptual understanding of the knowledge involved, being it mathematical subject knowledge or knowledge of students or pedagogical.

2.4.1.4 Adaptive reasoning

Kilpatrick, Swafford and Findell (2001) define adaptive reasoning as the "capacity to think logically about the relationships among concepts and situations (p. 129)". They further describe adaptive reasoning in mathematics as "the glue that holds everything together (p.129)". Adaptive reasoning for a teacher includes the ability to reflect and analyse their practice and use the reflection to improve their practice. A teacher who disagrees with a student's response to a mathematical question, for example, needs to analyse the situation and find out why they think a student made such a mistake and how such mistake can be avoided. Adaptive reasoning refers to the ability to think reasonably about the interaction among concepts and situations (Ball, 2003, Kilpatrick, Swafford and Findell, 2001). Markers are teachers from specific schools, who also need to learn from the common mistakes, made by the students and develop new strategies on how to help their students not to make similar mistakes.

In the past, many conceptions of mathematical logic have been limited to formal proof and other forms of deductive interpretation (Ernest, 1991). Today's conceptions of reasoning also include other processes, including not only informal explanation and validation but also spontaneous and inductive reasoning based on example, similarity and metaphor (English, 1997).

Adaptive reasoning does not stand alone; it interacts with the other strands of mathematical proficiency, mostly during problem solving. Teachers should draw on their strategic competence to prepare and represent a problem using heuristic approaches that may provide a solution strategy. They also depend on their conceptual understanding to enhance their ability to analyse a situation.

I believe that one cannot analyse a concept that one does not understand. For example, if a student uses a different method that a specific teacher does not understand then such a teacher will not be able to make the correct judgment when marking examination papers.

2.4.1.5 Productive dispositiou

Kilpatrick, Swafford and Findell (2001) describe productive disposition as a tendency to see sense in mathematics, to perceive it as both useful and worthwhile, to believe that steady effort in learning mathematics pays off and to see oneself as an effective learner and active person of mathematics. For teachers and learners to develop the abilities of all other four strands of mathematical proficiency; *conceptual understanding, procedural fluency, strategic competence, and adaptive reasoning,* they must believe that mathematics is not arbitrary and that it is not impossible for them to understand mathematics. Teachers, just like students, must have a sense of belonging in the mathematical practice for them to develop all other abilities in the strands of mathematical proficiency (Ball, 2003; Kilpatrick, Swafford and Findell, 2001).

Teachers' disposition toward mathematics is a major factor in shaping their practice success. I agree with Ball (1989), who stated that teachers, who view their mathematical ability as unchanging, see all challenges in their practice as measuring their ability rather than providing opportunities to learn and are likely to avoid challenging tasks in their practice.

2.4.2 Possible influences the strands of mathematical proficiency have on marking.

2.4.2.1 Conceptual understanding

A teacher (marker) with conceptual understanding should be able to understand why a student's correct response to a test or examination question is the correct answer and what makes it correct, i.e. what the number, solution, or result represents (Kilpatrick, Swafford and Findell, 2001). If a particular response is not correct, a teacher with conceptual understanding should be able to figure out where the student went wrong and be able to assist where possible.

Another aspect of conceptual understanding that can be linked to marking of assessment is the one which involves connecting representations (such as words, drawings, symbols, diagrams, tables, graphs, equation, etc.), procedures, and concepts (Carpenter, 1988). For example, if a teacher understands the relation between the different features in the equations and can relate such features to their graphical representation such a teacher (marker) can easily make a correct interpretation of such representation when involved in examination marking.

2.4.2.2 Procedural fluency

Mathematical proficiency requires that a marker master both the concept and procedural skill (Kilpatrick, Swafford and Findell, 2001) in order to reason and to see whether the procedures used in learners' responses are right or wrong.

When a (teacher) marker learns marking procedures through understanding, they are more likely to remember the procedures and less likely to make mistakes in their marking. Leinhardt and Smith (1985) are of the opinion that more experienced teachers are more fluent in their instructional routine. This includes the way they assess their learners and how they use assessment in enhancing the instruction. This should also include making accurate judgments not only of assessment at school but also when marking national examination.

2.4.2.3 Strategic competence

Strategic competence calls for markers to be aware of how questions are constructed, how their solution is represented and even how to solve these specific problems (Kilpatrick, Swafford and Findell, 2001). This will enable a marker to identify features in the learners' response that can possibly be similar to the features in the mark scheme.

As a result, in the context of this research, this means teachers with strategic competence will be able to understand better how a specific student solved an examination problem and also, whether the written responses are worth a mark.

2.4.2.4 Adaptive reasoning

When marking learners' responses in the examination, Suto, Crisp & Greatorex (2008) states that a marker is involved in a succession of mental processes, which in my view are all related to adaptive reasoning. For example, if a learner uses different features in their response than those shown by the mark scheme, a marker needs to think logically to find a connection, if any, before making a decision to whether the answers are right or wrong. I therefore feel the ability to think adaptively is very important for good, flexible marking.

2.4.2.5 Productive disposition

Productive disposition demands markers as teachers to see mathematics, the learners understanding and their practice as interrelated. They need to see that the learners thinking through the examination responses and mathematics make sense through reflecting on how they make their judgment on learners' response (Kilpatrick, Swafford and Findell, 2001).

A marking exercise should be seen by each marker as part of learning and should learn through different features of learners' response being it correct or not, so that they can continuously improve their own practice. This will help them to develop a greater productive disposition towards learning about mathematics, learners' thinking and the marking practice.

2.5. Conclusion

As part of assessment, national examination is a very important component of national education. Therefore, all its activities have to be performed in a manner that assures the validity and reliability of its results.

The marking of national examination is one of the very important activities of the examination process. Marking is done mainly by teachers in Namibia, therefore the validity and reliability of its results highly depends on the accuracy of the judgement made by these teachers.

It is assumed that teachers appointed under the same criteria attain similar marking performance. It is expected that the judgments made by the teachers depends on their mathematical knowledge. However, the teacher's knowledge needed for effective marking is not immediately apparent. This is because even the teacher's knowledge is been influence by many factors.

The research defines the knowledge needed for accurate and valid marking through Kilpatrick, Swafford and Findell, 2001's mathematical proficiency. Although complex, the researcher believes that a good marker is a marker who is proficient in mathematics.

The review of literature shows that there is a strong relation between the markers' performance and their subject knowledge. It has also emerged from the literature that most Namibian grade 10 markers have not received adequate training in the mathematics subject content. As a result of this, I feel the mathematical proficiency of grade 10 mathematics markers in Namibia could be a possible influence on the learners' performance during the national examination marking. It is apparent that Namibia is a vast country and teachers appointed for marking come from different parts of the country.

Some markers come from schools that are well resourced than others and some come from poor socioeconomic backgrounds.

I am however, aware that mathematical proficiency might not be the only influence. There could be other influences, amongst others:

- Teaching experience
- Marking experience
- Markers' stress due to markers' work load

In the next chapter the methodology of the research will be discussed.

CHAPTER 3: METHODOLOGY

3.1. Introduction

This chapter describes research strategies; including the methods used for the study in order to improve the reliability of the research outcome. Firstly, the research goals and the research approach are discussed. Secondly, the chapter introduces the research instruments that were developed and utilised in the pursuit of the research goal. Furthermore, research sampling methods and the sample are discussed. The techniques and methods of data collection and the procedures for maintaining the validity and reliability of the data are also discussed. The chapter also highlights ethical issues of the participating sample. Additionally, the methods used to analyse the data will be discussed. Finally, the chapter concludes.

3.2 Research goal

This research has been shaped and directed by its goal. Patton (1990) defines the term *goal* in a broad sense to include motives, desires and purpose. A goal is anything that leads someone to a study or is accomplished by doing research.

This goal includes exploring a number of issues that helps in understanding the differences in marking performance of JSC mathematics markers in Namibia. The specific purposes of the research were;

- To create a clear and detailed understanding of factors that could possibly affect the marking accuracy of teachers.
- To explore the potential effects markers' mathematics content knowledge has on their marking accuracy.

After an initial engagement, a further issue emerged from the data. This lead to a third, emergent goal for the study:

- To explore the effects of the moderator's input on improving the markers' accuracy on specific questions.

3.3. Research approach

This section discusses the way in which the data about the case had been gathered, analysed and used. This research follows the approach of an interpretive case study. According to Janse van Rensburg (2001) there are major research philosophies that underly any research study. These philosophies inform the ontology (the nature of existence) and epistemology (what is known to be true) of the research. One of these philosophies is the interpretive approach taken in this project.

3.3.1 Interpretivism

In an interpretive paradigm, the research is done in order to understand a situation in a natural context. As stated by Cohen, Manion, & Morison (2000) in the framework of interpretative theory the research makes an effort to understand the subjective world of people's experience. As mentioned before, the goal of this research is to understand the differences in marking performance of JSC mathematics markers.

The content knowledge of marker as one of the factors affecting their marking performance has been measured by giving the markers a test that can be graded and therefore obtaining quantitative objective data. However, in order to develop a deeper understanding of the markers' content knowledge and to explore other possible influences, a smaller group of 4 markers were interviewed to obtain more qualitative data.

3.3.2 Quantitative and qualitative approach

The research followed a combination of both quantitative and qualitative approaches. Patton (1990) described combining qualitative and quantitative approaches as a powerful tool in obtaining a clear picture of the data and of the research subjects. He also suggested that combining qualitative and quantitative research approaches allows triangulation of data, which is essential in obtaining validity in research.

As stated by Shulman, (1988) quantitative methods involve a large group and a random sample of individuals. In this research, the full group of markers was asked to write a test that was marked and graded. The whole group consisted of 86 markers, where 31 markers marked paper 1 and 54 marked paper 2. In Namibia JSC national examination consists of two papers: namely, paper 1 (short answers questions) and paper 2 (structured questions). Dealing with a bigger group of markers provided a wide range of performance in marking and in the diagnostic test given. It also provided quantitative data that was analysed and made it easier for the researcher to draw general conclusions.

The qualitative data was obtained through interviews. The four participants were interviewed to ascertain their theories on marking and to allow them to highlight the other factors affecting their marking performance through their experience. Some numerical data are also discussed to give qualitative details for analysis. In this way the researcher makes claims based on constructivist perspectives (Creswell, 2003). Through the constructivist theory of knowledge, knowledge is constructed and modified through the participants experience and not passively received from some knowledge source (Von Glasersfeld, 1987).

3.4 Research method

This research followed the method of a case study.

3.4.1 A case study

The research is a case study. The research explored a single observable fact or entity bounded by time and activity and detailed information through a variety of data collected (Creswell, 1998). The difference in the marking performance of JSC mathematics national examination markers is one observable fact. Therefore, the research is studying a single instance of a bounded system (Cohen, Manion, & Morison, 2000; Patton, 1990; Creswell, 1998). The bounded system in this research was a group of mathematics markers for the JSC national examination where the researchers' interest was to understand the markers' differences in marking performance.

According to Galliers (1991) a case study method allows a research to ask 'how' and 'why' questions. The research was targeted to asking 'why' were there differences in markers' marking performance of JSC mathematics national examination and also 'how' the identified factors like the markers' mathematics content knowledge are influencing their marking performance.

3.5. Research Setting

The group of appointed markers assembled for a marking session in one venue – the Windhoek show grounds. The marking took one week, it started on a Saturday and ended on the following Friday. The marking took place under my supervision as DNEA Education Officer. As mentioned earlier, the principal examiners (the chief marker and the assistant chief marker) supervised the group of markers. Chief markers met three days before the marking period started in order to revise the marking scheme and do other administrative work. Two days before the markers arrived team leaders joined the chief marker in order to discuss and finalise the standardisation of the marking scheme and also do some administrative work for their teams. Team leaders were also allowed to mark the portion of their scripts while chief markers moderate them.

3.6. Research population and sample

The 86 JSC mathematics markers were all given a diagnostic test. However the analysis concentrated on the markers who marked paper 2. Paper 2 questions are usually more structured than the paper 1 questions. This made the paper 2 harder to mark than paper 1. Therefore, the research focused on paper 2 markers, since they were the once who showed significant differences in their marking performance. Using a marking rate generated from the moderation records of markers, a sample of 13 markers was selected for a question-by-question analysis. The 13 markers were selected from different categories of markers; 3 were good markers, 5 were average markers and 5 were poor markers. However, for a comprehensive qualitative investigation of the markers' differences in marking, a further sample of four mathematics markers was selected from all three categories. They were three females and one male. Their names were Thomas, Selma, Johanna and Sara (all fictitious names). The participating teachers had varying teaching and national examination marking experience. The selection of the participants was such that one was a weak marker, one average marker and two good markers. The diversity in performance was chosen to ensure a spread of all levels of marking proficiency.

3.7. Ethical considerations

To be able to do the research with the national examination markers, written permission was obtained from the Director of National Examinations and Assessment Directorate of the Ministry of Education. The researcher also explained in detail what the test was all about to the team leaders, who in turn helped explaining it to the bigger group (86 markers) in their smaller teams. However, to prevent the teachers from preparing for the test they were not informed about the test in advance. The four interviewed participants, who the study focused on; were each asked to consent to the interview,. In the consent form the interviewed participants were

- given the research procedures and the purpose,
- promised confidentiality of the information obtained during the research,
- instructed that they would be allowed to freely withdraw or discontinue their participation in the research without prejudice.

The process of providing consent empowers participants to be able to contribute their inputs to the study findings without fear. As stated by Cohen, Manion & Morrison (2000) that " consent protects and respects the right of self determination and places some of the responsibilities on the participants" (pp. 51) This was therefore an informed consent since individuals were given enough information allowing them to choose whether to participate in the study or not (Cohen, Manion & Morrison, 2000).

3.8. Data Collection

3.8.1 Research design and Data Collection Instruments

The mathematical content knowledge of an individual is a complex idea, which includes their subject matter knowledge and the pedagogical content knowledge. As a result, in order to study the content knowledge of markers, the markers were given a diagnostic test to diagnose their strength and weakness in the mathematics JSC subject matter knowledge. For this data, I have adopted the model described by Cohen, Manion & Morrison (2000) as the testing and assessment model. They described the testing and assessment research model as appropriate to diagnose strengths and weaknesses and to assess performance and abilities.

