

**AN ANALYSIS OF THE DISTRIBUTION AND USE OF  
TEACHING AIDS IN MATHEMATICS IN SELECTED  
WINDHOEK SECONDARY SCHOOLS**

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## **ABSTRACT**

This study investigates the types of mathematics teaching aids available at both public and private secondary schools in Windhoek. The study characterises their usage and source as well as teachers' perceptions towards the use of such teaching resources in the Mathematics classroom. The study is grounded in an interpretive paradigm and employed a mixed methods approach to generate both quantitative and qualitative data in two sequential phases. Phase 1 of the research process, which involved 75 Mathematics teachers, took the form of an audit of the availability and use of teaching aids at 25 secondary schools in Windhoek. A case study methodology was adopted in Phase 2 which focused on five purposively selected schools that displayed different characteristics in terms of the availability of teaching resources. The study found that the majority of teachers at secondary schools in Windhoek have a positive attitude towards the importance and role of teaching aids in Mathematics, seeing them as promoters of hands-on engagement, visual reasoning, active participation and motivation amongst learners. However, in some instances schools are under-resourced with respect to certain types of teaching aids, specifically graph boards, geoboards, geometric models and computers. A need for appropriate in-school support on the use of teaching aids was also identified.

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I dedicate this thesis to my wife Doreen, my daughter Tatenda and my son Tinayeishe for just being there for me. My wife gave me her support and encouragement as I went through long hours of reading and writing. My children went for a long time without daddy's care as I sacrificed most of my time to this study! I promise to make up for the lost time.

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## **ABBREVIATIONS USED**

BETD	Basic Education Teacher Diploma
ICT	Information and Communication Technology
IGCSE	International General Certificate of Secondary Education
LCE	Learner-Centred Education
MBEC	Ministry of Basic Education and Culture
MEC	Ministry of Education and Culture
MoE	Ministry of Education
NCTM	National Council of Teachers of Mathematics
PDL	Physically Distributed Learning
SBS	School-Based Studies
ZPD	Zone of Proximal Development

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# CHAPTER 1

## INTRODUCTION OF THE STUDY

*Knowing about and understanding teachers, learners, content, or environments - or even knowing and understanding all of these entities - is not a substitute for knowing about and understanding the dynamic relationships among them that constitute the core of the educational process.*

(Ball & Forzani, 2007, p. 531)

### 1.1 INTRODUCTION

The main focus of this study is to assess the availability and usage of teaching aids at secondary schools in the Windhoek metropolitan area, as well as to elicit the perceptions of teachers towards the use of teaching aids in their Mathematics lessons. This chapter introduces the study. Firstly the contextual background and landscape of the study is described, followed by brief descriptions of the research goals, research design and the research process. The chapter concludes with a brief overview of the structure of the thesis.

### 1.2 CONTEXT OF THE RESEARCH

The educational system in Namibia went through a process of transformation after the country obtained political independence in 1990. The new government's vision to bring about quality education for all its citizenry in the post-independence era, as well as the expectations that it held for teachers, was clearly articulated in the policy document on quality education:

The most important challenge in improving the quality of our education system is to ensure that our teachers are well prepared for the major responsibilities they carry. More than anything else, it is the teachers who structure the learning environment. It is they who can keep learning exciting and satisfying or alternatively who make schooling a pain. (MEC, 1993, p. 37)

Bearing in mind that learner-centred education (LCE) was at the heart of the new educational system, the policy on quality education further recognized that the challenge was "to develop instructional strategies that make it possible for learners from varying backgrounds and with differing abilities to all progress" (MEC, 1993, p. 39). It further stipulated that the basic education system saw Mathematics as a subject designed to promote functional numeracy and mathematical thinking by helping learners to develop positive attitudes towards the subject,

acquire basic mathematical concepts as well as to develop a “lively, questioning, appreciative and creative intellect” (p. 56). The use of appropriate teaching aids and resources was encouraged as a potential means to achieve this vision. The Broad Curriculum document of the Basic Education Teacher Diploma (BETD) in Namibia clearly outlines the Ministry of Education’s expectations from teachers with regard to LCE and the usage of teaching aids in schools:

Teachers should be able to select content and methods on the basis of the learners’ needs, use local and natural resources as an alternative or supplement to readymade study materials and thus develop their own and the learners’ creativity. A learner-centred approach demands a high degree of learner participation, contribution and production. (Ministry of Education [MoE], 2009, p. 2)

Teachers not only play a pivotal role in the teaching of mathematics in a learner-centred environment but facilitate the participation of all learners through the use of teaching resources. The Namibian teacher is therefore expected to spearhead the teaching and learning process by encouraging active involvement and participation of learners.

It is almost two decades after the original policy document on education spelled out the roadmap to quality education in Namibia, and the question is: How successful has the laying down of teaching methods and teaching approaches been in creating an educational environment where quality, efficiency and effectiveness in learning and teaching prevail in schools? As a teacher educator working with trainee Mathematics teachers both at upper primary and junior secondary level I have had the privilege of visiting these student teachers during their teaching practice sessions at some of the schools in the Windhoek metropolitan area. The lesson observations during student teachers’ school-based studies (SBS) generally encompassed evaluating both the preparation and lesson presentation activities. Feedback from student teachers showed that in many cases very little support was being provided to student teachers by their qualified mentor teachers in the schools in terms of the effective use of teaching aids in Mathematics. This situation resulted in a critical gap between theory and practice, and this was the impetus for me to carry out a study on teaching resources in the Namibian context.

### **1.3 RESEARCH GOALS**

The purpose of this study is to audit the availability and use of Mathematics teaching aids found in secondary schools situated in Windhoek, as well as to ascertain the perceptions of teachers towards the use of such tools in their everyday lessons. Three important research questions frame the study:

- 1) What type of teaching and learning aids are available for Mathematics teachers in the private and public secondary schools in Windhoek?
- 2) What is the nature or character of the use of the available teaching aids?
- 3) What are the teachers' general perceptions on the availability and use of teaching aids in Mathematics at secondary school level?

### **1.4 RESEARCH DESIGN**

This study is orientated in the interpretive paradigm (Creswell, 2003) and employed a mixed methods approach to gather data in two clear sequential stages, obtaining both quantitative as well as qualitative data (Maree, 2007). In the first phase, quantitative data was collected from 75 teachers at 25 secondary schools in the Windhoek metropolitan area by means of a questionnaire. This provided the initial data with regard to the overall availability and use of teaching aids in Mathematics. Thereafter, the results of the audit were used to purposefully select five secondary schools from which qualitative data was collected by means of an instrumental case study (Yin, 2009, p. 18) in order to investigate teachers' perceptions regarding the use of teaching aids in the Mathematics classroom and to develop an understanding of teacher practice in relation to the use of teaching aids in their respective schools. The primary reason for choosing a mixed methods design was to use the qualitative data "to help clarify issues that arose from the quantitative results" (Maree, 2007, p. 272).

### **1.5 RESEARCH PROCESS**

The combination of two sequential phases in gathering both quantitative and qualitative data aimed at providing a form of triangulation to ensure greater validity and reliability of the data and findings. The research was conducted in the Windhoek urban area where the researcher works. The choice of Windhoek as the research site was a purposeful and pragmatic decision

which allowed the researcher convenient access to all schools during both phases of the data acquisition process.

### **Phase 1**

Phase 1 took the form of a teaching aid audit. A structured questionnaire with a list of various teaching aids was used during the audit to determine the availability, use and source of these teaching aids. The researcher piloted the questionnaire and feedback from this pilot process was used to refine the questionnaire.

### **Phase 2**

Phase 2 took the form of a case study. Purposeful sampling in the second phase of the research targeted teachers from five selected schools based on Phase 1 quantitative data. The five selected schools included (i) two schools that had adequate resources and showed good practice in the use of teaching aids, (ii) two schools where the availability of teaching aids was a great challenge, and (iii) one school with a moderate supply of teaching resources. Semi-structured interviews were conducted with teachers from these schools guided by data stemming from Phase 1 of the study.

## **1.6 OVERVIEW OF THE THESIS**

This section provides a brief overview of the following chapters in the thesis.

**Chapter two** examines literature relevant to the study, commencing with a focus on the rationale for using teaching aids in Mathematics lessons at secondary school level. This is followed by a review of literature on how past and current research has characterized teaching aids in the teaching and learning process. The theoretical rationale for how learner-centered education relates to the use of teaching aids in mathematics is then discussed. Finally, the conceptual framework of Kilpatrick, et al.'s (2001) teaching for mathematical proficiency is reviewed with specific reference to the strands of conceptual understanding and productive disposition.

**Chapter 3** provides an outline and description of the methodology used in this study. This chapter encompasses the research goals, research orientation, research design, the data collection methods, sampling, data analysis, the ethical considerations as well as issues pertaining to validity.

**Chapter 4** deals with the presentation, analysis and discussion of both the quantitative and qualitative data collected during the study. The quantitative data is used to draw up a rich profile of the availability, use and source of teaching aids in the Windhoek metropolitan area. The chapter concludes with a discussion of the qualitative data in terms of emerging themes: the hands-on nature of concrete objects; reality and visualization; enhanced teaching of concepts; active participation and interest; inadequate resources and the need to improvise; motivation and learner performance; and time and support from the ministry.

**Chapter 5** is the final chapter of the thesis and provides a summary of the research findings along with a brief discussion of the limitations as well as the significance of the study. The chapter concludes with recommendations for future research.

## CHAPTER 2

### LITERATURE REVIEW

*Manipulative materials in teaching mathematics to students hold the promise that manipulatives will help students understand mathematics.*

(Heddens, 1997)

#### 2.1 INTRODUCTION

The purpose of this chapter is to provide a contextual backdrop to the study. Firstly, the rationale for using teaching aids at secondary school level is discussed with particular reference to the Namibian context. This leads to a review of past and current research focusing on the different meanings or interpretations as well as the uses of teaching aids in Mathematics teaching and learning at school level. Thirdly, the theoretical rationale for how the learning theory of learner-centered education relates to the use of teaching aids in mathematics is discussed. In addition, the conceptual framework of Kilpatrick, et al.'s (2001) teaching for mathematical proficiency is reviewed with specific reference to the strands of conceptual understanding and productive disposition.

#### 2.2 THE RATIONALE OF USING TEACHING AIDS AT SECONDARY (MIDDLE) SCHOOL LEVEL

Learner-Centred Education (LCE) was introduced in 1991 as a foundation policy for the new educational system of Namibia after attainment of independence. The Ministry of Education and Culture (MEC) (2003) highlights the importance of the learners' active participation and meaningful contribution in a learner-centred approach:

Learning is seen as an interactive, shared and productive process where teaching creates learning opportunities which will enable learners to explore different ways of knowing and developing a whole range of their thinking abilities both within and across the whole curriculum. (MEC, 2003, p. 8)

However, the academic performance of learners in Mathematics in Grade 10 and Grade 12 in Namibian National Examinations has not been impressive in past years. The Government publication indicates for instance that in 2006 a total of 30 700 learners wrote Grade 10 Mathematics examinations but only 37.2% managed to obtain a mark greater than 50%. A

similar scenario was experienced in the Grade 12 Mathematics IGCSE of the same year where only 37.2% of the pupils who wrote the exam managed to obtain a pass, i.e. a mark above 45% (Ministry of Education [MoE], 2006, pp. 61-65). The trend in the failure of learners in Mathematics in Grade 10 and Grade 12 national examinations in subsequent years has not significantly changed. The need to improve the general understanding of basic concepts and academic performance in Mathematics at secondary school level cannot be ignored. To this end, classroom teachers and researchers have been urged “to improve the techniques to help children learn mathematical concepts and symbols by calling for greater use of concrete objects in lesson delivery” (Uttal, Scudder & DeLoache, 1997, p. 38).

As a teacher educator of mathematics working with trainee teachers, the importance of resources in the teaching of mathematics at secondary school level is strongly emphasized in the teacher training curriculum. However, formative as well as summative reports emanating from school visits during the teaching practice of student teachers indicate that qualified teachers are not comprehensively implementing the use of teaching aids in secondary school mathematics lessons.

The inadequate use of teaching aids in the teaching and learning of mathematics is by no means unique to Namibia. For example, according to Yara and Otieno (2010) the education system in Kenya has a number of shortcomings which include “inadequate teaching and learning resources in secondary schools” (p. 126) in mathematics. It is further claimed that most Kenyan secondary teachers are well trained and qualified to guide their learners, but “good teaching and learning materials seem not to be seen in most mathematics lessons” (Yara & Otieno, 2010, p. 126). In Nigeria, the teaching problems and lack of teaching aids have been cited as some of the major factors that contributed to poor performance in mathematics (Aburime, 2007). It also emerged that the uses of “simple, cheap, improvised manipulatives” (Aburime, 2007, p. 14) in teaching and learning have the potential to improve Mathematics achievement at secondary school level. Research showed that learners taught with eighteen simple geometric manipulatives constructed from ordinary cardboard paper outperformed a control group that did not use teaching aids (Aburime, 2007). Evidence from comprehensive studies carried out in the USA by Suydam and Higgins (1977) on the use of manipulatives concluded that “lessons using manipulative materials have a higher probability of producing greater mathematical achievement than do non-manipulative lessons” (p. 83).

The use of manipulatives produced superior student performance when compared with non-manipulative approaches as evidenced by achievement tests that were given in the research studies (Suydam & Higgins, 1977, p. 56). In the USA, when 32% of eighth graders fell below the basic proficiency level of mathematics many prominent mathematics educators blamed “ineffectual curricula and teaching methods” (Weiss, 2006, p. 239). In response to this observation, Weiss (2006, p. 238) proposed that the incorporation of appropriate mathematical manipulatives and teaching aids into the teaching and learning process may well go some way to rectifying this failing by enhancing the teaching of mathematical concepts and reasoning.

In a study on the influence of teaching aids in Mathematics (Raphael & Wahlstrom, 1989, p. 189) an examination of the interrelationships between the use of teaching aids, content coverage and student achievement was carried out on teachers and principals of 120 randomly selected schools in Canada. The study revealed that greater use of teaching aids in Mathematics at secondary school level allowed for greater coverage of topics. In the geometry lessons the occasional use of a variety of geometric teaching aids appeared to be the most effective in positively influencing student achievement. In examining the relationship between experienced teachers and the use of teaching aids it was also discovered that “more experienced teachers selected teaching aids as compared to less experienced teachers” (Raphael & Wahlstrom, 1989, p. 189). The availability and appropriate use of relevant teaching aids in schools are thus likely to enhance the teaching and learning of Mathematics.

A study in some of Nigeria’s districts revealed that learners “retain better what they have been taught” (Afolabi & Adeleke, 2010, p. 407) and their *interest* in learning mathematics is greatly sustained through the use of teaching aids. The use of teaching aids does not only improve learners’ perception of the learning experience itself but also provides an opportunity for learners to become actively involved in lessons (Van der Merwe & Van Rooyen, 2004, p. 229). The use of teaching aids also increases learners’ motivation by using attractive, interesting and challenging materials in the lesson. In a study carried out among 350 Taiwanese junior high school learners to explore the relationships between the adolescents’ mathematics attitudes and perceptions towards virtual manipulatives (Lee & Chen, 2010) it was concluded that the adolescents tended to be more satisfied with the use

and benefit of the manipulatives for problem-solving processes. The results of the study further suggest that the Taiwanese adolescents who displayed “relatively higher freedom from fear of learning mathematics” (Lee & Chen, 2010, p. 20) considered virtual manipulatives as easier control tools and believed that they enhanced their learning performance. This suggests that a positive perception of learners towards the use of teaching aids in mathematics lessons could also enhance learning, enhance motivation towards the subject and improve academic performance of the learners.

Maduna (2002) describes teaching aids as “constructed objects which represent reality” (p. 8) through which teachers are able to offer learners “an opportunity to reason and make their own deductions” (p. 8) while at the same time enhancing their natural tendency toward exploration and investigation. Moyer (2001) further supports this belief by pointing out that teaching aids are “objects that are designed to represent explicitly and concretely” (p. 176) abstract mathematical ideas. Teaching aids thus provide learners with hands-on experiences, and Mathematics teachers need to promote the use of a variety of teaching aids to help learners focus on the underlying mathematical concepts and skills.

In their study on the role of teaching aids in geometry and arithmetic tasks among young children, Martin, Lukong and Reaves (2007) cite a significant quantity of research claiming that working with teaching aids improves performance on mathematical tasks. Good mathematics teaching aids should be durable, simplistic, attractive and manageable (Heddens, 1997) because they will help learners “to relate real world situations to mathematics symbolism”. Teachers should therefore select teaching aids that are relevant to the topic/concept being discussed and are appropriate to the developmental level of the learners. An interesting observation according to Weiss (2006) is that substantial research on the “use and efficacy of manipulatives for elementary age and students with disabilities” has been intensive yet research on the use of teaching aids “for older and higher level mathematics is conspicuously lacking” (p. 240). It is further argued that although teaching aids have been widely used for learners with disabilities, their use might “be insightful for any teacher who is attempting to find methods to reach students who do not respond to learning mathematics in traditional ways” (Weiss, 2006, p. 240). Swan and Marshall (2010) emphasize that teachers should have a “clear understanding of how manipulatives assist children to learn

mathematics” (p. 16) because lack of such teaching knowledge is likely to have a negative impact on the learning itself.

In a survey of middle schools in Western Australia, Perry and Howard (as cited in Swan & Marshall, 2010, p. 16) found that the use of manipulatives was widely supported by most primary teachers across all years and for all fields of mathematics. Research studies on the use of teaching aids encouraged Swan and Marshall (2010) to stress that “professional development that deepens teachers’ knowledge of materials and their uses needs to be undertaken” (p. 16) because most teachers who had participated in the research studies believed that manipulatives benefit learners’ mathematics learning. It was observed in the same study that there was little use of teaching aids in secondary school mathematics while a significant percentage of teachers pointed out that they needed professional training on the use of teaching aids in the subject (Swan & Marshall, 2010, p. 18).

In advocating for the use of manipulative material in the learning of arithmetic and geometry, the concept of Physically Distributed Learning (PDL) demonstrates “that action with manipulatives supports learning when it provides a way for children to simultaneously and iteratively adapt and interpret their environment” (Martin, et al., 2007, p. 1). Many researchers and teachers believe that hands-on objects can help students learn mathematics concepts (NCTM & van de Walle, as cited in Martin, et al., 2007, p. 1). Numerous theorists and researchers on mathematics education have underscored the importance of manipulatives in both arithmetic and geometry contexts.

Traditional teaching of mathematics has focused more on rote or procedural aspects of learning, often at the expense of conceptual development. Weiss (2006, p. 239) points out that in the USA, the National Council of Teachers of Mathematics (NCTM) in 2000 developed principles and standards to address reform in the teaching of mathematics by putting emphasis on pedagogy that embraced students experiencing hands-on activities, encouraging conceptual understanding as well as strategic thinking – experiences that could readily be achieved through the use of teaching aids. This resonates with the Namibian focus on learner-centred education which foregrounds the importance of the learners’ active participation and meaningful contribution in a learner-centred approach (MEC, 2003).

The use of teaching aids at secondary school level should be encouraged because their use promotes rather than hinders the process of learning mathematics. Learners who use teaching aids in mathematics have an advantage of mastering concepts through guided lessons and “experience the learning process through multiple senses” (Weiss, 2006, p. 242). However, on a note of caution, teaching aids alone should not be seen to have an isolated impact on the overall academic performance of learners but should rather be seen as “one component in effective teaching” (Weiss, 2006, p. 240) – one component of a complex process.

### **2.3 THE DIFFERENT MEANINGS AND USES OF “TEACHING AIDS” IN MATHEMATICS**

Mathematicians have used a variety of tools and teaching aids to support the learning of mathematics throughout history (Durmus & Karakirik, 2006). The types of teaching aids that will be focused on in this particular study include graph boards, interactive whiteboards, geoboards, mathematical instruments for the chalkboard, charts and posters, geometric models, mathematical sets, calculators, graph paper, overhead projectors, computers, improvised teaching aids made using available resources, as well as any other physical artefact that facilitates teaching and learning. Since the terminology used in the research literature is somewhat inconsistent with respect to teaching aids, what follows is an attempt to make sense of the terminological terrain.

Teaching aids have been defined as objects that a teacher uses, or which are given to learners to use, in order to achieve specific learning and teaching outcomes (Van der Merwe & Van Rooyen, 2004, p. 229). Teaching aids, which Van der Merwe and Van Rooyen (2006) refer to as teaching media, can be divided into three groups: (i) media encouraging *concrete* experiences, (ii) media encouraging *iconic* experiences, and (iii) media encouraging *abstract* experiences (p. 229). Examples of *concrete* experiences are practical lessons or working with models or replicas. The second group of *iconic* experiences includes pictures, drawings, posters, slides etc., while the third group of *abstract* experiences can be in form of maps, diagrams, etc.

One type of teaching aid that is widely used in mathematics education is the so-called *manipulative*. Manipulatives represent a variety of physical objects that enhance learners’

understanding of concepts and relations and can be used to explore mathematical ideas by using a hands-on approach. Such manipulatives include base ten blocks, algebra tiles, fraction pieces, pattern blocks as well as geometric solids that can make abstract ideas and symbols more meaningful (Durmus & Karakirik, 2006). Mathematics manipulatives, according to Swan and Marshall (2010), are objects that can be “handled by an individual in a sensory manner during which conscious and unconscious mathematical thinking will be fostered” (p. 14). Furthermore, mathematics manipulatives have “the potential to lead to an awareness and development of concepts” (Swan & Marshall, 2010, p. 14) because hands-on learning builds a better understanding. The need for every learner to be provided with an opportunity to play with manipulatives in the teaching and learning process, rather than just concentrating on the teachers’ demonstrations, is underscored.

In addition to *physical* manipulatives there are also *virtual* manipulatives. Lee and Chen (2010) define *virtual* manipulatives as computer generated images that represent concrete objects and further assert that using such types of teaching aids in instruction represents “a new trend of integrating technology into mathematics teaching and learning” (p. 17).

Developments in modern technology, specifically audio-visual technology, are enabling learners and teachers to swiftly and easily access electronic audio-visual learning resources. Audio-visual media has been defined as “pictorial, graphic, and auditory media such as pictures, movies, audio or visual tapes, slides, charts, graphs, boards, etc. whose role is to supplement and support other instructional strategies and techniques” (Clark & Star, 1991, p. 379). In addition, different types of projectors such as slide projectors, overhead projectors and micro-projectors allow teachers to prepare their teaching content in advance thereby reducing the tedious job of copying material onto the chalkboard (Clark & Star, 1991, pp. 383-384). Audio-visual media can not only help clarify ideas and concepts but can also lead to interesting and vivid learning experiences. According to Clark and Star (1991), the “success of audio visual materials depends on skillful teaching” (p. 379) and they challenge teachers to consider the “suitability, visibility, clearness, level of understanding, ease of presentation and availability of the material” (p. 380) in selecting an audio-visual teaching aid. It should however be pointed out that the danger of using audio-visual aids such as films, video tapes etc. as instructional aids is that sometimes the learners think of these activities as recreational and thus might not pay full attention to them.