This research technique was appropriate for this research because the research explored mathematics teachers' strengths and weakness in mathematical proficiency and then investigated how these may have affected their performance in the marking of national examinations. Cohen, Manion, Morison (2000) stated that since the testing method is characterized by materials designed to provide scores that can be aggregated, it enables individuals and groups to be compared. It also provides a chance for in-depth diagnosis and the investigation of performance. The participants were given a multiple-choice test in order to provide objective data that can be analysed both quantitatively and qualitatively. The test result of markers enabled the researcher to compare the questions they performed weaker in the test with the questions they performed weakly in the marking. This was done in order to do a comparison of levels of performance in the test and in marking. In other words in order to find out whether the markers weakness in any topic in a test could mean poor marking in such topics or vice versa.

In order to develop a deeper understanding of the markers content knowledge and to explore other possible influences a smaller group (4 markers) was interviewed. The interview gave a chance to the participants to express what they felt about the test and possibly expose the other possible factors that influence their marking performance. Therefore, a mixture of quantitative and qualitative data was collected for analysis. As mentioned before, this allows a 'triangulation of data', which is fundamental in obtaining the validity in research.

3.8.1.1 Diagnostic test development

The diagnostic test was a multiple choice question paper, which was developed especially for this research. The test was targeted to evaluate their understanding of the mathematics content knowledge of the JSC syllabus. It covered most of the topics in the grade 10 syllabus with an addition of about 3 questions from the grade 10 additional mathematics syllabus which were included in order to differentiate between the performance of markers. The grade 10 themes/ topics are shown below.

Themes of the grade 10 syllabus

1. Numbers
    - *1.1 Number concepts*
    - *1.2 Fractions percentages*
    - *1.3 Ratio, rate and proportion*
2. Money and finance
3. Measures
4. Mensuration
5. Geometry
6. Algebra
7. Graphs and functions
8. Statistics and probability
9. Trigonometry

Assessment Objectives and competency levels of the JSC syllabus

In order to differentiate well between the markers performance in the test, the test questions were of varying assessment objectives and competency levels.

The assessment levels in the syllabus are:

A- Knowledge with understanding

B- Application of knowledge and skills

While the competency levels are:

Level 1: Memorized Knowledge

Level 2: Conceptual Understanding

Level 3: Problem Solving/ Reasoning; and Pedagogical Content Knowledge

(Namibia. Ministry of Education [MoE], 2006)

Table 3.1 shows the test specification grid indicating individual questions assessment objectives and competence levels.

Table 3.1 test specification grid indicating

QUESTION NUMBER	ASSESS OBJ.	THEME	LEVEL 1	LEVEL2	LEVEL3
1	A	Statistics and probability	✓		
2	A	Number concepts	✓		
3	A	Number concepts		✓	
4	A	Number concepts		✓	
5	B	Money and finance		✓	
6	B	Measures		✓	
7	B	Measures		✓	
8	B	Number concepts			✓
9	A	Number concepts	✓		
10	A	Fractions percentages		✓	
11	A	Number concepts		✓	
12	A	Algebra		✓	
13	A	Algebra			✓
14	A	Number concepts			✓
15	B	Ratio, rate and proportion		✓	
16	A	Fractions percentages	✓		
17	B	Money and finance		✓	
18	B	Money and finance	✓		

19	A	Algebra		✓	
20	A	Algebra			✓
21	A	Trigonometry	✓		
22	B	Trigonometry	✓		
23	B	Trigonometry		✓	
24	B	Statistics and probability	✓		
25	B	Ratio, rate and proportion			✓
26	B	Statistics and probability			✓
27	B	Ratio, rate and proportion		✓	
28	A	Graphs and functions		✓	
29	B	Graphs and functions	✓		
30	B	Graphs and functions			✓

The test was designed in such a way that it has two columns. The first column consisted of the questions and the answer options and the second column was blank space, which provided opportunities for the markers to show their workings.

To ensure reliability and validity of the test questions, they were moderated first by my colleague who is usually involved in the moderation of the grade 10 question papers and finally by my research supervisor. The test was also piloted with two markers that are more experienced. The piloting result enabled the researcher to iron out ambiguous questions and assured that the research was at the expected level. For example, question 24 was originally as shown in Table 2 (a), which was thought to be unclear and so was changed as shown in Table 2 (b).

Table 3.2 (a) question 24 before piloting

24. A die has six faces. What is the probability that the die will land on 2 when tossed? ☐ **A** 6 ☐ **B** 3	

☐ **C** $\frac{1}{3}$ ☐ **D** $\frac{1}{6}$	

Table 3. 2 (b) question 24 after the piloting

24. A die has six faces, which are numbered 1 to 6. What is the probability that the die will land on 2 when tossed? ☐ **A** 6 ☐ **B** 3 ☐ **C** $\frac{1}{3}$ ☐ **D** $\frac{1}{6}$	

3.8.1.2 Interview question development

The interview schedule consisted of 14 predetermined questions, all with possibilities of probing where necessary. The interview questions were constructed based on the following structure (in three different categories)

- As a teacher and a marker
- Diagnostic Test
- Additional Comments

To ensure validity and reliability, the interview questions were discussed with my supervisor and then piloted to make sure that each interviewee understands what is expected of him or her.

As mentioned before, the piloting of the test and the interview questions was done with people who were more experienced in marking. This was good for the research because in the interviews they gave clear explanations of the marking process and gave the researcher a chance to probe on the issues they mentioned during their explanation. It also gave the researcher a better opportunity to formulate better probing questions in case similar answers are obtained from the interviewed participants.

3.8.2 Data collection Procedures

Before the marking started, the diagnostic test was given to all teachers available for marking except the team leaders and chief markers. For this research, team leaders were asked to select their best markers, the average markers and weaker markers in their teams. This selection was based on their first 20 moderated scripts. From the team leaders' selection four teachers were selected as the interview participating sample of the research. The selected sample was interviewed in a separate room during the marking week.

The team leaders compiled markers moderation records, which were the third data collection instrument. The moderation records reflected the difference in the marks given by the markers and that given by the team leaders (appendix D) per question for all scripts moderated. These differences enabled the researcher to assign markers' error score for all the markers involved.

3.8. 3 Data Analysis

The data collected was organised and analysed. The test results for 86 markers were tabulated and the tabulated data was used to draw a bar chart. However, the rest of the research analysis was done based on the information obtained from the group of 54 markers of paper 2 (structured question paper). The moderation record of markers gave quantitative details, which were used to rate markers on one scale. The scale was worked out from the number of errors a marker made throughout the marking. Therefore, for the sake of clarity in this research the markers were assigned 'the marking error score'. The marking error score was calculated from the root mean square of the errors they made in marking The markers' marking error scores were used to group all markers in three categories; good, average and poor.

Tables were drawn showing the incorrectly answered questions in the test and the questions marked wrongly by each marker. The tables also showed the total number of errors made by each marker per question. These tables were included in the appendices and a summary table was used in the discussion. The summary tables showed the number of errors made both in the test and the marking per each topic in the grade 10 syllabi.

In order to get a clear indication of whether the test performance of markers correlated with their marking performance a Pearson product moment correlation coefficient was worked out between the markers' marking error score and the percentage test error score. The Pearson Product-Moment Correlation Coefficient (r) or correlation coefficient for short is a measure of the degree of linear relationship between two variables (Cohen, Cohen, West, & Aiken, 2003). The correlation coefficient may take on any value between plus and minus one ($-1.00 \leq r \leq +1.00$). The sign of the correlation coefficient (+, -) defines the direction of the relationship, either positive or negative. A positive correlation coefficient means that as the value of one variable increases, the value of the other variable increases; as one decreases the other decreases. A negative correlation coefficient indicates that as one variable increases, the other decreases, and vice-versa.

The data obtained from the sample of four interviewed markers was analysed through qualitative content analysis in order to identify the emerging characteristics and concepts. The qualitative data was used to compile markers' marking profiles regarding the knowledge about assessment in general and in particular their knowledge of the marking process. These included a description of what they felt about a particular issue including quotes were necessary. The quotes were compiled in such a way that it referred to the interview transcription no (T1 for transcription 1) followed by the responded line no (R1 for respondent line 1). The markers' marking profiles also included all emerging factors that could influence the markers marking performance. The interview questions were also analysed in such a way to find whether the participant's feeling about the tests was reflected by how they performed in the test.

On initial reading of the moderation records, it appeared the impact of the moderators input was not immediately apparent for some teams. In response to this it was decided to do a further analysis of the moderation record documents. This was done by comparing the periodic performance of three selected teams. The teams were selected based on how their markers were placed in the different marking categories. One team had all their markers categorised as good markers; one had their markers spread through all categories and the other had their markers only in the average and poor categories. From these teams three markers were selected for the periodic performance analysis. Three markers were selected because it was viewed that for a team of six markers half (3) would be a good representation of the team. All markers selected for further analysis were assigned a marking error score after every 20 scripts moderated.

3.9. Conclusion

The study was conducted such that it incorporated both qualitative and quantitative method in order to 'triangulate' the data regarding the influence of markers' mathematics factors influencing the marking performance of JSC mathematics markers in Namibia. The other reason for using both qualitative and quantitative methods is that, although the research sample is relatively small, they had diverse academic qualifications and have come from regions with diverse socio-economic backgrounds. The markers background has an influencing factor on their mathematical content knowledge. In the next chapter the findings will be analysed and discussed.

CHAPTER 4: ANALYSIS AND DISCUSSION OF THE RESEARCH FINDINGS

4.1 Introdnction

This chapter presents an analysis of the findings of the case study. The main goal of the study was to establish a clear understanding of the differences in marking performance of JSC mathematics markers in Namibia. The specific objective was to investigate the performance of JSC mathematics markers in order to find the possible factors that influence their accuracy in marking. The research was aimed to find out whether poor markers can be trained either in mathematical content knowledge or otherwise in order to try and improve their marking performance in the future.

Additionally, the chapter gives an explanation of how the data was collected, followed by the presentation of the findings. Profiles of different categories of markers were created in order to highlight whether their mathematical content knowledge has any influence on their marking performance. Furthermore, profiles of the four interviewed markers were created to give a clarification of their marking performance, their performance in the test and bring to light other possible influence on their marking performance. Finally, the findings are discussed point-by-point highlighting the possible factors influencing JSC mathematics markers marking performance.

4.2 Research findings

The findings analysed were collected through a diagnostic test, markers' moderation record forms and interviews. Moderation records show how markers perform in their marking. As mentioned earlier the moderators randomly pick scripts already marked by markers and remark them. The moderation record form reflects the differences in marks per question between the marker's mark and the moderator's mark (see appendix D). The test performance and the marking performance were compared by comparing the markers' marking error score with how they performed in the test.

4.2.1 Diagnostic test and marking performance comparison

A total of 86 markers wrote the diagnostic test. Out of 86 markers 32 marked paper 1 and 54 marked paper 2. Markers make fewer mistakes when marking paper 1 compared to paper 2. In order to illustrate the test performance of the whole group of markers the test result of all 86 markers presented in a bar chart in figure 4.1. The diagnostic test was composed of 30 multiple choice questions, where each question was worth a mark.

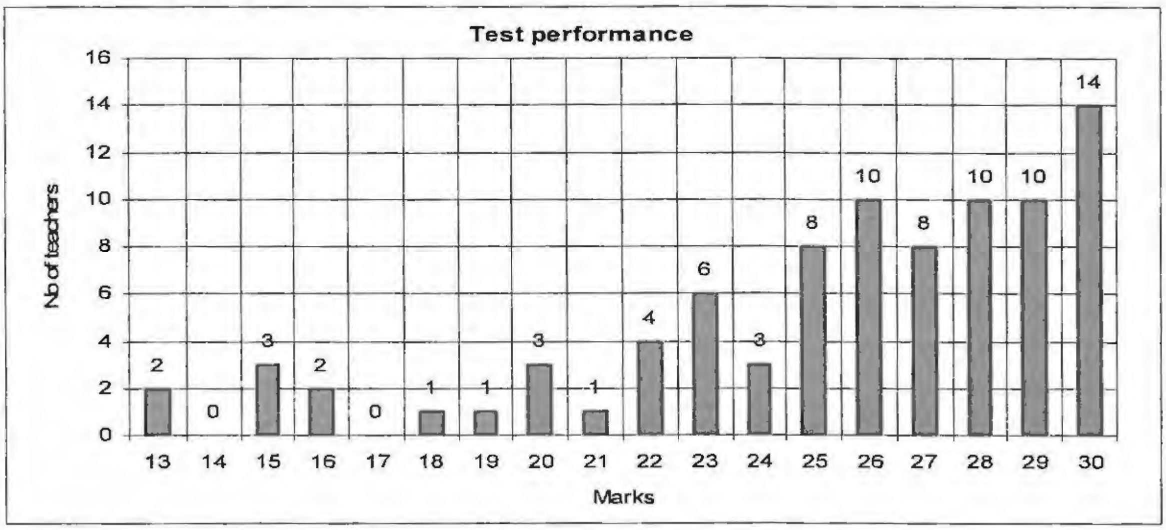


Figure 4.1; Diagnostic test performance of all markers

The marking performance of the markers is shown through their moderation records, which are compiled by their team leaders (moderators). The moderation records form as mentioned before, indicates the difference in marks between the marker's mark and the moderator's mark per scripts (see appendix D). A rating scale was worked out using the root mean square of the differences in marks for all scripts moderated for each marker. The formula used to work out the rating scale for each marker is given by; 100 x RMS = 100 x$\sqrt{\frac{d_1^2 + ... + d_n^2}{n}}$. The rating scale made it possible to assign each marker with a marking error score.

Table 4.1: Markers' test scores and marking error score

Marker's Code	Test Score	Test errors	% test errors	a	Marker's Marking error score	k
1:06	28	2	7	0.043956044	21	1
6:03	24	6	20	0.058823529	24	0
1:04	29	1	3	0.117021277	34	1
8:03	30	0	0	0.151162791	39	1
1:05	27	3	10	0.21978022	47	2
6:07	30	0	0	0.22826087	48	2
1:07	30	0	0	0.252747253	50	3
6:02	27	3	10	0.294117647	54	5
1:03	24	6	20	0.348837209	59	4
5:02	28	2	7	0.364705882	60	2
7:06	30	0	0	0.382978723	62	3
7:04	30	0	0	0.415584416	64	4
6:05	27	3	10	0.435294118	66	6
9:05	29	1	3	0.452380952	67	4
6:04 (Johanna)	28	2	7	0.466666667	68	5
8:05	25	5	17	0.46835443	68	6
2:05	30	0	0	0.493670886	70	5
5:07	25	5	17	0.541176471	75	6
5:04	25	5	17	0.588235294	77	5
8:06	28	2	7	0.586206897	77	4
2:03 (Thomas)	30	0	0	0.6125	78	3
9:02	28	2	7	0.674418605	82	7
5:05	29	1	3	0.741176471	86	12
1:02	20	10	33	0.88372093	94	10
9:04	30	0	0	1.035714286	102	13
9:03	26	4	13	1.071428571	104	7
7:03	23	7	23	1.112676056	105	11
8:07	26	4	13	1.107142857	105	10
5:03	23	7	23	1.130434783	106	15
5:06	20	10	33	1.152941176	107	11
2:06	23	7	23	1.178571429	108	14
2:04	26	4	13	1.240963855	111	16
7:07	25	5	17	1.253012048	112	16
9:06 (Sara)	23	7	23	1.25	112	15
3:07	25	5	17	1.340909091	116	30
9:07	28	2	7	1.404494382	119	9
2:02	29	1	3	1.435897436	120	13
4:02	27	3	10	1.517647059	123	22
3:05	30	0	0	1.579545455	126	16
8:04	25	5	17	1.666666667	129	5
4:04	23	7	23	2.0625	144	18
4:06	28	2	7	2.111111111	145	29
4:07	25	5	17	2.133333333	146	26

3:04	29	1	3	2.125	147	23
4:05	30	0	0	2.816091954	168	29
3:03	28	2	7	2.9	170	20
4:03	26	4	13	2.940594059	171	38
7:02	30	0	0	3.301369863	182	25
2:07	25	5	17	4.159090909	204	31
3:02	15	15	50	4.329545455	208	29
7: 05 (Selma)	20	10	33	4.554347826	213	35
6:06	19	11	36	4.564705882	214	19
8:02	26	4	13	4.987654321	223	9
3:06	22	8	26	8.238636364	287	36

The marking error scores and the test scores for the 54 paper 2 markers are given in Table 4.1 above. In table 4.1 **a** = $\frac{d_1^2 + ... + d_n^2}{n}$ where d represent the difference the marker's mark and the moderator's mark per script. The table also include other information that was viewed as important for this study. The letter **k** in the last column of table 4.1 is the number of scripts with differences with 2 or more marks. It was important for the number of scripts with differences with 2 or more marks to be noted because ideally the bigger the differences between the marker's mark and that of the moderator's mark the poorer the marker is in marking.

The group has a varying marking performance as shown by table 4.1. Marking error score in table 4.1 were used to group markers in three different categories, which are good, average and poor markers. Markers with the marking error score between 0 and 100 are categorize as good markers, between 110 and 200 are categorized as average markers and between 210 and 300 are categorized as poor makers as shown in Table 4.2 below. The shaded area in Table 4.2 below shows the borderline between each two category.

Table 4. 2: Grades per category

Marking rate	0 - 100		110 - 200		210 - 300
Markers' category	GOOD		AVERAGE		POOR

To understand whether the content covered by the test is a good measure of the content needed for marking, the test performance was compared to the marking performance. To do this a percentage test error score was compared to percentage marking error score.

This was targeted to reveal whether the poor performer in the test (markers with a high percentage test error score) would be a poor performer in marking (markers with a high percentage marking error score).

Figure 4.2 below is a comparison of percentage of test errors and percentage of marking error score for the paper 2 markers. As mentioned before paper 2 markers (54 markers) were the only ones used for this research analysis because paper 2 consisted of more structured questions. Markers are more likely to make errors with structured question rather than the short answer question. This helps understanding how different categories' marking performance compares to their test performance.

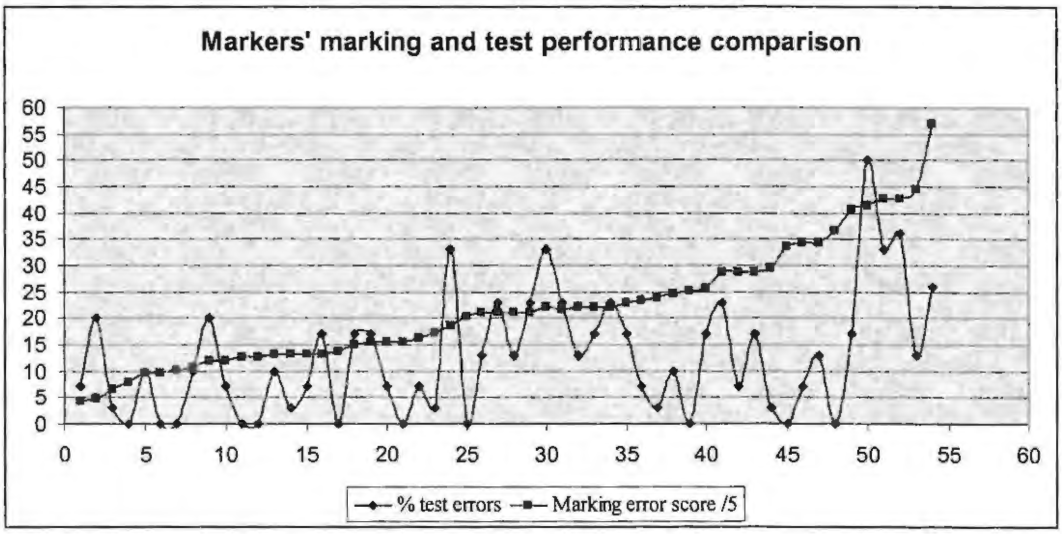


Figure 4. 2; A comparison of percentage test errors and percentage marking error score for the 54 markers

In order to better understand the relationship between the markers' content knowledge tested by the diagnostic test and the markers' performance a Pearson product moment correlation was worked out. The Pearson product moment correlation coefficient, r, of the percentage marking error score and percentage test error score for the paper 2 markers was worked out as equal to 0.43127. The Pearson product moment correlation coefficient, r, is a dimensionless index that ranges from -1 to 0 to 1 to 0 inclusive (Cohen., Cohen, West, & Aiken, 2003) that is calculated as follows:

$r = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2\sum(y-\bar{y})^2}}$ where x and y are the samples average (percentage of markers grade) and average (percentage of test errors).

The correlation coefficient reflects the extent of a linear relationship between two data sets. If r is between -1 and 0 than the correlation is negative but if r falls between 0 and 1 the correlation is positive (Cohen, J; Cohen P; West & Aiken, 2003; Njabili, 1993). A positive correlation coefficient means that as the value of one variable increases, the value of the other variable increases; as one decreases the other decreases while negative correlation coefficient indicates that as one variable increases, the other decreases, A correlation coefficient of r = 0.50 and above indicates a stronger degree of linear relationship than a correlation coefficient one of r = 0.40. Similarly a correlation coefficient of r = -0.50 and above shows a larger degree of relationship than one of r = -0.40. Therefore a correlation coefficient of zero (r = 0.0) indicates that there is no linear relationship and correlation coefficients of r =+1.0 and r =-1.0 indicate a perfect linear relationship (Cohen, J; Cohen P; West & Aiken, 2003). Therefore, the marking performance and the diagnostic test performance are positively correlated. However, the correlation (r = 0.43127) is fairly weak. This could imply that there are other very significant factors that are also influencing the markers' marking performance.

4.2.2 Description of markers categories

This section gives a profile of three different markers categories based on relationship between the topic markers performed weak in marking and in the test. A sample of 3 good markers, 5 average markers and 5 poor markers were selected. Their incorrect questions in the test and the questions they marked incorrectly are tabulated and compared in order to find out if their knowledge of some topic influences how they mark questions from such topics. The question by question comparison between the test incorrect questions and the questions marked incorrectly are shown in appendixes 5 to 6. The summary of the question by question comparison between the test incorrect questions and the questions marked incorrectly are shown in Table 4.3 (a) (b) and (c)

4.2.2.1 Good markers

As shown in Table 4.2 above (page 56) good markers are markers with a marking error score ranging from1 to 100. They performed well in the test. Therefore, only a sample of 3 good markers was taken for question by question comparison. Appendix 5 shows the question by question comparison for the good markers. This comparison is summarized in table 4.3 (a) below.

Table 4.3 (a) Summary for question by question comparison for the good markers

Marker	Topic	No of test Errors	No of marking Errors
M1(Thomas	Numbers	0	6
	Money and finance	0	9
	Measures	0	2
	Mensuration	No question	No question
	Geometry	0	7
	Algebra	0	1
	Graphs and functions	0	2
	Statistics and probability	0	0
	Trigonometry	0	No question
M2 (5:05)	Numbers	1	5
	Money and finance	0	12
	Measures	0	3
	Mensuration	No question	No question
	Geometry	0	8
	Algebra	0	2
	Graphs and functions	0	2
	Statistics and probability	0	0
	Trigonometry	0	No question
M 3 (Johanna	Numbers	0	0
	Money and finance	1	4
	Measures	1	5
	Mensuration	No question	No question
	Geometry	0	0
	Algebra	0	1
	Graphs and functions	0	0
	Statistics and probability	0	1
	Trigonometry	0	No question

Good markers' marking profile

Table 4.3 (a) shows that the total marking errors per topic of good markers ranged between 1 and 12. This means that the moderator's input helped the good markers not to repeat the same mistakes. However, the good markers who did not obtain full marks in the test had a few marking errors on questions that came from the same topics as their test incorrect questions. This suggests that their knowledge in such topics have influenced their marking accuracy when marking the questions from such topics.

4.2.2.2 Average markers

A sample of 5 average markers was taken for question by question comparison. The summary of this comparison is shown in table 4.3 (b) below.

Table 4.3 (b) Summary for question by question comparison for the Average markers

Marker	Topic	No of test Errors	No of marking Errors
M4(2:02)	Numbers	0	6
	Money and finance	1	16
	Measures	0	8
	Mensuration	No question	No question
	Geometry	0	9
	Algebra	0	0
	Graphs and functions	0	2
	Statistics and probability	0	2
	Trigonometry	0	No question
M5 (3:04)	Numbers	1	20
	Money and finance	0	16
	Measures	0	11
	Mensuration	No question	No question
	Geometry	0	13
	Algebra	0	2
	Graphs and functions	0	4
	Statistics and probability	0	2
	Trigonometry	0	No question
M6(4:02)	Numbers	1	9
	Money and finance	3	22
	Measures	0	12
	Mensuration	No question	No question
	Geometry	0	9
	Algebra	0	8
	Graphs and functions	0	2
	Statistics and probability	0	1
	Trigonometry	0	No question

M7 (7:07)	Numbers	2	22
	Money and finance	0	5
	Measures	0	2
	Mensuration	No question	No question
	Geometry	0	3
	Algebra	0	3
	Graphs and functions	1	1
	Statistics and probability	2	2
	Trigonometry	0	No question
M8 (Selma)	Numbers	2	11
	Money and finance	0	10
	Measures	0	4
	Mensuration	No question	No question
	Geometry	0	10
	Algebra	1	1
	Graphs and functions	2	2
	Statistics and probability	2	0
	Trigonometry	0	No question

Average markers' marking profile

As mentioned earlier the average markers also performed well in the test. Their total number of marking errors per topic ranged between 1 and 22. They had marking errors in most of the questions. In most cases a highest total number of marking errors were recorded in questions that came from the same topics as those questions they inaccurately solved in the test. For example as shown in table 4.3 (b) M 8 had incorrectly solved two questions on number concept in the test and had a total of 11 marking errors on number concept type of questions, M 7 had incorrectly solved two questions on number concept in the test and had a total of 22 marking errors on number concept type of questions. The same applies to M4, M5, and M6 their highest total of marking errors are from the same topics as those questions they inaccurately solved in the test

4.2.2.3 Poor markers

Like the average marker a total of 5 markers were picked for question by question analysis. A summary of this analysis is shown in table 4.3 (c).

Table 4.3 (c) Summary for question by question comparison for the poor markers

Marker	Topic	No of test Errors	No of marking Errors
M9 (2:07)	Numbers	2	23
	Money and finance	0	36
	Measures	0	3
	Mensuration	No question	No question
	Geometry	0	16
	Algebra	1	13
	Graphs and functions	2	8
	Statistics and probability	0	4
	Trigonometry	0	No question
M10 (3:02)	Numbers	6	22
	Money and finance	1	13
	Measures	0	19
	Mensuration	No question	No question
	Geometry		30
	Algebra	2	11
	Graphs and functions	3	2
	Statistics and probability	1	5
	Trigonometry	0	No question
M11(6:06)	Numbers	2	14
	Money and finance	2	11
	Measures	0	5
	Mensuration	No question	No question
	Geometry	0	10
	Algebra	2	3
	Graphs and functions	2	2
	Statistics and probability	2	2
	Trigonometry	0	No question
M12(3:06)	Numbers	0	28
	Money and finance	0	35
	Measures	0	14
	Mensuration	No question	No question
	Geometry	0	20
	Algebra	4	7
	Graphs and functions	3	5
	Statistics and probability	1	8
	Trigonometry	0	No question
M13(Sara)	Numbers	5	10
	Money and finance	0	15
	Measures	0	22
	Mensuration	No question	No question
	Geometry	0	12
	Algebra	3	1
	Graphs and functions	0	3
	Statistics and probability	1	4

Poor markers' marking profile

Poor markers performed poorly in the test. In particular, the sample of poor markers analysed performed poorly in the additional mathematics questions. The questions that came from the additional mathematics syllabus were question 14, 28, 29 and 30. Table 4.3(c) shows that they had marking errors in questions from all the topics examined by the question paper. Therefore, it was difficult to obtain a direct relationship between their test performance per topic and their performance in marking questions from the same topic. The total number of marking errors per topic made ranged from 1 to 36. This is an indication that the moderators input might not be enough to improve their marking accuracy in some topics.