Ruthven and Hennessy (2002) describe in detail how various research studies conducted primarily in the educational systems of the USA and England in past decades have unearthed how successfully the use of computer-based teaching aids and resources have been integrated into mainstream teaching and learning (p. 50). According to Ruthven and Hennessy (2002) the use of the computer as a teaching aid has been applauded by many Mathematics teachers as effective “in providing drill, practice and reinforcement, and in supporting analytic, creative and independent thinking” (p. 49) in the teaching and learning of Mathematics. Ruthven and Hennessy (2002) found out that the use of computer-based tools and resources to support the Mathematics teaching led to improvement of motivation among the learners and the building of confidence as the learners enjoyed working with the computers. The number and range of activities completed by the learners over the course of the lesson also increased while the ICT provided variant mathematical strategies in contrast to those normally employed without the use of computers (Ruthven & Hennessy, 2002, p. 84).

The advancement in technology and the availability of powerful ICT tools such as digital cameras, scanners and internet access provide Mathematics teachers and learners with an abundant variety of digital images to harness and integrate everyday experiences from the outside world into the Mathematics classroom (Ahmed, Clark-Jeavons, & Oldknow, 2004, pp. 320-321). Digital images of physical features such as roof structures of buildings, bridges, etc. can be brought into the mathematics classroom for high school learners to discuss concepts such as geometry, sequences, translations, reflections, rotations, co-ordinate geometry, as well as the plotting of graphs. Ahmed, et al. (2004) assert that using digital images together with appropriate software “to provide geometric, numeric and algebraic tools for their analysis” (p. 322) would result in bringing the real world into classroom and further underscore that such images can be used for learners of all ages. In developing teachers’ use of technological tools it is imperative to identify how technological tools enhance the teaching and learning process as well as to ascertain teachers’ perceptions towards technology in relation to the mathematics being learnt (Ahmed, et al., 2004, p. 324). Ahmed, et al. (2004) maintain that the effective use of teaching aids used in the Mathematics classroom will greatly depend on the “type of tasks provided to learners, the role of the teacher as well as the climate and social culture of the classroom” (p. 327).

Ahmed, et al. (2004) define teaching aids or didactical materials as encompassing “structured and unstructured materials, including computers and calculators, used to support the teaching and learning of mathematics” (p. 314). Ahmed, et al. (2004) remark that the major reasons why mathematics is taught and how it can be learnt effectively are “bound to influence the approach to teaching” (p. 316) and consequently the use of teaching aids. Ahmed, et al. (2004) explain that the use of teaching aids encourages learners’ attitudes and patterns of thinking towards the subject because “teaching of mathematics is not mainly about content but about processes such as abstraction, generalization, proof, etc.” (p. 317). Teaching aids in Mathematics are likely to have a positive effect on the learning process if they meet certain criteria. According to Ahmed, et al. (2004) the following characteristics are important:

They must allow for learner-centred activity with the learner being in charge of the process. They must utilize the learners’ current knowledge and must also help develop links between learners’ current mental schemata while interacting with the tools. They must reinforce current knowledge and assist future problem solving through enhancing future access to knowledge. (p. 319)

It is clear from the above discussion on the terminology and uses of teaching aids that the terminology used in the research literature is often somewhat idiosyncratic. In the interests of clarity, within this study the term “teaching aid” is used as an all-encompassing umbrella term referring to all teaching resources found and used in the Mathematics classroom to enhance teaching and learning.

## **2.4 THEORETICAL AND CONCEPTUAL FRAMEWORK**

The main purpose of this section of the literature review is to provide a theoretical rationale for how the learning theory underpinning Learner-Centred Education (LCE) relates to the use of teaching aids in the Mathematics classroom at secondary school level. A number of related theoretical ideas will be explored, including constructivism, social constructivism, the zone of proximal development (ZPD), the notion of scaffolding, as well as aspects of Kilpatrick, et al.’s (2001) framework of teaching for mathematical proficiency.

## 2.4.1 Learner-Centred Education and Teaching Aids

Learner-Centred Education (LCE) is defined as an approach where “teachers put the needs of learners at the centre of what they do in the classroom, rather than the learner being made to fit whatever needs the teacher has decided upon” (Ministry of Basic Education and Culture [MBEC], 1999, p. 2). Cornelius-White and Harbaugh (2010) characterize learner-centred education as an approach to teaching and learning that “prioritizes facilitative relationships, the uniqueness of every learner, and the best evidence on learning process to promote comprehensive student success through engaged achievement” (p. xv). Learner-centred instruction (Cornelius-White & Harbaugh, 2010) recognises that learners are “naturally active, not passive recipients. They want to explore, learn and grow” (p. 35). It is further highlighted that a competent teacher should be responsible for developing different learning activities to ascertain learners’ prior knowledge that will enhance learners’ development of new knowledge. The main focus of LCE is therefore to ensure that after having progressed through the learning process, learners are able to create a meaningful and coherent representation of the knowledge acquired. It has been suggested that for teaching to be effective it should proceed from direct experiences to abstract learning by using symbolic representation in written or verbal form (Bruner, as cited in Van der Merwe & Van Rooyen, 2004, p. 235). The main indicators of successful LCE include, among other factors, an acknowledgement of prior knowledge, skills and interests, the desire and eagerness to learn and the learners’ active involvement in learning (MBEC, 1999).

The Mathematics teacher in the Namibian educational context is encouraged to develop among learners a culture of curiosity and an eagerness to learn and investigate through the use of teaching aids. Teaching aids are a means of encouraging participation of learners in Mathematics lessons. Cornelius-White and Harbaugh (2010) argue that participation can help both “traditional academic goals of schooling and the more holistic concerns for emotional and behavioural health and life engagement” (p. 56) because teachers can purposefully design and use teaching aids to “effectively foster participation through helping students to discover and pursue self-directed interests and build cooperative skills” (p. 58). It is further suggested that participation is likely to make learners feel responsible for learning “when they voice their opinions and thoughts in the classroom” (Cornelius-White & Harbaugh, 2010, p. 55). Teaching aids in Mathematics in a learner-centred environment should help learners connect their senses and help them develop their perceptions of their learning and the learning

environment. LCE is concerned with intrinsic motivation such as “development of curiosity or interest in the subject matter or wanting to become proficient to the best of one’s ability” (Cornelius-White & Harbaugh, 2010, p. 59). According to MBEC (1999), a more LCE lesson is one where the learners are seated in groups rather in rows, talk and initiate some activities more than the teacher (p. 7). Teaching aids are therefore likely to support Mathematics teachers in implementing learner-centred education. In a learner-centred approach, teachers should be “readily available to learners as a resource but avoid being relied upon as the sole authority in the classroom” (Cornelius-White & Harbaugh, 2010, p. 63).

The learner-centred approach in the teaching and learning process at secondary school level seems to be more favourable than the more traditional teacher-based approach because LCE is concerned with the “development of the whole learner – the aptitude for learning, communication and problem solving skills, and critical and creative thinking” (Cornelius-White & Harbaugh, 2010, p. 105). It is further argued that LCE is thoroughly co-operative, prioritizing the fostering of facilitative relationships as one of the most foundational and influential practices in education (Cornelius-White & Harbaugh, 2010, p. 139).

The concept of LCE has its roots in social constructivism which stresses the importance of the nature of the learner’s social interaction with knowledgeable members of the society. The learning theory of constructivism is historically attributed to Piaget who argued that “children construct their own understanding through interaction with their environment – that is, through their actions on objects in the world” (McInerney & McInerney, 2006, p. 37).

#### **2.4.2 Constructivism, the Zone of Proximal Development and Scaffolding**

Constructivism is defined as an active process in which “learners construct and internalize new concepts, ideas and knowledge based on their own present and past knowledge and experiences” (Cohen, Manion & Morrison, 2010, p. 181). Constructivism therefore suggests that the learners construct knowledge out of their own experiences rather than receiving it, and this in turn is a fundamental precept of LCE. According to Cohen, et al. (2010) there are two types of constructivism, namely cognitive constructivism and social constructivism, both of which share the common view that knowledge is constructed through “the learner’s cognitive structures and processing, through active and participative learning and through recognition that learning is not fixed and inert, but is continually developing” (p. 181).

Cohen, et al., (2010) further assert that Jean Piaget's early studies on an individual's thinking and learning pioneered the theory of cognitive constructivism while social constructivism owes much of its development to the writings of Lev Vygotsky (p. 182). McInerney and McInerney (2006) concur that Piaget's personal constructivism (cognitive constructivism) emphasizes that "children should be actively engaged in the content to be learnt" (p. 50) as well as having "an optimal match between the development stage of the child and logical properties of the material to be learnt" (p. 50). Constructivism supports the view that learning is an active process and therefore the teaching and learning is more learner-oriented. Constructivism as a learning theory promotes LCE because it gives learners an opportunity to generate and assimilate new knowledge into their existing knowledge base. Cohen, et al., (2010) underscore some characteristics of cognitive constructivism which might be useful for secondary teachers in developing learner-oriented lessons through the use of teaching aids in their mathematics classrooms:

- (a) Knowledge and understanding are constructed internally by the learner rather than transmitted from an external source such as a teacher.
- (b) Learning is self-directed and active and whatever someone knows is not passively received but actively assembled by the learner.
- (c) Learning derives from experiences and is marked by the learners' capacities to explore and experiment. (p. 182)

Social constructivism, as espoused by Vygotsky, extends the concept of constructivism by incorporating the role of the society and culture into the process of an individual's cognitive development. A central theme in Vygotsky social constructivist theory is that it encourages the learner to arrive at his or her version of truth influenced by his/her background and culture. This social-cultural milieu is not restricted to the classroom, but also incorporates parents, teachers and peers interacting with the learner through social engagement. Social constructivism puts greater emphasis on the importance of the learners being actively involved in the learning process, thereby encouraging motivation. Vygotsky (1978) argues that "learning and development are interrelated from the child's very first day of life" (p. 84). The Ministry of Education and Culture (MEC) (2003) stresses that the main principle of LCE is to "use the social context of the learner as a resource, and to relate learning to the social context" (p. 21). The MEC (2003) points out that in a learner-centred approach there should be a strong triangular relationship between three elements: teachers, learners, and the teaching aids (p. 26). It is further claimed that the teaching tasks in LCE should promote co-

operative learning which develops learners' thinking through stimulating reflection, comparison and exploration as well as continually improving on their acquired knowledge (pp. 26-27).

Vygotsky's constructivist theory is renowned for its contribution to the development of modern learning theories in education especially through his concept of the Zone of Proximal Development (ZPD). Vygotsky (1978) in his own words defines the ZPD as:

...the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. (p. 86)

The ZPD concept suggests that in the learning process learners first encounter problems or tasks which they cannot easily solve alone but which, with the help of peers, teachers and other adults, they are ultimately able to accomplish. In a learner-centred approach, teachers might therefore use different types of teaching aids in Mathematics lessons to provide valuable assistance to all learners in the zone of proximal development. Learner-Centred Education promotes sharing of ideas and views through the active participation and collaborative learning of learners during lessons to achieve set objectives and competencies. Vygotsky (1978) further maintains that the ZPD is important in the learning process because it defines "those functions that have not yet matured but are in the process of maturation, functions that will mature tomorrow but are currently in an embryonic state" (p. 86).