4.2.3 Description of the interviewed participants

In order to develop a clear understanding of the markers' content knowledge as well as to explore other possible factors influencing the markers' marking performance, four markers were interviewed. This section gives the profiles of the four interviewed participants. The profiles are based on their knowledge on assessment and what they felt about the mathematical content covered by the diagnostic test.

Table 4.4: Periodic marking error score of the interviewed participants

Marker's code	Marking error score after the first 20 scripts	Marking error score after the second 20 scripts	Marking error score after the third 20 scripts	Marking error score after the fourth 20 scripts	Marking error score after the last few scripts
Thomas	59	74	120	33	0
Johanna	114	67	55	0	29
Selma	266	181	244	173	167
Sara	132	145	87	62	0

4.2.3.1 Thomas

Thomas has been marking the JSC mathematics national examination for the past 6 years. He has been a mathematics teacher for 22 years. His team leader selected him as the best marker in the team. This was also reflected by the marking error score assigned to him which was 78. His performance in marking remained more or less the same at the beginning and improved slightly towards the end of the marking period as shown in Table 4.4 above.

Despite his love for mathematics, Thomas wanted to study medicine, but chances were not so readily available for him, thus he opted to become a mathematics teacher. He had this to say about the issue, " ...the first choice was to study medical profession but those days the chances where not so readily available..."(T1,R1).

Thomas believed that his content knowledge in mathematics was enhanced by his years of experience as a teacher (T1,R4-R5). Although he acknowledges that the content knowledge he learned at the college was the basis for teaching, he felt that as a teacher of mathematics, he needed to do more to enhance his knowledge needed for teaching practice. He was of the opinion that the content he learned at the teachers' training college was important but basic. He added that as a teacher, he had to do more to learn what he knows today. He therefore believed that he performs better in his teaching duties if he is continuously learning and taking part in different activities. Thomas felt there is no specific topic in the grade 10 syllabus that he thought was difficult for him. However, he thought there are some topics that were not so easy to teach. He gave an example of transformation, algebra and trigonometry. He said that learners finds hard to understand them, especially he is teaching grade 12 (T1,R7).

Thomas understood all procedures to be taken during examination period at their school. He also believed that because of the knowledge he acquired over the years, setting examination is easy. His explanation about the procedure an examination question papers goes through at his school; shows that his school has a well organised examination process. He had this to say during the interview.

> After setting the paper you normally give it in with the HOD to be distributed to the subject head, they moderate it and hand it back to you. You (the teacher) make the changes you must show the changes that you have done, and then you hand it back. It's typed, copied, and then the examination itself, the learners write the paper, you mark it you get to set a time span in which to mark the papers. After that, you compile your subject schedule. And you hand it in to your subject head now he moderate the marked scripts and check the marks and hand to the secretary or the team that enters it into the computer system and the reports are processed.

This shows that the marking process at Thomas's school is more or less similar to the national examination marking process (T1,R9).

Additionally, Thomas believed that marking national examination has taught him a lot. He admitted that marking the national examination has been a good experience, however, he felt national examination marking was more stressful for the markers (teachers) than the way they mark at their respective schools (T1,R10). He recommended that extending the marking period or giving markers fewer scripts to mark could reduce the markers' pressure (T1,R13). He also pointed out that national examination marking is more lenient to learners compared to the marking he does back at school. However, he believed that if he marks at school the way he marks during the national examination he would mislead his learners. He said at school learners are given their marked script back and some learners would not understand why they are given marks so easily.

Thomas performed very well in the diagnostic test. He obtained full marks. He performed the best in the test compared to the other three interviewed participants. His test performance also reflects a high level of mathematical conceptual understanding, which is a positive influence on his performance as a marker. The test results also showed that Thomas knowledge of the JSC curricula is quite good. Apart from his good performance in the test, he also became conscious of the fact that some questions in the test were on the level higher additional mathematics level. He had this to say during the interview "some questions were from the additional mathematics syllabi". His performance in the questions from the additional mathematics syllabi example question 28, 29 and 30 was also good.

He analysed the test as fair. He also said in the interview that although the test is not simple, all grade 10 teachers should be able to understand it well. Additionally, he suggested that such a test could be used in the process of appointing markers in future. He further noted "when I worked through it I noticed that this is the kind of test that should make it clear to someone when appointing markers for JSC. They should at least pass this test very good in order to become markers".

4.2.3.2 Johanna

Johanna was marking the JSC mathematics national examination for the first year. She has been a mathematics teacher for the past 6 years though not currently teaching grade 10. She teaches grade 11 and 12. Her team leader selected her as an average marker. The marking grade assigned to her placed her in the good markers' category. Her marking performance improved significantly throughout the marking period as shown by table 4.4 above.

Johanna started as Physical Training (PT) teacher who found herself teaching mathematics by chance (T2,R1). She had no formal training in mathematics and only studied mathematics up to grade 10. She however, gladly learned a lot through her colleague. She said during her interview "I would say I have someone Ms:. . . she was my HOD and my subject head when I started teaching and she had much experience she told me things, she learned me things and I became angry because I had to mark over and over and set up a paper over and over. But today I am glad (T2, R4)."

Johanna believes that her content knowledge in mathematics is enhanced by her preparedness to learn everyday through people and her experiences throughout her teaching career. She, however, strongly feels she still needs a lot of help from people who are good in the subject and were willing to share. Johanna mentioned that teaching transformations: rotation and reflection to grade 10 learners is difficult for her. Although she understood transformation, she said it was not so easy to teach (T2, R8-R9).

Like Thomas, Johanna was aware of all procedures to be taken during examination period at their school. She described the procedure the examination question paper goes through at their school as follows;

> You set your paper, and then about 2, 3 weeks before hand we get a date when you must give it to your subject head. Then it is moderated, if there is some places they feel it is not good enough or you made a mistake or some thing like that they give it back. So there is about a week for moderation and then it goes for duplication yes and it comes into the safe we put it into bundles and goes to the safe schedule. And you hand it in to.

Before Johanna was appointed as a marker, she was interested in knowing how national examination marking is done. She said; she was always surprised by the performance of her former grade 10 learners. They performed very well in grade 10 mathematics and yet performed very poor in grade 11 mathematics (T2, R14-R16). She also wanted to come and learn so that she could go back and teaches her fellow teachers the marking procedures used during national examination marking (T2, R14). Like Thomas, she felt marking at the national level was less strict on learners compared to how she marks at school.

The diagnostic test result of Johanna was good. She obtained 28 marks out of the total 30 marks. She was the second best amongst the four of the interviewees. Despite her not having any formal training in mathematics after grade 10, her test performance reflects a good level of conceptual understanding. Although her mathematical conceptual understanding is not the only influence, it has impacted on her performance as a marker. The marking grade assigned to her places her in the good markers' category.

When asked how she felt about the test, she had this to say "I think its up to standard you actually balled me out with one (question) I got the answer but I couldn't write down how I got the answer (T2, R18)." She added that; "this should be the knowledge grade 10 teachers know. She recognises that a teacher should have subject content knowledge higher than the level they are teaching. She, however, thought some test questions were a little easier than others. One of the points that clearly stood out was Johanna's love for teaching mathematics. She said once during the interview that she became a mathematics teacher because one of her fellow teacher challenged her that she did not have a 'brain' for mathematics. Despite not having any academic training in mathematics, she has grown to love teaching the subject such that she was teaching grade 11 and 12 and wanted to learn more.

4.2.3.3 Selma

Selma was marking the JSC mathematics national examination for the first year. She had been a mathematics teacher for the past 16 years. Her team leader selected her as weak marker in the team. She was one of the weaker markers amongst the four teachers interviewed for the research. Her weak performance in marking is also reflected by her moderation record compiled by her team leader. The marking error score placed her in the category of poor makers which was 213/300. Her performance in marking remained more or less the same throughout the whole marking period.

Selma became a mathematics teacher because she understood that the country needed mathematics teachers. She also believed that she was good in mathematics. She was therefore encouraged by her performance in mathematics to continue with mathematics throughout her academic and professional training (T3, R2). Selma was aware that the content she learned in the teacher training college was limited. She said during the interview that the teacher training college's mathematics curriculum should be improved to include sufficient content for teachers (T3, R4). During her college training the mathematics curriculum covered content up to grade 10 level only.

During the interview Selma struggled to bring to mind a topic area from the grade 10 syllabus that she enjoys teaching. She then stated that in the JSC mathematics curriculum she found it easier to teach the four basic operations (x, +, - and ÷). Nevertheless, she was conscious of her weak point when teaching. She said that she does not know how to make her teaching realistic enough for the learners. She associated her problems in teaching to the fact that the school she taught at was in remote area. She further stated that she struggles to teach grade 10 algebra, she said it was difficult for her to make her learners understand algebra well (T3, R6).

Unlike Thomas and Johanna, at Selma's school the grade 10 examination was conducted per region. A number of teachers were selected to form a group. The group is asked to set a regional question paper and make sure the question paper is moderated before it is given to school for writing. The learners' scripts are marked by teachers at school. This, she said, was only done for grade 10 and the other grades subject teachers are responsible for setting up the examination question papers (T3, R10). This gave an indication that her school's examination process was not structured well enough to enable her to gain experience of the assessment process, most specifically the marking process.

Selma has never marked before, so like Johanna and Sara, she applied to come and mark so that she can learn and go back to her school and share with her colleagues the way the national examination is marked. The fact that she wanted to learn from the process she said motivated her to apply for marking. Unlike Thomas and Johanna, Selma felt national examination marking is too strict on learners. She felt it does not accommodate all learners' working. The learner's working includes step by step method of getting to the final answer (T3, R12). In other words, she felt during the marking of national examination, the marker only mark the final answer. She had this to say during the interview "... as we use to mark we mark every step we split that mark to accommodate the learner but the way a saw here it's a little different (T3, R12)." What Selma stated above is the opposite of what really happens, because when marking national examination the marks assigned to the question are distributed through the candidates work not only to the final answer as she states. This means even if the final answer is wrong but the candidate working is correct the learner is awarded a fraction of the total marks assigned to the question. It is likely that she completely misunderstood how to apply the mark scheme or it was not explained to her properly by her team leader (moderator). This had a very negative influence on her marking performance.

Selma noted that a marker's background either advantaged or disadvantaged in terms of socioeconomic structure might affect their overall understanding. She mentioned during the interview when asked her feeling about the marking process; "that one I think it is not very easy to answer since we are coming from different areas some advantaged some disadvantaged" (T3, R15)

The diagnostic result of Selma was poor compared to the performance of the whole group. She obtained 23 marks out of the total 30 marks. Her test performance indicates that her mathematical conceptual understanding is poor compared to that of Thomas and

Johanna. In addition, like Thomas and Johanna, her conceptual understanding had an influence on her performance as a marker. In other words, since her marking performance was poor, it indicates that her poor conceptual understanding had influenced her marking accuracy.

She analysed the given test as fair as she said "not easy and also not so difficult." She pointed out some questions that she thought were easy and a few that were difficult. During the interview she pointed on question 26, 28 and 30 as the difficult one. She had this to say;

> I think I had to rub the one on average, *[silence, let me show you question 26]* and *this* one [pointing at 28] was a difficult question so I just did not know because I found the y-intercept and then the gradient because I can see there is a negative number here so the coordinate is *[silence]* and then here I could not see any negative number.

4.2.3.4 Sara

Sara was also marking the mathematics national examination for the first time. She had been a mathematics teacher for the past 8 years. Her team leader selected her as weak marker in the team. This marking error score placed her in the category of average makers. Her marking performance improved towards the end of the marking period as shown by table 4.4 above.

Sara became a mathematics teacher because she was convinced she was good in mathematics. She said she had always been performing well in mathematics and she had a C in grade 12 mathematics final exams. Sara believed she learned a lot of mathematics content in the teacher training college and still thinks she needs to learn more (T4, R1-R4). Sara said she likes teaching grade 10 trigonometry and circle geometry. Although she found trigonometry challenging to teach, she managed to teach it well through hard work (T4, R6-R7).

The end of term examination process at her school was not very well structured to give all teachers a better understanding and experience of the marking process. When asked to give a detailed description of the examination process at her school she said;

> First, the teacher has to set up a question, after then there will be a due date. After finishing setting up a question paper, have to submit to the HOD for moderation purposes. Then if there is something maybe that needs correction then the HOD has to bring back to the teacher (T4, R9).

She had never marked before and so like Johanna and Selma she applied to come and mark so that she gains marking experience. She also said she wanted to learn so that she could go back to school and train her learners how to answer questions (T4, R11). At one point during the interview Sara said "the marking of national examination was strictly according to the mark scheme." Then again, like Thomas and Johanna, she felt national examination marking is less strict on learners. It was however not clear what she meant when she said during the interview that;

> When marking you has to look strictly on the marking scheme. For example on this mark scheme you will find a word even if there is no unit it's just correct. Then at school maybe we use to penalize learners if there is no unit we are not going to mark (T4, R12-R13).

For the reason that looking strictly on the marking scheme would mean that all learners' working that are correct but not reflected by the marking scheme would not be awarded a mark which is not the case here.

Sara felt the time used for markers' training was too long. Markers' training session took up the first day of marking. It involved discussing the general administrative rules and how to apply the marking scheme. The marking scheme discussion is done in order to make sure all possible answers are included and all markers understand how to apply the marking scheme uniformly. She was concerned that if a lot of time was wasted during the training then markers would not have enough for marking (T4, R16-R17). Therefore, according to her, markers would in the end mark too quickly, in so doing making more errors in their marking.

The diagnostic result of Sara was very poor compared to the performance of the whole group. She obtained 20 marks out of the total 30 marks. Her understanding of mathematics concepts, as tested by the diagnostic test, was poor as per her test results. This may have negatively influenced her marking accuracy. She analysed the test as good but challenging. She said during the interview, "I think it is (the test) good, it was a bit challenging but on the other side it was enjoyable." She pointed out that some questions where very easy. She said the question on probability (question 24) was difficult because according to her the topic of probability is no longer there in grade 10 syllabi. This was a misinterpretation of the grade 10 curriculum because the topic of probability is still part of the syllabi under the section statistics and probability.