The teacher in a learner-centred approach therefore serves as a facilitator in the learning process as the learners are guided to arrive at their own conclusions. The use of teaching aids especially in Mathematics at secondary school level might promote the ZPD concept through interaction between more competent and less competent learners in classroom discussions as well as provide the necessary guidance and direction towards independent thinking. Mathematics teachers might therefore make use of the ZPD concept in their lessons to identify and use teaching aids to promote co-operative learning activities in their lessons and ensure that learners at different levels assist each other in the learning process. The view on cognitive development from both Vygotsky and Piaget emphasizes the importance of active involvement of learners in the learning process as well as the peer interaction in real world experiences (McInerney & McInerney, 2006, p. 37). Co-operative learning provides learners with an opportunity to work in small groups to accomplish shared goals and produce

“positive results in terms of self-esteem, peer support, internal locus of control ... and time on task” (p. 195).

Reid-Griffin and Carter (2004) define the ZPD as “a zone of possibilities, what the individual is able to accomplish when assisted by more capable others in the presence of mediating tools” (p. 496). This reasoning supports the use of teaching aids in facilitating the learning process because, according to Reid-Griffin and Carter (2004), what these more capable others do is “give clues, explanations, and help with using physical tools or give other forms of assistance, which provide guidance for the individual to accomplish the task” (p. 496). The notion of scaffolding can also be described as the support given to a learner by a more expert individual in one-on-one interactions (Sherin, Reiser & Edelson, 2004, p. 387). Reid-Griffin and Carter (2004) argue that “Bruner coined the term scaffolding to describe this complex process of assistance from more capable others” (p. 496) which entails that the teacher has the “primary responsibility of scaffolding” (p. 496). Scaffolding was also defined as the support provided so that a learner can “engage in activities that would otherwise be beyond their abilities” (Jackson, et al., as quoted in Sherin, et al., 2004, p. 387). Researchers have defined the notion of scaffolding as “a construct originally crafted to characterize how more experienced peers or adults can assist the learners” (Reiser, 2004, p. 274) and this vital support in the learning process does not only “assist learners in accomplishing tasks, but also enables them to learn from experience” (p. 275). The concept of the ZPD and the notion of scaffolding have become important guiding ideas in education today because “within them are embedded a psycho-social model of teaching and learning” (Bliss, Askew & Macrae, 1996, p. 38). In striving to achieve learner-centred instruction through the use of teaching aids in Mathematics, McInerney and McInerney (2006) maintain that scaffolding facilitates the learning process because “if the learning experience has been carefully structured and situated within the child’s zone of proximal development, the child should be able to perform the task independently” (p. 59). Teaching aids are usually designed by teachers to support the learning process so that learners are guided to achieve a higher degree of understanding, one which would not be attainable if the learners were not supported. Reiser (2004) however emphasizes that there are two critical notions of scaffolding that teachers using teaching aids could take cognisance of at secondary school level:

- (i) learners receive assistance to succeed in more complex tasks that would otherwise be too difficult, and

- (ii) learners draw from that experience and improve in the process skills and/or content understanding (p. 282)

Reid-Griffin and Carter (2004) insisted, however, that the process of scaffolding is complex in the classroom context because too little help leads to frustration and failure while too much assistance removes the challenge from the learner (p. 496).

The presence of teaching aids in the scaffolding process is believed to broaden the range of experiences and increase the opportunity for learners to develop their own understandings (Reid-Griffin & Carter, 2004, p. 497). According to Bliss, et al. (1996) it is important for teachers to realize that “to help learning requires diagnosis, through dialogue, of learners’ levels of development and their progress” (p. 60). In applying scaffolding in the teaching of Mathematics, Bliss, et al. (1996) argue that “teachers need to believe that children can learn difficult and complex ideas; this is what school is about” (p. 60) and further remark that they must be content that “often learners can only do this one step or a few steps at a time” (p. 60).

With specific reference to technology, the use of technological teaching aids can effectively promote the notion of scaffolding (Reiser, 2004) because “software tools can help structure the learning task, guiding learners through the key components and supporting their planning and performance” (p. 273). The teaching tools (aids) can also improve the learners “performance and understanding of the task in terms of key disciplinary content and strategies and thus problematize this important content” (Reiser, 2004, p. 273). Scaffolding therefore “promises to be an important benefit in integrating technological tools into the classroom” (Reiser, 2004, p. 276).

### **2.4.3 Teaching for Mathematical Proficiency**

The main thrust of this section of the literature review is analysing how Kilpatrick, et al. (2001) frame the concept of teaching for mathematical proficiency by underscoring the importance of the interlinked relationships between various strands. For the purposes of this study the focus will be on only two of the five strands, namely conceptual understanding and productive disposition, and on how these two strands can be used to inform the study with specific reference to the data collection and analysis protocols.

Teachers' selections of tasks and their interactions with learners during the teaching and learning process are guided by their "beliefs about what students need to learn and are capable of learning" (Kilpatrick, et al., 2001, p. 338). This implies that low expectations can lead a teacher to interact with certain learners in ways that fail to support their development of mathematical proficiency. Kilpatrick, et al.'s model of teaching for mathematical proficiency (Kilpatrick, et al., 2001, pp. 313-314) highly values the interactions among the teachers, learners and the content, taking into consideration the social and environmental influences.

The proposed study will use Kilpatrick, et al.'s (2001) conceptual framework of teaching for mathematical proficiency as an important component in the design and development of the data collection and analysis protocols. Kilpatrick, et al. (2001) argue that improving learners' learning "depends on the capabilities of classroom teachers" (p. 12) and that these teachers need "access to resources and expertise that will assist them in improving instruction" (p. 12). It is important to elicit from teachers what type of aids they use in their mathematics classroom and how these aids support teaching for mathematical proficiency. Teaching for mathematical proficiency according to Kilpatrick, et al. (2001) is interwoven in five interrelated components:

- ✓ Conceptual understanding of core knowledge of mathematics, students and instructional practices needed for teaching.
- ✓ Procedural fluency in carrying out basic instructional routines.
- ✓ Strategic competence in planning effective instruction and solving problems that arise while teaching
- ✓ Adaptive reasoning in justifying and explaining one's practices and in reflecting on those practices.
- ✓ Productive disposition toward mathematics, teaching, learning and the improvement of practice. (p. 10)

The five strands for mathematical proficiency can only be attained through real involvement of learners. In order to understand a particular concept well, or to develop the skill of solving a mathematical problem, learners need to go through a process of active participation. Teaching aids can provide valuable support for the learning process when teachers "interact over time with the students to help them build links between the object, the symbol and the mathematical idea both represent" (Kilpatrick, et al., 2001, p. 354). The teaching and learning of Mathematics is viewed as a product of an integrated attainment of all five strands previously outlined, but for the purposes of this particular study the focus will be on *conceptual understanding* and *productive disposition*.

Kilpatrick, et al. (2001) define conceptual understanding as “a functional and integrated grasp of mathematical ideas” (p. 118) and further argue that learning with understanding is more powerful than merely memorizing because organization improves retention and also promotes fluency in the learning process. Hiebert and Lefevre (1986) characterise conceptual understanding as “knowledge that is rich in relationships” (p. 3) and further explain that it can be viewed as a “connected web of knowledge, a network which the linking of relationships are as prominent as the discrete pieces of information” (p. 3).

Conceptual knowledge develops “through the creation of relationships between existing knowledge and new information that is just entering the system” (Hiebert & Lefevre, 1986, p. 4) and teaching the meaning of content under analysis and supporting learners through the use of teaching aids could improve their conceptual understanding of various mathematics topics at secondary school level. Conceptual knowledge can also be defined as “implicit or explicit understanding of the principles that govern a domain and of the interrelationships between units of knowledge in a domain” (Rittle-Johnson, Siegler & Alibali, 2001, pp. 346-347). Martinie (2005) suggests that conceptual understanding enables learners to “comprehend the ideas that they study and find connections among them as well as between the concepts and the procedures they perform” (p. 188). The best way for students to learn mathematics is by “actively doing mathematics that is meaningful, interesting and important” (Martinie, 2005, p. 188) and this suggests that the use of teaching aids in Mathematics could enhance the learners’ understanding of mathematical concepts and improve their creativity in solving everyday problems.

Kilpatrick, et al. (2001) further elaborate that a significant indicator of conceptual understanding is the ability to represent mathematical situations in different ways. A learner who has acquired conceptual understanding of a topic in Mathematics is able to see connections among concepts and procedures to be followed for solving new and familiar tasks. Teaching aids may serve as “tools for teachers to translate abstractions into a form that enables learners to relate new knowledge to existing knowledge” (Moyer, 2001, p. 194). This implies that conceptual understanding, as espoused by Kilpatrick, et al. (2001) assists learners in avoiding critical errors in solving mathematics problems. Martinie (2005) asserts that “when real life contexts are used and when students build new information on what they already know, then the knowledge they gain is powerful” (p. 189). Kilpatrick, et al. (2001)

emphasize that although some traditional teachers believed in rote teaching, it is argued that the procedural skills need the support of conceptual understanding because understanding makes learning skills easier. For instance, if learners have conceptual understanding they are less likely to forget the critical steps that enhance learning in Mathematics. Conceptual understanding is therefore very important because learners who learn with comprehension can modify or adapt procedures to make them easier to learn. Teaching for conceptual understanding in Mathematics is likely to be promoted through the use of teaching aids because in the learning process “tools can shape the students’ performance and understanding of the task in terms of key disciplinary content and strategies and thus problematize this important content” (Reiser, 2004, p. 373). Kilpatrick, et al. (2001) challenge teachers to manage instruction in ways that help Mathematics learners to develop proficiency in solving day-to-day tasks. Teaching aids can help the process of learning by “guiding learners through key components and supporting their planning and performance” (Reiser, 2004, p. 373). The use of teaching aids in mathematics instruction at secondary level is likely to assist learners in mastering concepts, ideas, definitions, and symbols because conceptual understanding supports retention of activities experienced in lessons. Learners with conceptual understanding know more than just isolated facts and methods in Mathematics but rather have an organized and coherent appreciation for the knowledge being taught (Kilpatrick, et al., 2001). The effective use of mathematics manipulatives “contributes to conceptualisation and understanding” (Heddens, 1997, p. 2) in addition to providing an opportunity for teachers to assess and meet the needs of learners as “they construct personal mathematical knowledge” (p. 4). It is further argued that learners with conceptual understanding (Kilpatrick, et al., 2001) have the potential to represent mathematical situations in different ways when solving problems. Teaching for mathematical proficiency therefore requires learners to have a deeper understanding in solving mathematical problems and to be able to generate new knowledge when faced with unfamiliar problems. Learners become familiar with mathematical concepts through using teaching aids. Conceptual knowledge grows by construction of new knowledge, and relationships between constructed concepts are strengthened when one practices with tasks involving those concepts.