4.3. Moderators' input

As mentioned before all markers were moderated by their team leader markers (moderators). Initially, before marking starts each team sit in a standardization meeting in which all markers with their team leader (moderator) review and discuss the mark scheme. The training of markers is a crucial component of the marking process. Sara tends to not see the need of long discussions during the markers' training session. This affected her concentration during such training and eventually her accuracy in marking as expected. This was possibly difficult because of her poor knowledge.

When marking starts the team leader remarked a randomly selected number of scripts marked by each marker and immediately give feedback. As MOE (2007 (c)) states that after each moderated scripts it is essential that the marker is informed of any deviation from the accepted standard and requested to remark the scripts marked since the previous moderation and correct any misinterpretation of the mark scheme.

Most good and average markers were found to improve their marking performance throughout the marking period. For example Table 4.4 shows that the periodic marking error score for Thomas, Johanna (good markers) and Sara (average marker) decreased significantly towards the end of marking. This is an indication that the moderators input have helped in improving their marking accuracy. However, the poor markers' marking performance continued being poor throughout the marking period. Table 4.4 shows that the periodic marking error score for Selma (poor marker) stayed more or less the same till the end of the marking period despite the fact that the team leader continuously discussed all her misinterpretation of the mark scheme with her on the questions she had made errors

The research data also showed another very interesting trend in performance between different teams. Some teams seemed to have all their markers placed only in the categories of either average or poor markers. A good example of this is team 3 and 4 (see table 4.1) and some teams had a spread of abilities i.e. some markers were good some were average and some were poor an example of this was team 6. There were also some teams that had all their markers as good markers. These trends suggest that there were difference on the impact made by different moderators' input. In light of this, to be able to create a clear picture of how the moderators' input differed from team to team a further analysis of the moderation record was needed.

4.4 Further analysis

The moderators moderate throughout the marking period. It is expected that due to the continuous feedback the markers get from their moderators, their marking performance should become better throughout the marking process. This means that markers should progressively make fewer mistakes throughout the marking period. Therefore if a periodic markers marking error score is worked out gradually, it should become less and less as the marking process progress. To be able to observe how the impact of the moderators' input varies from team to team, four different teams (team 2, 3, 6, and 7) were selected for a periodic performance comparison analysis (see table 4.4). The moderation records of three randomly selected markers from each of the four teams were analysed. This analysis involved working out a marking error score to these markers after every 20 scripts moderated. The information obtained from this analysis was presented in the bar chart in figure 4.3.

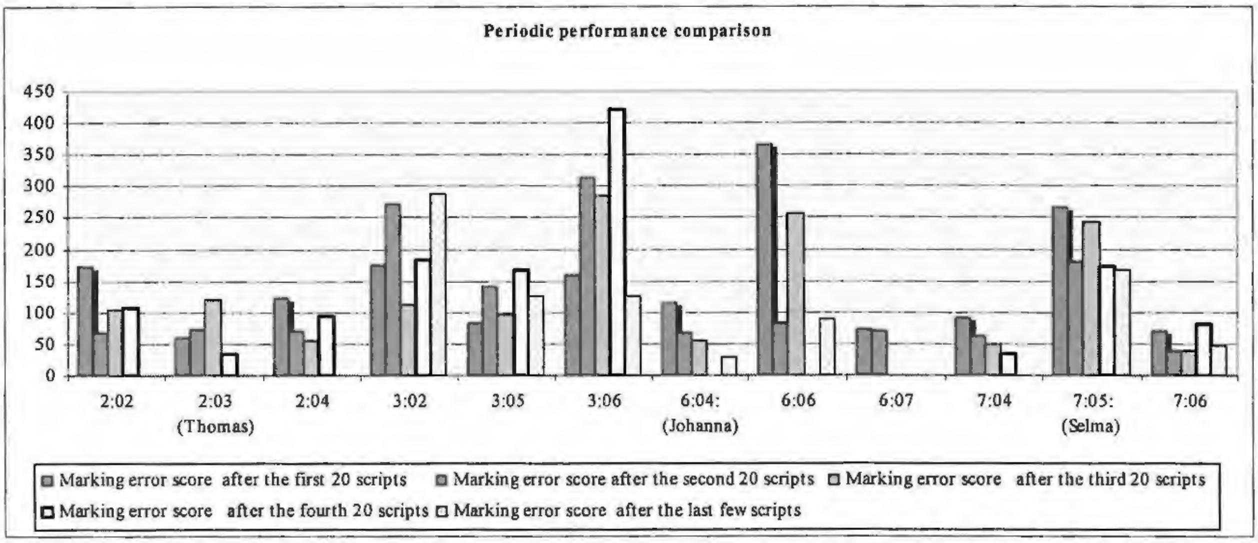


Figure 4.3 Teams periodic marking performance comparison

4.4.1 Synthesis

Figure 4.3 shows that although the markers were given feedback on their moderated scripts the impact of the moderator's input was not apparent in some teams like team 3. However, team 6 and 7 show clearly that the marking error score decreases with time. This means that the number of errors made by a marker lessen with time due to the moderators' input. Another interesting feature was shown by markers from team 2 whose marking rate were low from the first 20 scripts moderated and also became lower as marking progressed. This could also be attributed to the fact that the team leader trained the markers well during the first standardisation meeting. Additionally the moderators' (team leaders) input of team 2 made a clear impact on the performance of the markers. As mentioned before the moderators input after every scripts moderated, where markers are informed of any deviations from the accepted marking scheme and urged not to repeat them again or even asked to go back to the scripts marked after the last moderation.

4.5 Discussion

4.5.1 Markers content knowledge

The main goal of the research for the study was to establish a clear understanding of the differences in marking performance of JSC mathematics markers in Namibia. This included exploring the potential effects markers mathematics content knowledge has on their marking accuracy. The research provided sufficient data to show that there were differences in markers marking performance throughout the JSC mathematics marking session for 2007 national examination. This was evident from the marking error scores assigned which ranged from 21 to 144 (Table 4.1). The marker with the smallest marking error scores was the best marker. Some markers made more marking errors than the others and a number of them made marking errors that involved more marks then other see Table 4.1. As to whether this was caused by the markers' mathematical subject knowledge was partly supported by the fact that good and average markers had less incorrect questions in the test and poor markers had more. This was also supported by the positive Pearson product moment correlation coefficient between the markers' test error scores and their marking performance as indicated by their marking error scores.

Throughout the markers' marking categories, especially the average and poor markers had more marking errors in questions that came from the same topic as their test incorrect questions. Example in Table 4.3 (b) M5 had only answered wrongly one question on numbers and had the highest number of marking errors (20) in questions that came from the topic of numbers. In addition, average and poor markers had more errors in many other topic questions. For example Table 4.3 (c) shows although marker 10 (M10) had only answered wrongly 6 question on numbers, 1 from money and finance, 2 from algebra, 3 from graphs and functions and 1 from statistics and probabilities, the marker had marking errors in questions coming from all topics with the highest number of marking errors in geometry questions. It was also evident from the findings that poor markers' category had in most cases a very high total number of errors in marking some if not all questions see Table 4.3 (c). The research findings show facts that suggest that both average and poor performing markers are not comfortable with their content knowledge. For example Selma and Sara gave an indication that they needed to learn more mathematical content knowledge than what they already know. In their study Nadas & Suto (2008); Mewborn (2001) have found that markers' subject knowledge has an influence on markers self-confidence during the marking process. However Johanna who was a good marker had no formal education in mathematics and yet performed well in both the test and in her marking. This shows that in Namibia (a developing country) it is very difficult to directly relate the teachers' mathematical content knowledge to their formal qualification in mathematics. In actual fact it is some teachers who seemed to have some formal training that turned out to be poor markers. For example Selma had a BETD diploma where she said she majored in mathematics and at the same time she turned out to be a poor marker.

The positive Pearson product correlation coefficient ($r = 0.43$) was sensible but not an excellent correlation. To be able to use the test as an instrument for selection of markers into different categories all other factors affecting the markers marking performance should be eliminated. The Pearson product correlation coefficient of $r = 0.43$ suggest that the markers' mathematical content knowledge is not the only factor affecting the markers marking performance.

4.5.2 Further influences

The research also aimed to clearly identify and understand other factors affecting the markers marking performance. Despite some success in positive identification of the relationship between the teachers' mathematical subject content knowledge and the marker's performance, the results also indicated that there were other factors that influenced the markers' marking performance. Markers' knowledge of the JSC curricula and their general knowledge of the marking process were some factors identified.

4.5.2.1 The markers' understanding of the exam marking process.

Another factor that undoubtedly affected the markers' marking performance was their knowledge of the marking process. Thomas and Johanna (good markers) described a very well structure examination – marking process that their school carry out while that of Selma's and Sara's school seem not to have been so well structured to give them the necessary experience.

The research findings also revealed that the accuracy in marking of a marker is affected by the amount of pressure put on the markers. Research by Suto, Crisp & Greatorex (2008) shows that marking involved different cognitive strategies, which required markers', high level of concentration. Thomas, Johanna and Sara were cognisant of the need to extend the marking time or to reduce the number of scripts marked in order to reduce what Thomas termed as the marking stress. Markers are assigned a quota of scripts per day, which have to be marked between 7 am and 10 pm. The quota puts pressure on many markers especially the slow markers. They try to mark fast to complete their daily quota and as a result make a lot of errors.

4.5.2.2. Markers' interpretation and usage of the marking scheme

Interpreting and using the marking scheme is very important contributors to the markers performance in marking. This is about making sense of, and then marking with reference to, the mark scheme. This is related to teachers' conceptual knowledge. The poor and average markers tend to struggle interpreting and using the marking scheme. For example, Sara was not very clear when describing how the mark scheme should be applied. Also, when Selma was describing how the marking scheme is applied, she appeared to have been explaining the opposite of how the mark scheme is applied. This gave an indication that Selma had completely misunderstood how to apply the marking scheme, which is the important issue that a marker has to know about the marking process. As MoE (2007 c) stated that it is essential for all markers to have a common understanding on how to apply the mark scheme.

4.5.2.3 The markers' knowledge of the curriculum

Although the knowledge of the curricula is not directly measured in this research, the results show that some of the poor performing markers had little knowledge of the JSC mathematics curricula. This was evident in Sara's case where she seems to think the topic of probability is no longer in the JSC syllabus, which was not the case. When a teacher does not know the curricula they will not be able to perform the duties that require reference to the curricula especially assessment of which marking examination is part of.

4.5.2.4 The markers teaching and marking experience

Years of teaching experience did not show direct relationship to the markers performance. The weaker and the average marker were more experienced in teaching than the one of the good markers. The years of marking experience are not varying between the average marker and the weaker ones. However, Thomas who has been marking for 6 years and one of the good markers seemed to be more confidence in marking due to his experience in marking. Research by Nadas & Suto (2008) shows that expert markers are more confident in marking and tend to make fewer mistakes. This suggests that Thomas's six years of marking experience have also positively influenced his performance in marking. Nadas & Suto (2008) also reveal that teaching and marking experience has a great influence on markers self-confidence during the marking process.

4.6 Conclusion

This chapter presented the analysis of the results of the study. As mentioned before the main goal of the study was to establish a clear understanding of the differences in marking performance of JSC mathematics markers in Namibia. The study specifically explored the content knowledge and its influence on the marking performance of JSC mathematics markers. The research data also highlighted other possible factors that influence their accuracy in marking. It emerged from the data that there were differences in the impact the team moderators' input have on the markers' marking performance. Therefore a further analysis of the moderation records was done to establish the trends in the periodic marking performance of teams and discussed.

CHAPTER 5: CONCLUSION

5.1 Introduction

This chapter gives the conclusion drawn from the discussion of the analyzed data in chapter 4. It also includes the suggestion on the probable value of the study. The chapter further points out the possible limitations of the study. Lastly, it gives suggestions for further research.

5.2 Differences in marking performance

There were significant differences in the marking performance of JSC mathematics markers. Markers who performed well in the test in many cases showed a good performance in their marking.

The marking performance of markers in the three categories was affected in different ways by the factors highlighted by the research. The markers' marking performance was influenced by their mathematical content knowledge. However, results also show that marker's mathematics content knowledge needed for the marking practice cannot be measured only by their formal mathematical qualification. This is because markers come from different socioeconomic backgrounds and this seemed to have affected the development and expansion of their mathematical content knowledge. On one hand some markers tend to think that poor background has influenced the level of their content knowledge. On the other hand Johanna who had no formal training in mathematics yet had performed well in the test and the marking. As mentioned by Kilpatrick, Swafford and Findell (2001) it does not follow that the more advanced qualifications a teacher have in mathematics the better his or her performance in teaching activities in mathematics is Johanna seems to have had resources available and people who were willing and able to help her learn. Therefore, the findings support the policies like ETSIP policies that are aimed to improve teachers' mathematical content knowledge. At the same time, the findings tend to challenge the policies mentioned above that enough is not done. In other words although efforts were done to improve the teacher's mathematical content knowledge through out the country, a lot still needs to be done. For example, adequate resources still need to be made available in all the regions especially regions with socially disadvantaged communities.

The result also shows that for some markers the moderators' input is not immediately apparent in some of the questions. The markers continued making mistakes until the end of the marking session. This was shown by the periodic marking error score assigned. Example Selma (poor marker) had a marking error score of 266 after the first 20 moderated scripts, 181 after the second 20 moderated scripts, 244 after the third 20 moderated scripts, 173 after the forth 20 moderated scripts and 167 after the last few scripts moderated. When this is compared to Thomas (good marker) who had a marking error score of 59 after the first 20 moderated scripts, 74 after the second 20 moderated scripts, 120 after the third 20 moderated scripts, 33 after the forth 20 moderated scripts and 0 after the last few scripts moderated the difference in continuous performance is clear.

This is also an indication that there were other factors that affected the marking performance other than the markers content knowledge. These as shown by the research findings were, the influence of the moderators input, the markers understanding of the marking process, the markers interpretation and usage of the marking scheme and the markers marking experience. Although some of the factors were directly influenced by the markers content knowledge example the markers interpretation and usage of the marking scheme the research data shows that some markers who performed fairly well in the test, performed poorly in the marking. A good example is Selma who had a 23/30 in the test but yet was a poor marker.