Productive disposition is defined as the “habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one’s own efficacy” (Kilpatrick, et al., 2001, p. 116). Kilpatrick, et al. (2001) explain that the process of

developing productive disposition requires frequent opportunities to “make sense of mathematics, recognise the benefits of perseverance, and to experience the rewards of sense making in mathematics” (p. 131). This reasoning is supported by White (2003) who points out that a productive mathematical classroom allows learners to “concentrate on sense making and reasoning, it allows teachers to reflect on students’ understanding and to stimulate mathematical thinking” (p. 37). The use of teaching aids in Mathematics is likely to help learners develop positive attitudes and beliefs towards the Mathematics content because the greater the number of concepts they understand the more sensible mathematics becomes. The Mathematics teacher plays a pivotal role in encouraging learners to maintain a positive attitude towards mathematics, and the motivation for school Mathematics learning “depends primarily on the interaction of students with teachers and of students with mathematical tasks” (Kilpatrick, et al., 2001, p. 339). Kilpatrick, et al. (2001) argue that when teaching aids are used well in Mathematics lessons they enable learners and teachers to “have a conversation that is grounded in a common referential medium, and they can provide material on which the learners can act productively provided they reflect on their actions in relation to the mathematics being taught” (p. 354). Teaching to enhance productive disposition among learners through the use of teaching aids in Mathematics is likely to contribute towards a learner-centred approach by encouraging learners to participate actively. White (2003) states that productive classroom discussion requires teachers to engage all learners in discourse by “monitoring their participation in discussions and deciding when and how to encourage each learner to participate” (pp. 37-38). In addition to the importance of conceptual understanding and procedural fluency that underlie mathematical proficiency, learners who are “successful in mathematics have a set of attitudes and beliefs that support their learning” (Kilpatrick, et al., 2001, p. 171) because they see Mathematics as a “meaningful, interesting and worthwhile activity” (p. 171). Teachers can therefore motivate their learners to strive for mathematical proficiency by using teaching aids to help them appreciate what they are learning through taking advantage of the learners’ “existing intrinsic motivation by emphasizing topics they find interesting and tasks they find enjoyable” (Kilpatrick, et al., 2001, p. 340).

Teaching for mathematical proficiency might be supported at secondary school level by encouraging teachers to use teaching aids to promote both learners’ conceptual understanding and productive disposition. “Good teachers can be better teachers when they have plenty of materials with which to work” (Kasambira, 2004, p. 97). This appears to support the notion

that learners' attitudes and performance can be improved if they interact with teaching aids in Mathematics lessons. Teaching aids can play a critical role in learners' "construction of meaningful ideas" (Clements, 1999, p. 56) when used in the "context of educational tasks to actively engage children's thinking with teacher guidance" (p. 56).

## **2.5 CONCLUSION**

The literature review focused on the rationale of using teaching aids in Mathematics lessons at secondary school level. This was followed by a discussion on how past and current research characterizes teaching aids in the teaching and learning process.

The theoretical framework underpinning the learning theory of learner-centred education as the guiding educational policy in the current Namibian school system was reviewed with specific focus on constructivism, social constructivism as well as the concept of the zone of proximal development and the notion of scaffolding. The last part of the literature review looked at the conceptual framework based on Kilpatrick, et al.'s (2001) five strands of teaching for mathematical proficiency, with specific focus on conceptual understanding and productive disposition.

# **CHAPTER 3**

## **RESEARCH METHODOLOGY**

### **3.1 INTRODUCTION**

The main focus of this study was to survey the availability and use of teaching aids in Mathematics classrooms at secondary school level. This chapter outlines and articulates on the methodology employed in this research study and “considers and explains the logic behind research methods and techniques” (Welman, Kruger & Mitchell, 2005, p. 2).

The methodology chapter encompasses the research goals, research orientation, research design, the data collection methods, sampling, data analysis, the ethical considerations as well as issues pertaining to validity.

### **3.2 RESEARCH GOALS**

This study focuses on identifying and characterising the availability and usage of teaching aids in Mathematics at secondary schools located in Namibia’s capital city of Windhoek. The following questions were used to guide the research process:

- 1) What type of teaching and learning aids are available for Mathematics teachers in the private and public secondary schools in Windhoek?
- 2) What is the nature or character of the use of the available teaching aids?
- 3) What are the teachers’ general perceptions on the availability and use of teaching aids in Mathematics at secondary school level?

### **3.3 RESEARCH ORIENTATION**

This study is grounded in the interpretive paradigm making use of a mixed methods approach (Creswell, 2003, p. 18) wherein both quantitative and qualitative empirical data was collected in two sequential phases. According to Cohen, Manion and Morrison (2007) an interpretive paradigm “is characterised by a concern for the individual” (p. 21) and strives to comprehend

the “subjective world of human experience” (p. 21) by getting inside the research participant and attempting to understand from within.

Although the first phase of the study centred on quantitative data (a survey on the availability of teaching aids in secondary schools), the second phase was firmly rooted in the interpretive paradigm. The purpose of the second phase was to elaborate on the findings of the first phase by interacting with selected teachers in order to gain insight into the nature and use of teaching aids in schools. Oliver (2010) argues that the interpretive paradigm enables the researcher to comprehend and make sense of that which is being investigated and provides “the respondent with more opportunity to reflect their feelings and opinions” (p. 73).

### **3.4 RESEARCH DESIGN**

The research study followed a mixed methods design (Maree, 2007, p. 266) with two clear sequential stages of empirical data collection. The mixed methods approach employs strategies of inquiry that involve collecting both numeric and text information in order that the final database comprises both quantitative and qualitative information (Creswell, 2003).

The research process was conducted in two phases. In the first phase mostly quantitative data was collected by means of a standardized questionnaire instrument from all secondary schools in the Windhoek metropolitan area to provide information on the overall availability of teaching aids in Mathematics. Thereafter the statistical data from this audit was used to purposefully select five secondary schools from which qualitative data was collected by means of semi-structured interviews with teachers from the selected schools. The second phase of the research process thus took the form of an instrumental case study (Tellis, 1997). The five selected schools included (i) two schools which had adequate resources and showed good practice in the use of teaching aids, (ii) two schools where the availability of teaching aids was a great challenge, as well as (iii) one school with a moderate supply of teaching resources. The purpose of the second phase was to develop a more nuanced understanding of the data generated in the first phase.

The study uses a mixed methods approach because it integrates the elements of quantitative and qualitative research approaches “for the broad purposes of breadth of understanding and collaboration” (Johnson, Onwuegbuzie & Turner, 2007, p. 123). The combination of the two

sequential phases in gathering both qualitative and quantitative data in this research also provides “a form of methodological triangulation which helps to ensure greater validity of data and findings” (Oliver, 2010, p. 78). Thus, the main reason for choosing a mixed methods design was to use the qualitative data “to help clarify issues that arose from the quantitative results” (Maree, 2007, p. 272) and to deepen one’s understanding of the phenomenon under study.

### **3.5 THE CASE STUDY METHODOLOGY**

The second phase of the research process utilized a case study approach to get an in-depth understanding of the purposefully selected five secondary schools, the unit of analysis being the use of teaching aids and teachers’ perceptions towards these resources. A case study is defined as “an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (Yin, 2009, p. 18). According to Welman, et al. (2005) case study research is “directed at understanding the uniqueness and idiosyncrasy of a particular case in all its complexity” (p. 25). In this research, a case study methodology was conducted in Phase 2 of the research process (after the analysis of quantitative results from Phase 1) in order to enable the researcher to understand the real life experiences of practicing teachers as well as to gain access to the deeper perceptions of teachers offering Mathematics at secondary level. In a case study (Creswell, 2003, p. 15) the research aims at exploring in depth an event, process, one individual or more individuals. Considering that the survey in Phase 1 had looked at the views of close to a hundred teachers in Windhoek, the use of a case study provided an opportunity to clarify unanswered questions through interviews with purposefully selected teachers working at secondary school level. The term case study (Welman, et al., 2005, p. 193) refers to the fact that a limited number of units of analysis are studied in detail. It is claimed that “case studies can penetrate situations in ways that are not always susceptible to numerical analysis” (Cohen, et al., 2007, p. 253). Case studies are not only descriptive and detailed but have a narrow focus, combining both subjective and objective data (Dyer, as cited in Cohen, et al., 2007, p. 254).

### **3.6 DATA COLLECTION METHODS**

This study employed two strategies of inquiry to collect data sequentially in two separate phases:

#### **Phase 1**

Phase 1 took the form of a survey of the availability and use of teaching aids in Mathematics at secondary school level. A structured questionnaire (see Appendix A) with a list of various teaching aids was used during the survey to determine the availability and use of mathematics resources in all secondary schools in Windhoek. The rationale for opting for this type of data collection procedure was to reach as many participants as possible at an affordable cost and within a reasonable timeframe. The questionnaire was used to capture the opinions of practicing Mathematics teachers and both closed as well as open-ended questions were used. The questionnaire also made use of a Likert scale rating system to measure and help quantify the responses of the participants in relation to their attitude towards the use of teaching aids. The questionnaire was piloted with four Mathematics teachers from secondary schools offering mathematics from Grade 8 to Grade 12 to test whether the respondents could interpret the questions correctly. This initial pilot process allowed the researcher to refine the research instrument (Oliver, 2010, p. 97). The researcher visited each of the 30 secondary schools in person in order to hand out the questionnaire to all participating teachers. Although teachers were asked to write their names on the questionnaires for easy identification during the analysis process, neither teachers nor individual schools are identified in this report.

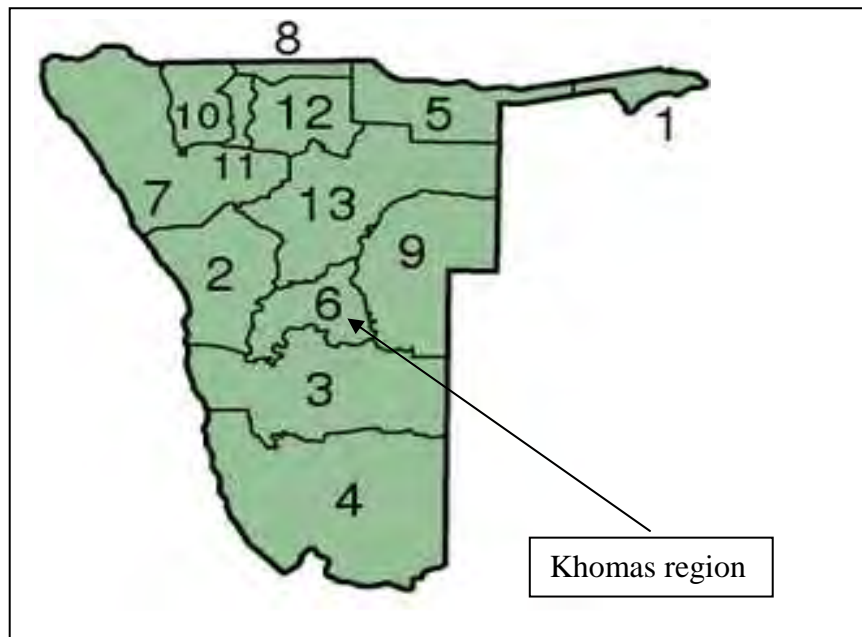
#### **Phase 2**

A case study methodology was used for Phase 2 as it enabled a limited number of cases to be explored while still providing a rich and in-depth understanding of the teachers' personal experiences as well as their overall perceptions of the availability and use of teaching aids. Five schools were purposefully selected in order to characterize the use of mathematical teaching aids in schools with different contexts: (i) two schools that had adequate resources and showed good practice in the use of teaching aids, (ii) two schools where the availability of teaching aids was a great challenge, and (iii) one school with a moderate supply of teaching resources. Semi-structured interviews were conducted with the five targeted teachers to corroborate and expand on data that emerged from Phase 1 of the study. The selection meant that one teacher per school was chosen from the five targeted schools. These semi-

structured interviews were developed from and informed by the survey in Phase 1 and they allowed the researcher to engage with and interpret the real life experiences of the selected teachers in their Mathematics classrooms. Cohen, et al. (2007) stress that research interviews enable participants to “discuss their interpretations of the world they live and to express how they regard the situations from their own point of view” (p. 349). The purposefully selected teachers who took part in Phase 2 of the study had teaching experience varying between three and 30 years.

### 3.7 RESEARCH SITES AND PARTICIPANTS

The research was conducted in the Khomas Region of Namibia (see Figure 3.1) and specifically involved 30 public and private secondary schools in the Windhoek urban area. A detailed account of the research sample and sites is explained below in line with the sequential phases of data collection in a mixed methods approach.



**Figure 3.1** Regions of Namibia

## **Phase 1**

### **Stage 1 - Pilot study**

A secondary school in Windhoek with four mathematics teachers was chosen for the pilot study to evaluate the strengths and weaknesses of the questionnaire as a data collection method for the survey. The school that was selected for the pilot survey has a big learner enrollment from Grades 8 to 12 and enjoys support from both the private industry as well as the government in its day to day operations. Yin (2009, p. 92) suggests that a pilot case study can help to refine the data collection instruments and strategies with respect to both the content of the data and the procedures to be followed in a research study. This phase of the research was principally useful in verifying the reliability, readability, format and applicability of the questionnaire (Cohen, et al., 2007, pp. 341-342). Feedback from this stage was used to modify the wording and structure of the questionnaire as well as the Likert scale rating and the open-ended question.

### **Stage 2 - Survey**

The questionnaire was administered to all mathematics teachers at all 30 public and private secondary schools in the Windhoek urban area, giving a possible maximum of 105 respondents. The number of mathematics teachers at each school differed depending on the learner enrolment and varied between one and four. Principals and Heads of the Mathematics Departments who also happened to be mathematics teachers also took part in the survey. The first phase of the research therefore focused on obtaining responses from as many participants as possible from all the targeted 30 secondary schools.

The teacher training campus of the University of Namibia, where the researcher works, is located in Windhoek. The choice of Windhoek as the research site was thus a purposeful and pragmatic decision which allowed the researcher convenient access to all schools during both phases of the data acquisition process. All the 30 secondary school are located within a reasonable distance from the researcher's workplace. The teacher trainees of the researcher's institute do their teaching practice in schools within the Windhoek urban area and a good rapport already existed between the training college and the various school principals.

## **Phase 2**

Phase 2 of the research process took the form of a case study. Non-probability purposive sampling was used (Maree, 2007, p. 179). Five schools that participated in Phase 1 were targeted for Phase 2. These five schools were carefully chosen so that they represented a broad spectrum in terms of teaching aid availability. This purposeful selection process was guided by data emanating from Phase 1 of the study. Sampling preference was given to key participants who, “on account of their position or experience, [had] more information than regular group members and/or [were] better able to articulate this information” (Welman, et al., 2005, p. 204). The case study was focused on obtaining an in-depth understanding and insight from five teachers purposefully selected from five different secondary schools based on Phase 1 results. Two teachers were selected from well-resourced schools that showed good use of teaching aids. A further two teachers were selected from under-resourced schools in terms of the supply of teaching aids in Mathematics. The fifth teacher was chosen from a school that was moderately supplied with teaching resources. The sampling process thus purposefully selected cases from both extremes (Yin, 2009, p. 59) as well as a school lying between these two extremes since the focus of the study is on both well-resourced and under-resourced contexts. The other factors that contributed to the selection of the five teachers who took part in Phase 2 included:

- The general responses that were given by the teachers in Phase 1 regarding the availability, use and source of the teaching aids at their schools.
- The willingness of both the participating teacher and the school principal.
- The teaching experience and general perceptions portrayed in the open-ended question of the questionnaire.

## **3.8 DATA ANALYSIS**

Analysis of data in this mixed methods study used both quantitative (descriptive numeric analysis) and qualitative (description and thematic text analysis) approaches (Creswell, 2003, p. 220). According to Maree (2007) mixed research is a procedure “for collecting, analysing and ‘mixing’ both qualitative and quantitative data at some stage of the research process” (p. 280). The mixing of the qualitative and quantitative data in this study occurred during both the data collection and data analysis processes.

The data analysis was carried out in two phases:

### **Phase 1**

The quantitative data collected from the questionnaires was analysed using spreadsheet software to identify any trends and patterns in the use and availability of teaching aids in schools. Graphs and tables were developed and used to analyse the source, frequency of use as well as the availability of teaching aids. The open-ended question of the questionnaire produced some qualitative data in the form of emerging themes identified from the teachers' perceptions towards the use of the resources in their classroom teaching. The data analysed in Phase 1 was also used to guide the second phase of the research study.

### **Phase 2**

The second phase focused on analysing qualitative data in conjunction with the quantitative data to provide a richly textured and more nuanced understanding of the use of teaching aids. The analysis of data in Phase 1 led to the generation of data through a case study of five selected schools in Phase 2. According to Cohen, et al., (2007), qualitative data usually focuses on a smaller number of participants than quantitative data, "yet the data tend to be detailed and rich" (p. 461). Qualitative data from the interviews was transcribed and coded. Coding is defined according to Welman, et al. (2005, p. 214) as a process of analysing and making sense of the information that has been generated. Themes that emerged from this process were gradually grouped to provide a rich and deep characterization of teachers' experiences and perceptions of the use of teaching aids in the Namibian Mathematics classroom at secondary school level.

During the data analysis process equal weighting was given to both quantitative and qualitative data, the results from the two phases being fully integrated at the interpretation and final discussion stage of the study.

**Table 3.1** Summary of the Research Process

Phase	Stage	Method/ Techniques	Aim	Data	Analysis
<b>Phase 1</b>	Stage 1	Piloting	To assess the feasibility of the research tools and to refine them if necessary.	Numeric data	Analysis of the effectiveness and reliability of questionnaire as a research tool.
	Stage 2	Questionnaire	To audit the availability and use of mathematical teaching aids in secondary schools.	Quantitative (numeric) data	MS Excel software used for descriptive statistical analysis -Emerging Themes
<b>Phase 2</b>		Semi-Structured Interviews	To get a deeper insight into perceptions and opinions of teachers on the use of teaching aids.	Qualitative data (transcripts)	Coding/Themes

### 3.9 VALIDITY

Welman, et al. (2005) define validity as “the extent to which the research findings accurately represent what is happening in the situation” (p. 142). Validity is an important issue that needs to be addressed effectively in any research (Cohen, et al., 2007, p. 133). It is further explained by Cohen, et al. (2007) that *internal* validity seeks to demonstrate that the explanation of a particular event, issue or set of data which a piece of research provides can actually be sustained by data, while *external* validity refers to the degree to which the results can be generalized to the wider population, cases or situations.

Prior to administering the questionnaire which was used in Phase 1, the questionnaire was first assessed by a number of critical colleagues in addition to being piloted at a secondary school. The research tool was gradually refined over the course of this process. The final questionnaire was also assessed by my supervisor before its implementation to ensure content validity. In addition, a colleague at the University of Namibia’s statistical department was consulted in order to ensure that the questionnaire would be effective in measuring the required data. The researcher personally took the questionnaires to all participating secondary schools to ensure that they were meaningfully completed as well as to clarify any queries.

The second phase of the research process elicited qualitative data which was used to provide a more nuanced understanding of the Phase 1 quantitative data, and as such acted as a form of triangulation (Cohen, et al., 2007, p. 141).

### **3.10 ETHICAL CONSIDERATIONS**

Cohen, et al. (2007, p. 51) point out that ethical issues may stem from the kinds of problems being investigated by social scientists and the methods they use to obtain valid and reliable data. In this study I heeded to the following ethical recommendations made by Cohen, et al. (2007, pp. 51-77):

- ✓ I fully revealed my identity and background as a researcher to the participants in all phases of the research process.
- ✓ The purpose of the research along with its procedures was explained in detail, and informed consent was obtained from all the participants.
- ✓ The participants took part in the study on a voluntary basis and they were informed of their right to withdraw their involvement at any time of the research process. The issue of confidentiality was highlighted and the participants were informed that their identity would be kept anonymous and that any data could only be exposed with their consent (see Appendix F).
- ✓ I made arrangements with participants during the initial audit phase to provide feedback of the audit results to participants who requested it.
- ✓ I also informed the participants of how the questionnaires and interview data (audio) would be stored during the research process and its destruction thereafter.
- ✓ I obtained written permission to conduct the research from the Regional Education Director for the Khomas region (see Appendix C) where the city of Windhoek is located, as well as from the principals of all participating schools. The teachers who participated in the case study in Phase 2 of the research also signed consent forms before the interviews were conducted.
- ✓ I strove to be objective, honest and to report on the process with accuracy and integrity.

### **3.11 CONCLUSION**

This study is grounded in an interpretive paradigm and employed a mixed methods approach to generate both numeric and text data in two sequential phases. The survey carried out in Phase 1 enabled a bigger population to be included in the study, while the case study (Phase 2) made it possible for the researcher to access teachers' experiences and perceptions on a much deeper and more nuanced level. The integration of the qualitative and quantitative data during the data collection and data analysis stages proved to be important in terms of answering the research questions. In the next chapter the data is presented and discussed.

## **CHAPTER 4**

### **RESULTS, ANALYSIS AND DISCUSSION**

#### **4.1 INTRODUCTION**

This chapter presents and discusses the results of the study. The central focus of the study was to carry out a survey on the availability and usage of teaching aids in Mathematics at secondary schools within the Windhoek metropolitan area. The study also characterised the nature of these teaching aids as well as the perceptions of Mathematics teachers towards the use of such teaching resources in their lessons. The study took place in two sequential phases and the data analysis focuses on (i) the quantitative data (collected in Phase 1) followed by (ii) the qualitative data (gathered from both Phase 1 and Phase 2).

Phase 1 took the form of a questionnaire. Questionnaires were delivered to 100 secondary school Mathematics teachers at 30 different secondary schools. 75 teachers at 25 of the schools completed the questionnaire. The school response rate was thus 83.3% and the total teacher response rate was 75%. The first part of this chapter discusses the quantitative data stemming from the questionnaire.

Qualitative data was derived from the open-ended questions in the Phase 1 questionnaire as well as subsequent semi-structured interviews that were informed by Phase 1 data. Through repeated engagement with the qualitative data a number of themes gradually emerged. These themes, which are discussed in the second part of this chapter, include: hands-on nature of concrete objects; reality and visualization; enhanced teaching of concepts; active participation and interest; inadequate resources and the need to improvise; motivation and learner performance; and time and support from the ministry. Although these themes are presented individually, it is however acknowledged that they are interrelated and overlapping.

## 4.2 QUANTITATIVE DATA

Quantitative data was derived from the Phase 1 questionnaire (see Appendix A) and identifies the types of teaching aids that are available in each Mathematics department, the frequency of their use as well as their source. A general overview of the data is initially presented. This is followed by a more detailed analysis of each particular teaching aid.