The research findings also revealed that the moderators' standardisation meeting and their input when providing feedback on errors made by markers had contributed to the differences in marking performance of the JSC mathematics national examination markers for 2007. It was shocking to realise that some teams had all their markers categorised as either poor or average markers. Other teams had all their markers categorised as good markers. This highlighted the differences in the leaders' performance and the effectiveness of their training and continuous feedback.

The findings also suggest that the markers' marking performance can be improved by extending the markers' training session for markers identified as weak during the trial marking as said by Thomas. Extending the marking period or reducing the number of scripts assigned to markers can also improve marking performance.

5.3 Possible value of the study

Very few studies are available on the issue of national examination marking and the quality of markers. Therefore the study will help in informing the academic community on the possible influences of the markers' performance in marking.

The research provided a better understanding of ways in which limited mathematical proficiency could relate to poor marking performance of teachers involved in the grade 10 mathematics marking. It has also shown that there are other factors (than the markers' mathematics proficiency) that are affecting the marking performance of mathematics markers. It has suggested ways to improve the situation and help DNEA to have enough competent markers in the future.

Finally, the research would help Namibian grade 10 mathematics teachers to better understand the possible influence of their own mathematical proficiency on their marking of the national examination and of their own assessment tools at school. Consequently, this would contribute to improving mathematical instruction and the general reliability of examination results in schools and as a result, improves learners' performance in the national examination.

5.4 Limitations

One of the limitations is that the study involved a small group of markers who were different from each other in many ways and they came from different regions of Namibia with different backgrounds. Some were from a socially and economically disadvantaged society than others.

A further limitation is that the study involved one examination paper out of the two. Using the other paper or even different subjects might have generated different results. Another cause of concern is how effective the test on measuring the teachers' content knowledge. In addition, there is no way of knowing how serious the markers took the test and the interview; whether they took time to work out the answers or they just guessed. Finally another source of limitation is that the marking period is limited to one week, which forced me to do the pilot of the test and interview before the marking started. Further research would need the marking period to be extended to allow time for evaluation of piloting.

5.5 Recommendations and further research

The study created an opportunity to the direction of further research. In this study it would be of assistance to carry out an investigation to find out if the impact of the moderators input on the differences in the marking performance of markers could be within all subject whose examination are marked under the supervision of DNEA.

I would recommend that DNEA implement testing teachers' subject content knowledge as a method of selecting markers. This would help to identify poor markers in advance and possibly provide extra training on the topics poorly performed.

Finally, further research on developing an objective markers grading tool based on their record of moderation could help in the objective selection of future good and affective team leaders.

6. REFERENCES

Ball D. L. (1989). *Breaking with experience in learning to teach mathematics: The role of the pre service methods course.* East Lansing: National Centre for Research on Teacher Learning, Michigan University.

Ball D. L. (1990). The mathematical understanding that prospective teachers bring to teacher education. *Elementary School Journal, 90,* 449-466.

Ball D. L. (2003). *Mathematics proficiency for all students: Toward a strategic research and development program in mathematics education.* RAND: Arlington.

Battista, M.T. (1994). Teacher beliefs and the reform movement in mathematics education. *Phi Delta Kappan. 75,* 462-470.

Boaler, J. (1997). *Experiencing school mathematics: Teaching styles, sex and setting.* Buckingham, UK: Open University Press.

Brink, D (2008). *Mathematical knowledge for teaching (MKT): What is it? Why does it matter? How do I obtain more of it?* Proceedings of Namibian mathematics teachers congress: Swakopmund.

Carpenter, T.P. (1988). Teaching as a problem solving. In R. I. Charles & E. A. Silver (Ed), *The teaching and assessing mathematical problem solving. 9,* 187-202. Reston, VA: National Council of Teachers of Mathematics.

Creswell, J.W. (1998). *Qualitative inquiry and research design. Choosing among five traditions.* Thousand Oaks, CA: Sage.

Creswell, J.W. (2003). Research design. *Qualitative, quantitative and mixed methods approaches.* Thousand Oaks, CA: Sage

Crisp, V. (2008) A review of literature regarding the validity of coursework and the rationale for its inclusion in the GCSE. *Research Matters, 5,* 20-24.

Cohen, J., Cohen P., West, S.G., & Aiken, L.S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.) Hillsdale, NJ: Lawrence Erlbaum Associates.

Cohen, L., Manion L. and Morison. K. (2000). *Research methods in education* (5th ed.). London: Routledge.

Deno, S.L. (1992). The nature and development of curriculum-based measurement. *Preventing School Failure, 36,* 5–10.

English, L.D (1997) Analogies, metaphors, and images: Vehicles for mathematical reasoning. In L. D. English (Ed.), *Mathematical reasoning: analogies, metaphors and images* (pp. 3-18). Mahwah, NJ: Erlbaum.

Ernest, P. (1991). *The Philosophy of Mathematics.* London: The Falmer press

Fennema, E., & Franke, M. L. (1992). Teachers' knowledge and its impact. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 147-164). New York: Macmillan.

Fenstermacher, G. (1986) Philosophy of research on teaching: three aspects, in: M. C. Wittrock: (Ed.) *Handbook of Research on Teaching,* (3rd ed.) (pp. 37-49). New York: Macmillan.

Fuchs, L.S., & Fuchs, D. (1986). Effects of systematic formative evaluation on student achievement: *A Meta-analysis. Exceptional Children,* 53, 199–208.

Galliers, R. D (1991) Strategic information system planning: Myth, reality and guidelines for successful implementation, *European Journal of Information System,* 1(1): 55-64

Janse van Rensburg, E. (2001) *An orientation to research.* Grahamstown: Rhodes environmental education unit.

Hoge, R.D., & Coladarci, T. (1989). Teacher-based judgments of academic achievement: *A review of literature. Review of Educational Research*, 59, 297–313.

Kilpatrick, J., Swafford, J. & Findell, B. (Eds.) (2001). *Adding it up: Helping children learn mathematics.* Washington, DC: National Academy Press

Leinhardt, G. & Smith, D. A. (1985).Expertise in mathematics instruction: Subject matter knowledge. *Journal of Educational Psychology,* 77, 247-271.

Martens, B.K., & Witt, J.C. (2004). Competence, persistence, and success: The positive psychology of behavioral skill instruction. *Psychology in the Schools*, 41, 19–30.

Mewborn D. (2001) Teachers content knowledge, teacher education, and their effects on the preparation of elementary teachers in the United States. *Mathematics Education Research Journal.* 3, 28-36.

Munby, H., Russell, T. & Martin, A. K. (2001) Teacher's knowledge and how it developes. In V. Richardson (Ed.), *Handbook of research on teaching (4th ed.)* (pp. 877-904). Washington DC: American Educational Research Association.

Nadas, R & Suto, I (2008) An exploration of self-confidence and insight into marking accuracy among GCSE maths and physics markers. *Research Matters,* 5, 9-15.

Namibia. Ministry of Education and Culture (1993) *Towards education for all: A development brief for education, culture and training.* Windhoek: Gamsberg Macmillan.

Namibia. Ministry of Basic Education Sport and Culture (2001) *Guidelines for teachers on setting and marking assessments.* Windhoek: DNEA.

Namibia. Ministry of Basic Education Sport and Culture (2002) *Improving mathematics in Namibia: Report of a national consultative process with recommendations.* Windhoek: Ministry of Education.

Namibia. Ministry of Education (2006 a) *Education and training sector improvement programme(ETSIP): Planning for a learning nation.* Windhoek: Ministry of Education.

Namibia. Ministry of Education. (2006 b) *Junior secondary phase: mathematics syllabus grade 8-10 including additional mathematics grades 9-10.* Okahandja: NIED.

Namibia. Ministry of Education (2007)(a). *Duties for markers for the October 2007 JSC examination.* Windhoek: DNEA.

Namibia. Ministry of Education (2007 c). *DNEA circular 36/2007: Recruitment of markers for the October 2007 JSC examination.* Windhoek: DNEA.

Namibia. Ministry of Education (2007 d). *Report on examination:JSC* Windhoek: DNEA.

Njabili, A. F (1993) *Practical guide for classroom measurement and testing: The basic essentials.*Dar es Salaam: Mture.

Patton, M.Q (1990). *Qualitative evaluation and research methods.* 2nd Edition. California: Sage.

Shepard L. A. (2001) The role of classroom assessment in teaching and learning. In V. Richardson (Ed.), *Handbook of research on teaching (4th ed.)* (pp. 106-611). Washington DC: American Educational Research Association.

Shinn, M.R., & Bamonto, S. (1998). Advanced applications of curriculum-based measurement: "Big ideas" and avoiding confusion. In M.R. Shinn (Ed.). *Advanced applications of curriculum-based measurement* (pp. 1–31). New York: Guilford Press.

Shulman, D. (1986) Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15, 4-14.

Shulman, L. (1987) Knowledge and teaching: foundations of the new reform, Harvard Educational Review, 57, 1-22.

Shulman, L. S (1988) Disciplines of inquiry in education: An overview. In R.M Jaeger (Ed), *Complementary methods for research in education. (pp.3-23).* Washington: AERA

Suto, I., Crisp, V. & Greatorex J. (2008) Investigating the judgmental marking process: an overview of our recent research. *Research Matters,* 5, 6-9.

Tjikuua, C. U. (2000) *Science education reform in Namibia.* Washington DC: World Bank.

Webb, N. L. (1992). Assessment of students' knowledge of mathematics: Steps towards a theory. In D.A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 661-683). New York: Macmillan.

Wragg E. C. (2001). *Assessment and learning in secondary school.* London: Routledge Falmer.

Von Glaserfeld, E. (1987). Learning as a constructive activity. In C Janvier (Ed.) *Problems of representation in the teaching and learning of Mathematic.* Lawrence Erlbaum: Hillslade NJ (pp. 41-69)

APPENDICES

APPENDIX A

Table: Question By Question Comparison Of Good Markers

Marker	Incorrect Test Questions		Incorrectly Marked Question		
	No	Topic	No	Topic	Total Errors
M1(Thomas)	None	_	1a 1b	Number concept (standard form)	1 1
	None		2	Number concept (sequence)	1
	None		3a 3c	Indices	1 1
	None		4b	Money and finance	3
	None		6b 6d	Money and finance (simple interest)	1 2
	None		7a 7c	Money and finance	2 1
	None		8d	Measurements (Volume)	1
	None		9c	Measurements (Area)	1
	None		10b	Algebra	1
	None		12b 12c	Graphs and functions + geometry	1 1
	None		13b	Statistics and probability	1
	None		14c	Ratio, rate and percentage, fraction percentage	1
	None		17a 17b	Geometry: Transformation	2 1
	None		18b 18c	Geometry (angels & and length of sides)	3 1
M2 (5:05)	25	Ratio, rate and proportion	1b	Number concept (standard form)	2
	None		2a	Number concept (sequence)	1
	None		3a	Indices	1
	None		4b	Money and finance	2
	None		5	Money and finance (compound interest)	4
	None		6a 6c	Money and finance (simple interest)	1 2
	None		7b 7c	Money and finance	2 1
	None		8c	Measurements	3

				(Volume)	
	None		10a 10b	Algebra	1 2
	None		12c	Graphs and functions + geometry	2
	None		13	Statistics and probability	1
	None		14c	Ratio, rate and percentage, fraction percentage	1
	None		16b 16c	Geometry	2 2
	None		18a 18b 18c	Geometry (angels & and length of sides)	1 2 1
M 3 (Johanna)	18	Money and finance	4b	Money and finance	2
	24	Statistics and probability	6b 6d	Money and finance (simple interest)	1 1
			8a 8b 8c	Measurements (Volume)	2 1 1
			9a	Measurements (Area)	1
			10a	Algebra	1
			13c	Statistics and probability	1

APPENDIX B

***Table:** Question By Question Comparison Of Average Markers*

Marker	Incorrect Test Questions		Incorrectly Marked Questions		
	No	Topic	No	Topic	Total Errors
M4 (2:02)	18	Money and finance	1a 1b	Number concept (standard form)	3 1
	None		4a 4b	Ratio, rates, percentage & money and finance s	1 2
	None		5	Money and finance (compound interest)	2
	None		6a 6b 6c 6d	Money and finance (simple interest)	1 1 1 1
	None		7a 7b 7c	Ratio, Money and finance (cost)	2 3 4
	None		8a 8b 8d	Measures (volume, ratio)	2 1 1
	None		9a 9c	Measures (area)	1 4
	None		12b 12c	Graphs and functions, geometry	1 1
	None		13a 13b 13c	Statistics and probabilities	1 1 1
	None		14a	Rate, ratio and percentage	1
	None		15a	Geometry (size of angles)	1
	None		18b 18c	Geometry (angels & and length of sides)	2 6
M5 (3:04)	4	Number concepts (multiplication)	1a 1b	Number concept (standard form)	2 1
	None		2a 2b 2c	Number concepts (sequence)	1 1 1
	None		3a 3c	Number concepts (indices)	4 1
	None		4a 4b	Ratio, rates, percentage & money and finance s	2 1
	None		5	Money and finance	6

				(compound interest)	
	None		6a 6b 6c 6d	Money and finance (simple interest)	1 2 1 2
	None		7a 7b 7c	Ratio, Money and finance (cost)	1 2 1
	None		8b 8c 8d	Measures (volume, ratio)	2 1 4
	None		9a 9b 9c	Measures (area)	1 3 1
	None		10a 10b	Algebra (simplify)	2 2
	None		12b 12c	Graphs and functions, geometry	3 1
	None		13b 13c	Statistics and probabilities	1 1
	None		14a 14b 14c	Rate, ratio and percentage	1 2 3
	None		15a	Geometry (size of angles)	1
	None		16a 16c	Geometry (size of angles)	1 1
	None		17a 17b	Geometry (transformation)	1 1
	None		18a 18b 18c	Geometry (angels & and length of sides)	1 3 4
M6 (4:02)	5	Money and finance	1a	Number concept (standard form)	2
	18	Money and finance	2c	Number concepts (sequence)	1
	27	Ratio, rate and proportion	4b	Ratio, rates, percentage & money	8

				and finance s	
	None		5	Money and finance (compound interest)	4
	None		6b 6c 6d	Money and finance (simple interest)	3 2 4
	None		7a 7b 7c	Ratio, Money and finance (cost)	1 1 1
	None		8b 8c 8d	Measures (volume, ratio)	1 2 6
	None		9a 9c	Measures (area)	2 1
	None		10b 10c	Algebra (simplify)	4 4
	None		12b 12c	Graphs and functions, geometry	1 1
	None		13b	Statistics and probabilities	1
	None		14a 14c	Rate, ratio and percentage	1 3
	None		16a 16c	Geometry (size of angles)	1 1
	None		17b	Geometry (transformation)	1
	None		18b 18c	Geometry (angels & and length of sides	3 3
M7 (7:07)	1	Statistics and probability	1a	Number concept (standard form)	2
	9	Number concepts (indices)	3a 3b	Number concepts (indices)	7 2
	10	Fractions percentages	4b 4c	Ratio, rates, percentage & money and finance s	3 1
	24	Statistics and probability	5	Money and finance (compound interest)	1
	30	Graphs and functions	6d	Money and finance (simple interest)	1
	None		7a 7b	Ratio, Money and finance (cost)	2 2
	None		8b 8c 8d	Measures (volume, ratio)	2 2 1
	None		9a 9d	Measures (area)	1 2
	None		10	Algebra (simplify)	1
	None		11	Algebra (word	2

				equation)	
	None		12b	Graphs and functions, geometry	2
	None		13c	Statistics and probabilities	1
	None		14c	Rate, ratio and percentage	6
	None		16c	Geometry (size of angles)	2
	None		17a	Geometry (transformation)	1
	None		18b	Geometry (angels & and length of sides)	2
M8 (Sara)	1	Statistics and probability	1 b	Number concept (standard form)	1
	9	Number concept	2 b	Number concept (sequence)	2
	14	Algebra (exponential functions); indices	3a 3c	Number concept (Indices)	5 1
	20	Algebra	4 b ii	Money and finance	1
	26	Statistics and probability	5	Money and finance (compound interest)	2
	28	Graphs and functions	6a 6b 6c 6d	Money and finance (simple interest)	1 1 1 1
	30	Graphs and functions	7b 7c	Money and finance	1 2
	None		8c 8b 8d	Measurements (Volume	1 1 1
	None		9 a	Measurements (Area)	1
	None		10 b	Algebra	1
	None		13b 13c	Statistics and probability	1 1
	None		14b 14c	Ratio, rate and percentage, fraction percentage	1 1
	None		16 c	Geometry	2
	None		17a 17b	Geometry: Transformation	1 2
	None		18b 18c	Geometry	2 3

APPENDIX C

***Table:** Question By Question Comparison Of Poor Markers*

Marker	Incorrect Test Questions		Incorrectly Marked Questions		
	No	Topic	No	Topic	Total Errors
M9 (2:07)	20	Algebra	1a 1b	Number concept (standard form)	4 5
	25	Ratio, rate and proportion	2a 2b	Number concepts (sequence)	3 2
	27	Ratio, rate and proportion	3a 3b 3c	Number concepts (indices)	4 1 1
	29	Graphs and functions	4a 4b 4c	Ratio, rates, percentage & money and finance s	1 7 1
	30	Graphs and functions	5	Money and finance (compound interest)	5
	None		6b 6c 6d	Money and finance (simple interest)	6 3 3
	None		7a 7b 7c	Ratio, Money and finance (cost)	5 3 3
	None		8a	Measures (volume, ratio)	1
	None		9b 9c	Measures (area)	1 1
	None		10a 10b	Algebra (simplify)	3 8
	None		11a	Algebra (word equation)	2
	None		12a 12b 12c	Graphs and functions, geometry	3 2 3
	None		13a 13b	Statistics and probabilities	3 1
	None		14c	Rate, ratio and percentage	2
	None		15d	Geometry (size of angles)	1
	None		16a 16c	Geometry (size of angles)	3 3
	None		17b	Geometry (transformation)	3
	None		18b 18c	Geometry (angels & and length of sides)	2 4
M10 (3:02)	3	Number concepts	1a 1b	Number concept (standard form)	2 1
	4	Number concepts	2b	Number concepts (sequence)	2

	8	Number concepts	3a 3c	Number concepts (indices)	5 1
	9	Number concepts (indices)	4b	Ratio, rates, percentage & money and finance s	5
	12	Algebra	5	Money and finance (compound interest)	1
	14	Number concepts (exponential equation); indices	6a 6b 6c	Money and finance (simple interest)	1 6 1
	15	Ratio, rate and proportion	7a 7b 7c	Ratio, Money and finance (cost)	2 2 2
	18	Money and finance	8c 8b	Measures (volume, ratio)	2 2
	19	Algebra	9a 9b 9c	Measures (area)	5 6 4
	20	Algebra	10a 10b	Algebra (simplify	5 4
	26	Statistics and probability	11c	Algebra (word equation)	2
	27	Ratio, rate and proportion	12a 12b 12c	Graphs and functions, geometry	2 2 2
	28	Graphs and functions	13b	Statistics and probabilities	5
	29	Graphs and functions	14c	Rate, ratio and percentage	4
	30	Graphs and functions (Parabola)	15a	Geometry (size of angles)	2
			16b 16c	Geometry (size of angles)	5 10
	None		17a 17b	Geometry (transformation)	4 2
	None		18b 18c	Geometry (angels & and length of sides)	2 3
M11 (6:06)	1	Statistics and probability	1a 1b	Number concept (standard form)	2 1
	5	Money and finance	2c	Number concepts (sequence)	2
	12	Algebra	3a 3c	Number concepts (indices)	1 4
	14	Algebra (exponential functions); indices	4b	Ratio, rates, percentage & money and finance s	1
	17	Money and finance	7a 7b 7c	Ratio, Money and finance (cost)	4 8 3
	24	Probability	8c	Measures (volume, ratio)	3

	25	Ratio, rate and proportion	9b	Measures (area)	2
	26	Statistics and probability	10b	Algebra (simplify)	3
	27	Ratio, rate and proportion	16c	Geometry (size of angles)	9
	28	Graphs and functions	17a 17c	Geometry (transformation)	2 1
	30	Graphs and functions (Parabola)	18c	Geometry (angels & and length of sides)	2
M12 (3:06)	12	Algebra	1a 1b	Number concept (standard form)	3 3
	13	Algebra (Indices)	2b 2c	Number concepts (sequence)	1 1
	14	Algebra (exponential functions); indices	3a 3b 3c	Number concepts (indices)	7 1 4
	24	Probability	4a 4b	Ratio, rates, percentage & money and finance s	1 13
	27	Algebra (Word equation)	5	Money and finance (compound interest)	4
	28	Graphs of functions (gradient of a line)	6a 6b 6c	Money and finance (simple interest)	5 5 6
	29	Graphs of functions (equation of a line)	7a 7c	Ratio, Money and finance (cost)	2 2
	30	Graphs of functions (parabola)	8c 8d	Measures (volume, ratio)	3 3
	None		9a 9c 9d	Measures (area)	3 4 1
	None		10b	Algebra (simplify)	4
	None		11a 11b	Algebra (word equation)	1 2
	None		12b 12c	Graphs and functions, geometry	5 2
	None		13a 13b 13c	Statistics and probabilities	1 2 5
	None		14b 14c	Rate, ratio and percentage	2 3
	None		15c 15d	Geometry (size of angles)	1 5
	None		16c	Geometry (size of angles)	4
	None		17a	Geometry (transformation)	1
	None		18b 18c	Geometry (angels & and length of sides)	3 4

M13 (Selma)	8	Number concept (time)	1 b	Number concept (standard form)	3
	9	Number concept (indices)	3 a	Indices	3
	10	Fractions percentages	4 b	Money and finance	4
	12	algebra	5	Money and finance (compound interest)	1
	19	algebra	6b 6c 6d	Money and finance (simple interest)	1 4 1
	20	algebra	7	Money and finance	4
	25	Ratio, rate and proportion	8a 8b 8c 8d	Measurements (Volume)	2 1 5 4
	26	Statistics and probability	9a 9b 9c 9d	Measurements (Area)	1 5 3 1
	27	Ratio, rate and proportion	10 b	Algebra	1
	28	Graphs and functions	12b 12c	Graphs and functions + geometry	3 3
	None		13a 13b 13c	Statistics and probability	1 3 1
	None		14 c	Ratio, rate and percentage, fraction percentage	4
	None		16b 16c	Geometry	1 1
	None		17 a	Geometry: Transformation	2
	None		18a 18b 18 c	Geometry	1 2 2

APPENDIX D

MINISTRY OF EDUCATION

DIRECTORATE OF NATIONAL EXAMINATIONS AND ASSESSMENT

RECORD OF MODERATION

NSSC Higher ☐ NSSC Ordinary ☐ JSC ☐

Subject: ____________________ **Paper:** ____________________

Subject Code: ____________________ **Chief Marker/Team Leader** ____________________

Marker's Name: ____________________ **Team Position:** ____________________

Centre No.	Candidate No.	Marker's Mark **(X)**	TL's Mark **(Y)**	CM's Mark **(Y)**	Difference **(Y-X)**	TL's Comments on questions and actions taken	Re-Marked (Y or N)	Action CM

Number moderated on page: __________ (25) Total number moderated of Marker:_________

Chief Marker's/ Team Leader's signature ________________________ Date _________________

Education Officer's signature ________________________ Date _________________

Instructions for Chief Markers/Assistant Chief Markers and Team Leaders

Chief Markers are required to moderate at least 10 % to 15 % of each Team Leaders' answer scripts, after the first 20 standardisation scripts were deducted. Also up to 2 % (JSC) and up to 5 % (NSSC) of the Markers' answer scripts must be moderated, of which 1 % should be moderated by the Team Leader.

If there is no Team Leaders, the Chief Marker must moderate 10 % to 15 % of each Marker's answer scripts, after the first 20 standardisation scripts were deducted.

Team Leaders are required to moderate at least 10 % to 15 % of each team Markers' answer scripts, after the first 20 standardisation scripts were deducted.

COMPLETED FORMS MUST BE RETAINED FOR THE GRADE REVIEW EXERCISE

APPENDIX E

MATHEMATICS DIAGNOSTIC TEST OCTOBER 2007

MARKERS CODE: | | | | |

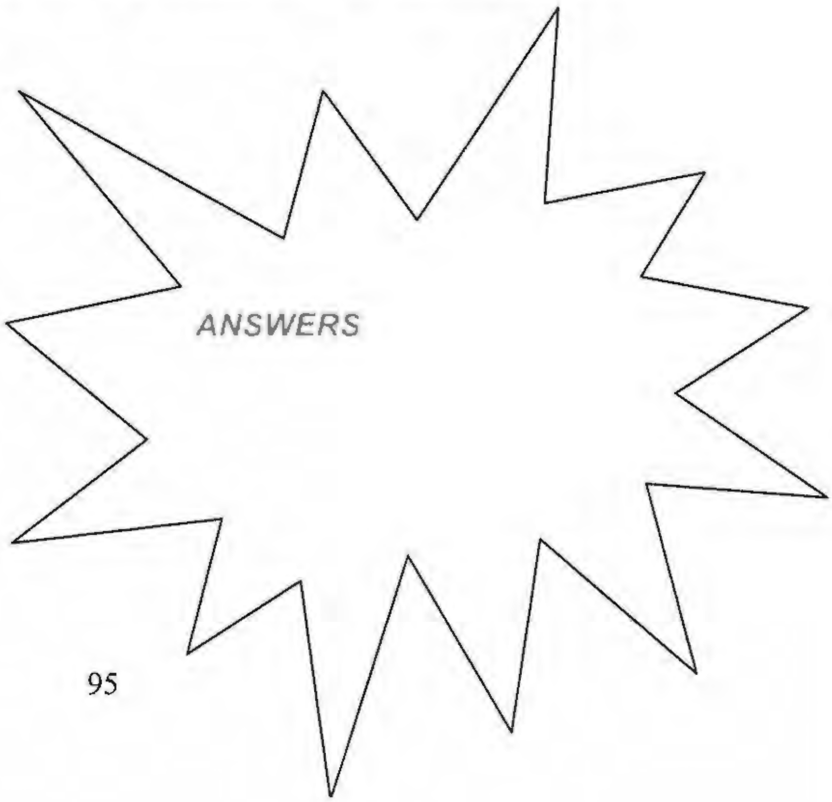
PAPER: | | (1 or 2)

READ THE INSTRUCTIONS BEFORE YOU START

There are 30 questions in this question paper. **Answer all questions.** For each question there are four possible answers labeled **A, B, C** and **D.** Using a pen/pencil make a tick in the box next to the option of your choice. **Show your working** in the blank box next to each question.

PLEASE DO NOT GUESS.

.