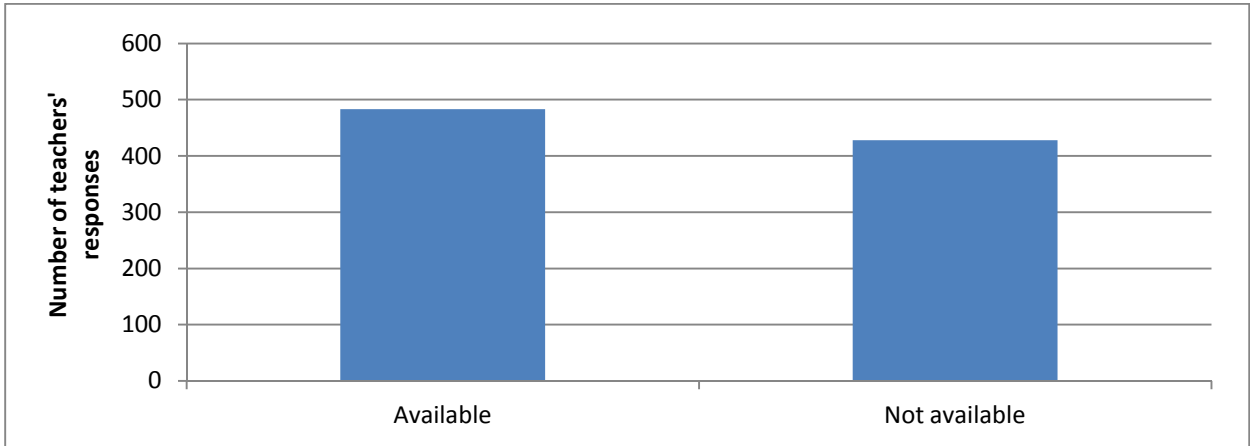
### 4.2.1 General overview

75 teachers at 25 secondary schools in the Windhoek urban area took part in the teaching aid audit which formed part of the Phase 1 questionnaire. Twelve different types of teaching aids were audited giving a total of 975 potential responses. In terms of the availability of the teaching aids there were a total of 911 responses<sup>1</sup>, 53% of which indicated that the particular teaching aid was available (Figure 4.1). This suggests that the different types of teaching aids surveyed are reasonably available in the schools that were audited. With respect to the use of teaching aids, the survey shows that only a limited number of teaching aids are used on a daily basis (11%) while 40% are used as frequently as possible. 49% of the teaching aids were indicated as being never used (Figure 4.2). On a note of clarity, careful analysis of the data revealed that all respondents who indicated that a particular teaching aid was “not available” also indicated that the teaching aid was “never used”. The teaching aids that are available but are never used can thus be determined by subtracting the tally for “not available” from the tally for “never used”, i.e. “never used” – “not available” = available but never used. A total of 442 teachers’ responses indicated teaching aids that were never used compared to a total of 428 responses for teaching aids not available. This suggests that only 14 responses indicate a teaching aid that *is* available but is never used.

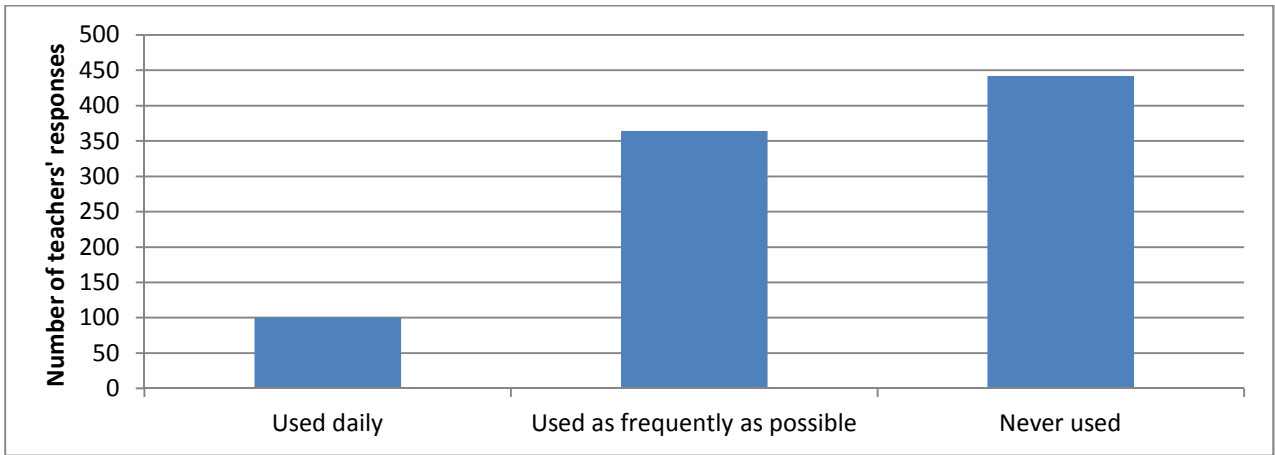
With respect to the source of those teaching aids surveyed (Figure 4.3), the major source was indicated as being school purchase (47%) followed by personal purchase (35%). The Ministry of Education was indicated as the source of only 11% of the teaching aids audited.

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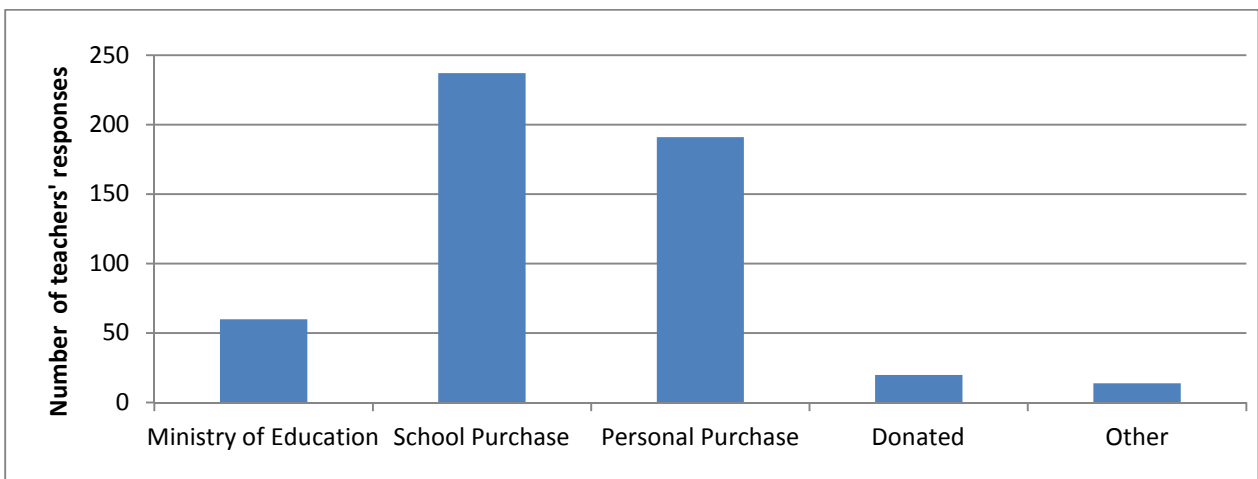
<sup>1</sup> The reason why there were only 911 responses instead of the potential 975 is that item 13 on the questionnaire related to the category of “any other teaching aids”. This category was left blank by most respondents.



**Figure 4.1** Availability vs. non-availability of all teaching aids.



**Figure 4.2** Frequency of use of all teaching aids.



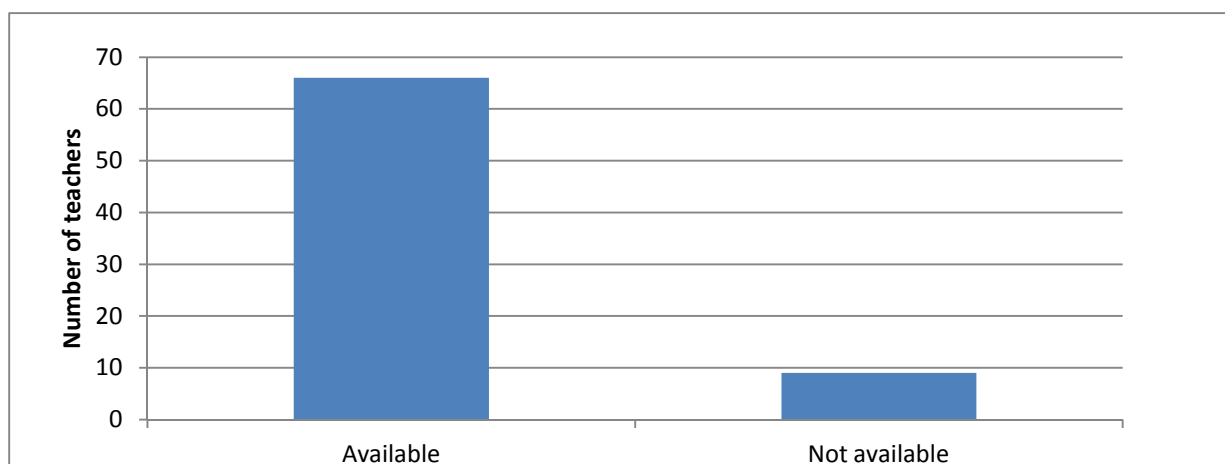
**Figure 4.3** Source of all teaching aids.

## 4.2.2 Analysis per teaching aid

A total of twelve specific types of teaching aid were surveyed, along with an additional category capturing any other teaching aids. This part of the data analysis focuses on each of these different types of teaching aid in turn with respect to their availability, use and source. The data is summarised in the form of bar graphs.

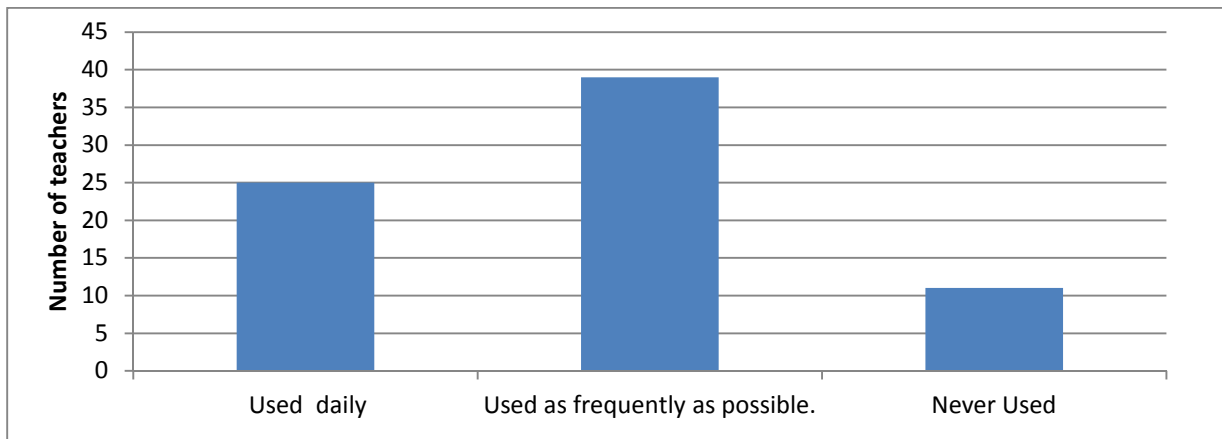
### 4.2.2.1 Chalkboard 30° & 60° set squares

The majority of teachers (88%) indicated that schools are in possession of chalkboard 30° & 60° set squares, as compared to only 12% who indicated that these items were not available (Figure 4.4(a)). 33% of respondents indicated that the chalkboard set squares were used on a daily basis while 52% indicated that they used the set squares as frequently as possible, dependant on the appropriateness of the topic being taught (Figure 4.4(b)). Although 15% of the responses indicated that chalkboard set squares were never used, this figure incorporates those respondents who indicated the non-availability of the item. This suggests that only two teachers are in possession of chalkboard set squares that are never used<sup>2</sup>. Figure 4.4(c) illustrates that 52% of respondents indicated that this type of teaching aid is supplied mostly from school budgets while 28% indicated that the Ministry of Education had provided the chalkboard set squares. Five teachers (6.7% of the total) personally purchased the chalkboard set squares that they use in the classroom.