Question	Show your working
1. What is the average of 6, 8, 13, 16, 17 ☐ **A** 10 ☐ **B** 12 ☐ **C** 15 ☐ **D** 60	*B*
2. When we subtract 2.1356 from 4.0071 the answer is ☐ **A** 2.1356 ☐ **B** 2.8715 ☐ **C** 2.1285 ☐ **D** 1.8715	*D*
3. 0.000202 written in standard form give ☐ **A** 2.02×10^{-6} ☐ **B** 2.02×10^{-4} ☐ **C** 2.02×10^{4} ☐ **D** 2.02×10^{6}	*B*
4. What number multiplied by 6 gives -24 as a result ☐ **A** -18 ☐ **B** -4 ☐ **C** 4 ☐ **D** -144	*B*
5. After Ben wrote a check of N$ 329.09 his balance was N$ 2329.01. What was his balance before he wrote the check? ☐ **A** N$ 1999.11 ☐ **B** N$ 1658.10 ☐ **C** N$ 2658.10 ☐ **D** N$ 2987.19	*C*
6. The cake has a mass of 3.65kg. What is the mass of the cake in grams? ☐ **A** 3.65g ☐ **B** 36.5g ☐ **C** 365g ☐ **D** 3650g	*D*

7. The dimensions of a box are 14cm, 20cm and 8cm. What is the volume of the box? ☐ **A** 112 cm^3 ☐ **B** 240 cm^3 ☐ **C** 280 cm^3 ☐ **D** 2240 cm^3	*D*
8. A bus traveling from Windhoek to Swakopmund takes 6 hours 40 minutes to arrive. What time will it arrive in Swakopmund if it left Windhoek at 06:30? ☐ **A** 12 : 40 ☐ **B** 12 : 10 ☐ **C** 13 : 10 ☐ **D** 13 : 40	*C*
9. Which of the following is a rational number? ☐ **A** $\sqrt{5}$ ☐ **B** $\sqrt{2}+1$ ☐ **C** $\left(\sqrt{17}\right)^2$ ☐ **D** $7^{-\frac{1}{2}}$	*C*
10. Which of the following numbers is the largest? ☐ **A** $\frac{4}{5}$ ☐ **B** $\frac{7}{8}$ ☐ **C** $\frac{11}{13}$ ☐ **D** $\frac{23}{27}$	*B*

11. What is the next number in the following sequence; -4, -1, +2? ☐ **A** 1 ☐ **B** 3 ☐ **C** 4 ☐ **D** 5	*D*
12. What is the value of x in the following equation? $2x+\frac{3}{2}=5$ ☐ **A** $3\frac{1}{2}$ ☐ **B** 7 ☐ **C** $1\frac{3}{4}$ ☐ **D** 8	*C*
13. $\frac{4x^6}{2x^4}=$ ☐ **A** $2x^{10}$ ☐ **B** $2x^2$ ☐ **C** $3x^{\frac{3}{2}}$ ☐ **D** $2x^{\frac{2}{3}}$	*B*

14. What is the value of *n* in the following expression? $3^{1+n} = \frac{1}{81}$ ☐ **A** $-\frac{4}{5}$ ☐ **B** -5 ☐ **C** -4 ☐ **D** $-\frac{5}{4}$	*B*
15. Aune uses 250 g of flour to cook porridge for 5 people. How much flour would she use when cooking porridge for 2 people? ☐ **A** 25 g ☐ **B** 50 g ☐ **C** 75 g ☐ **D** 100 g	*D*
16. What is 175% of 250? ☐ **A** 187.5 ☐ **B** 1875 ☐ **C** 437.5 ☐ **D** 43.75	*C*
17. David bought a car for N$ 35 000. He sold it 2 years later making 20% profit. How much did he sell his car? ☐ **A** N$ 28 000 ☐ **B** N$ 42 000 ☐ **C** N$ 56 000 ☐ **D** N$ 84 000	*B*

18. Mrs. Mabuku invests N$ 5 000 in a bank, at simple interest rate of 12%. How much money will she receive in 2 years? ☐ **A** N$ 1 200 ☐ **B** N$ 5 600 ☐ **C** N$ 6 200 ☐ **D** N$ 11 200	*C*
19. When the expression $-4x^2-16xy$ is factorized completely, the answer is ☐ **A** $4x^2(-x-4y)$ ☐ **B** $-4x\ (-x-4y)$ ☐ **C** $-4x^2(1+4y)$ ☐ **D** $-4x(x+4y)$	*D*
20. $\frac{-4x^2}{3y} \div \frac{2x^2}{-9y^2}$ Simplified gives you ☐ **A** $\frac{8x^5}{27y^3}$ ☐ **B** $-6y$ ☐ **C** $6y$ ☐ **D** $\frac{27y^3}{8x^5}$	*C*

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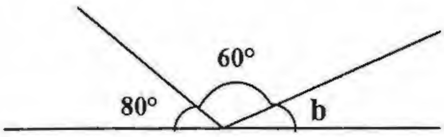
21.



What is the value of **b**?

☐ **A** 60°

☐ **B** 40°

☐ **C** 30°

☐ **D** 20°

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B

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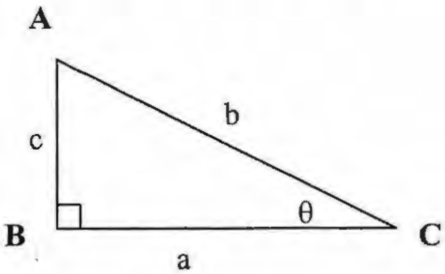
22.
ABC is a right-angled triangle.



What is the value of sin θ?

☐ **A** $\frac{a}{b}$

☐ **B** $\frac{c}{b}$

☐ **C** $\frac{c}{a}$

☐ **D** $\frac{a}{c}$

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B

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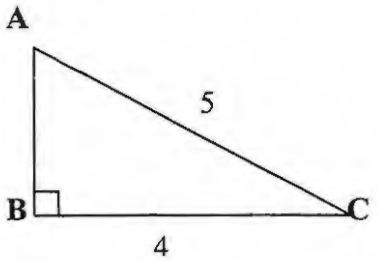
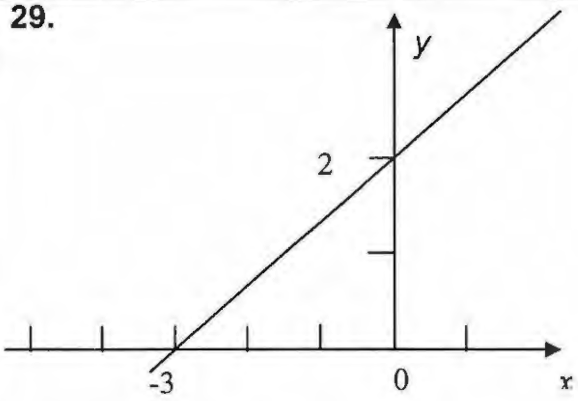
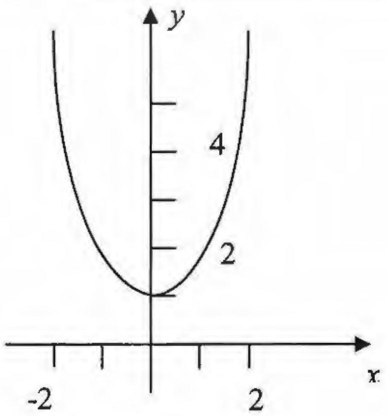
23. **ABC** is a right-angled triangle. If the length of **BC** = 4 and **AC** = 5  The length of AB is: ☐ **A** $\sqrt{5}$ ☐ **B** 3 ☐ **C** 2 ☐ **D** 1	*B*
24. A die has six faces, that are numbered 1 to 6. What is the probability that the die will land on 2 when tossed? ☐ **A** 6 ☐ **B** 3 ☐ **C** $\frac{1}{3}$ ☐ **D** $\frac{1}{6}$	*D*
25. In Babani Secondary School only 30 learners live in the school hostel. Each learner receives $\frac{3}{4}$ *l* of milk per day. A crate of milk contains 24 one-liter cartons of milk. How many crates of milk should the school buy to serve milk to 30 learners for two days? ☐ **A** 2 ☐ **B** 8 ☐ **C** 18	*A*

☐ **D** 32	
26. A learner obtain 75%, 77%, 65% and 62% in her first four tests. How much must she obtain in her fifth test in order to get an average of 75%? ☐ **A** 75 ☐ **B** 86 ☐ **C** 96 ☐ **D** 99	*C*
27. I a class of 42 learners the number of girls is equal to $\frac{3}{4}$ of the number of Boys. How many boys are in a class? ☐ **A** 14 ☐ **B** 24 ☐ **C** 28 ☐ **D** 21	*B*
28. What is the gradient of the line $-3y = 2x + 6$? ☐ **A** -6 ☐ **B** $-\frac{2}{3}$ ☐ **C** $\frac{2}{3}$ ☐ **D** 2	*B*

29.  What is the equation of the line? ☐ **A** $y=3x-2$ ☐ **B** $y=3x+2$ ☐ **C** $y=\frac{2}{3}x-2$ ☐ **D** $y=\frac{2}{3}x+2$	*D*
30.  The equation for the parabola is ☐ **A** $y=x+1$ ☐ **B** $y=x^2-1$ ☐ **C** $y=x^2+1$ ☐ **D** $y=x^2$	*C*

APPENDIX F

INTERVIEW QUESTIOINS

NOTE: *"I just had the opportunity to review your responses to the test you had written earlier. Thank you very much for taking part. Now I have some questions for you about your experiences of the test, in teaching and assessment and marking. You may skip any question if it causes any stress. Remember that your comments are strictly confidential and none of your remarks will be associated with you by name.*

In your consent form, you indicated your permission to allow tape recording of this interview. If that is still agreeable to you, I would like to turn on the recorder and begin our interview. Do you have any questions before we begin?"

A. As a teacher and a marker

1. What motivated you to become a teacher? (Motivation for Teaching) *Probe: past experiences as a student; model teachers; family profession; social status, economic factors; cultural factors*

2. What were the most useful or influential courses or experiences you had during your teacher training course that have impacted your teaching? Describe how and why these were especially useful. *(Probe for three responses)*

3. How do you think the mathematical content knowledge you learned during your teacher-training programme influence your work as a teacher?

4. Describe any specific content areas that you consider your strengths within the Namibian Grade 10 mathematics curriculum *(e.g., numbers, trigonometry, algebra, etc.).*

5. Describe the procedures for the end of the term examination at your school *(from the setting of question papers to the marking of the learners scripts)*

6. What motivated you to apply and become a marker for grade 10 mathematics?

7. How is the marking you are doing here different from what you do at school?

8. Given what you now know about assessment and marking national examination, what do you think should be done to improve national examination marking? Be specific and give reasons why these would have been useful in mathematics marking. *("Deficiencies")*

B. Diagnostic Test

9. How did you feel about the test that you wrote earlier in the week?

10. Was there any specific question, which was too easy for you? Please elaborate! *(Probe with a specific question in mind that was performed well)*

11. Was there any specific question that was difficult or unapproachable to you? (*Probe with a specific question in mind that was performed poorly)*

12. Are there any other issues that you would like to raise about specific questions in the test?

D. Additional Comments

13. Is there anything else you would like to tell me about your teaching experiences, teacher education or about the test? *(Other)*

14. How do you think **this test**, or **the content explored in this test** is relevant for your marking work?

Thank you very much for talking with me and for being available to write the test.

APPENDIX G

CONSENT FOR PARTICIPANTS
Research Information Sheet

Researcher: **Elizabeth Mutuku**
Education Officer: Science and Mathematics
Directorate of National Examination and Assessment
Ministry of Education
Phone: 0812846494

Exploring the mathematical content knowledge and skills of grade 10 mathematics national examination markers in Namibia*: A Case Study*

Teacher's Name____________________________________

Contact No.______________________________________

A research project is being conducted to explore the mathematical content knowledge and skills of grade 10 mathematics national examination markers in Namibia. The goal of this project is to investigate how the level of mathematical content knowledge and skills for some of the teachers used in the grade 10 mathematics marking have an influence on their marking.

The research is as part fulfilment of my masters programme with Rhodes University. In addition, it will provide information that will contribute to recommendations on the way forward for the Directorate of National Examination and Assessment (DNEA). Your experiences are important and vital to help me in this regard.

You will be asked to write a test and take part in an interview. The interview section will be centred on the content of the test and the examination being marked and may other issues about mathematics teaching, assessment and marking assessment. You are free to stop the interview at anytime, or refuse to participate with no penalty. Just inform me that you wish to stop or are feeling uncomfortable with the questions. The results of this project will be strictly confidential and no names or identifying factors will be used when the results are published. If you have any questions concerning the research project, feel free to ask me.

Research Consent Form

Exploring the mathematical content knowledge and skills of grade 10 mathematics national examination markers in Namibia: A Case Study

Researcher: **Elizabeth Mutuku**
Education Officer: Science and Mathematics
Directorate of National Examination and Assessment
Ministry of Education
Phone: 0812846494

- I have read the Information Sheet and the nature and the purpose of the research project has been explained to me. I understand and agree to take part.
- I understand that while information gained during the study may be **tape-recorded and published**, I will not be identified and my personal responses will remain confidential.
- I understand that I can withdraw from the study at any stage and this will not affect my status now or in the future.
- I have had an opportunity to discuss taking part in this study with the researcher.
- I confirm that I am over 18 years of age.

Name of Participant:______________________________

Signed: ____

Dated: ____

I certify that I have explained the study to the participant and consider that he/she understands what is involved.

Signed: ____

APPENDIX H

P.O.Box 20639
Windhoek, Namibia
Tel 061- 251479

19 September 2007

Mr IJF van der Merwe
The Director,
Directorate of National Examination and Assessment
Ministry of Education

Dear Sir

Permission to conduct a research with grade 10 mathematics markers.

The above refers; as per our discussion on 7 June 2007, I am hereby requesting your permission to conduct a research with the grade 10 mathematics markers.

The research will be aimed to evaluate the level of mathematical content knowledge and skills of grade 10 mathematics markers and to assess the influence these has on their marking practice.

The research data will be collected using a diagnostic test, which will be written by all markers within the period of one hour. Thereafter I will purposively select four teachers as my research sample and with their consent, I will conduct interviews and further evaluation. Further evaluation will include studying their moderation records compiled by their team leader or chief markers during the marking.

Despite the fact that the research is in part fulfilment of my masters course, I strongly believe this research will benefit the Directorate of National Examination and Assessment in finding the possible causes of poor performance in marking by some markers and hopefully lead us to possible solutions for this problem.

Thank you for your endless support in this matter and for considering this request.

Respectfully,
Elizabeth Mutuku
EO: Science and Mathematics

APPENDIX I

REPUBLIC OF NAMIBIA

MINISTRY OF EDUCATION

DIRECTORATE NATIONAL EXAMINATIONS AND ASSESSMENT

File Number:

Enquiries: I.F.J. vd Merwe
Telephone: 2933432
Fax (061) 2933431

Government Office Park
Ground Floor
Luther Street
Private Bag 12026
WINDHOEK

25 September 2007

Ms E. Mutuku
P O Box 20639
WINDHOEK

Dear Ms Mutuku

Re: PERMISSION TO CONDUCT RESEARCH WITH GRADE 10 MATHEMATICS MARKERS

Your letter dated 19 September 2007 regarding the abovementioned matter refers.

Approval is herewith granted for you to conduct a research as part fulfilment of your masters course involving a number of JSC Mathematics markers. Please ensure to only involve people in your research who are willing to participate and also liaise with your immediate supervisor Mr L. Ras.

You are wished well with your studies and I am looking forward to the outcome of your research.

Yours faithfully

MINISTRY OF EDUCATION
EXAMINATIONS
25 SEP 2007
PRIVATE BAG 12026

I.F.J. VD MERWE
DIRECTOR: NATIONAL EXAMINATIONS AND ASSESSMENT