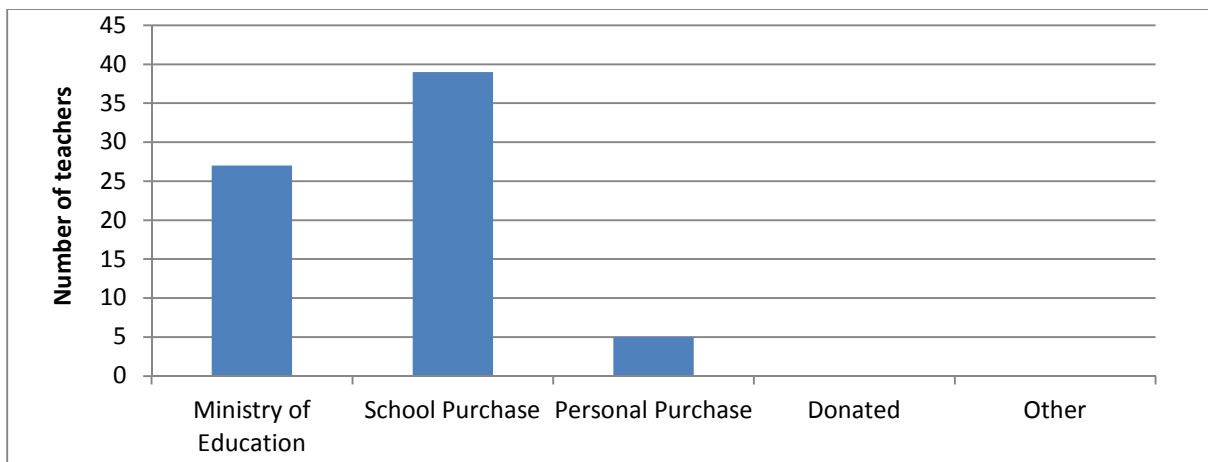


**Figure 4.4(a)** Availability vs. non-availability of chalkboard 30° & 60° set squares.

<sup>2</sup> Refer to explanation provided in Section 4.2.1.



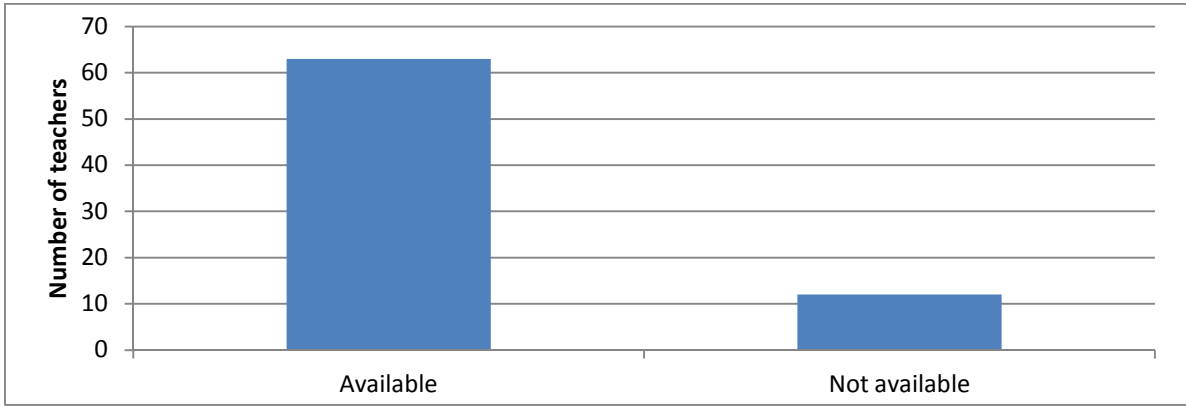
**Fig. 4.4(b)** Frequency of use of chalkboard 30° & 60° set squares.



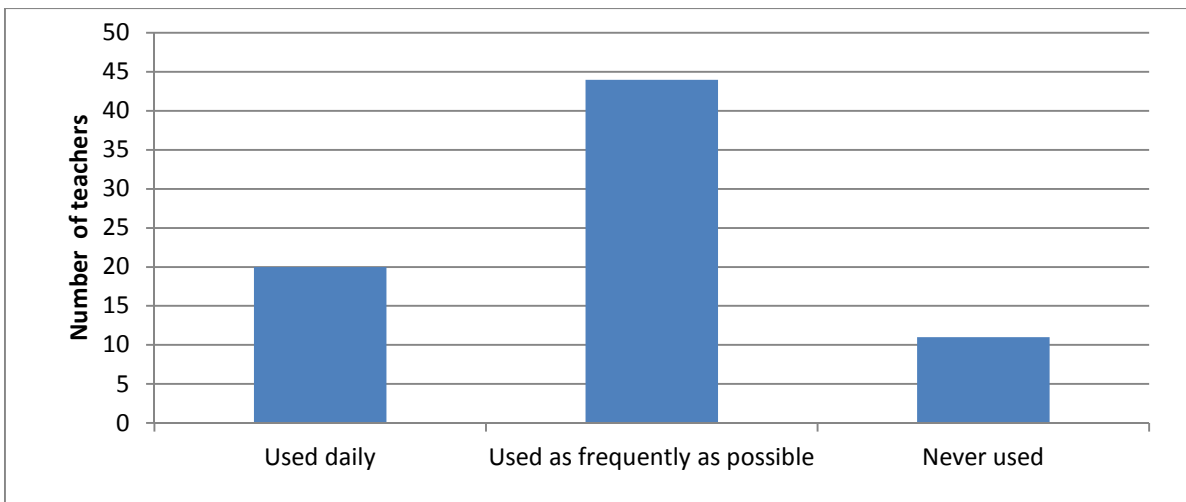
**Figure 4.4(c)** Source of chalkboard 30° & 60° set squares.

#### 4.2.2.2 Chalkboard rulers, protractors & compasses

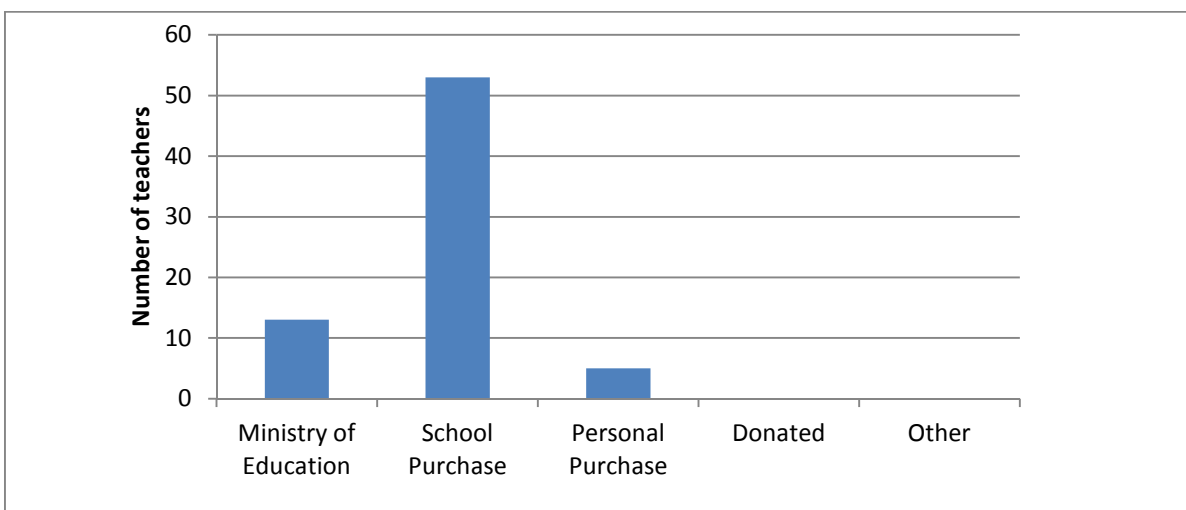
84% of the teachers indicated that chalkboard rulers, protractors and compasses are available with only 16% of the teachers indicating that these tools were not available (Figure 4.5(a)). The percentage of teachers who used this type of teaching aid on a daily basis is approximately 27%, with 59% using them as frequently as possible (Figure 4.5(b)). There were no instances of these particular teaching aids being present but unused. The vast majority of teachers indicated that their school had been responsible for the purchase of the chalkboard rulers, protractors and compasses (Figure 4.5(c)).



**Figure 4.5(a)** Availability vs. non-availability of chalkboard rulers, protractors & compasses.



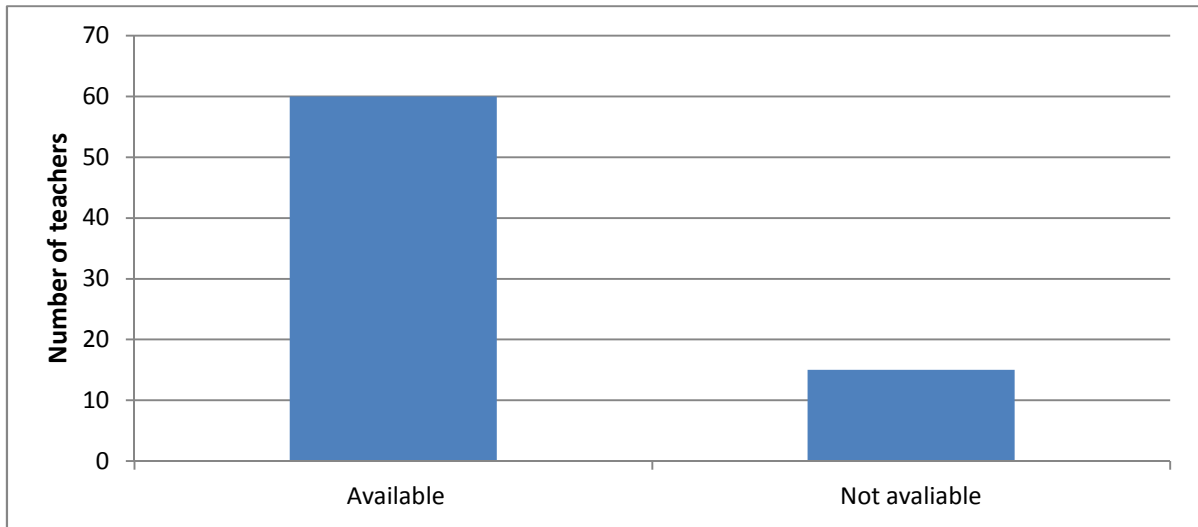
**Figure 4.5(b)** Frequency of use of chalkboard rulers, protractors & compasses.



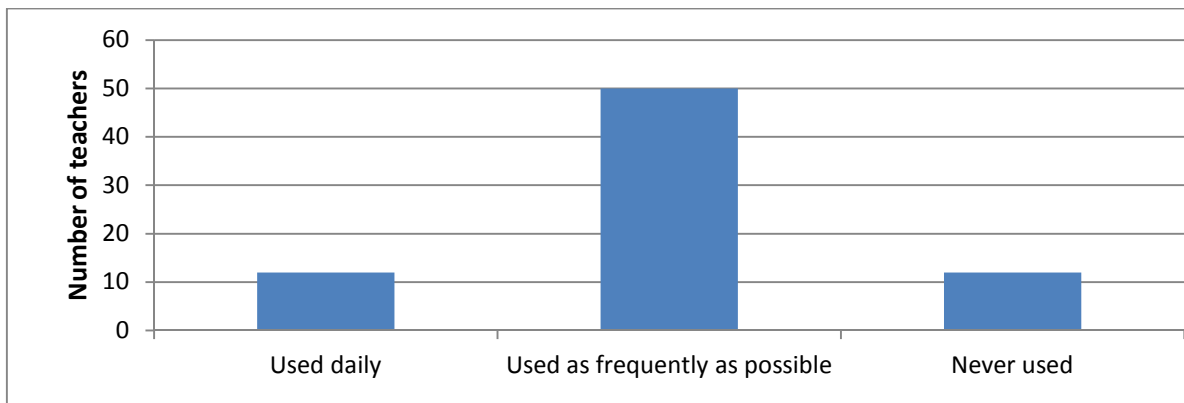
**Figure 4.5(c)** Source of chalkboard rulers, protractors & compasses.

### 4.2.2.3 Charts and/or posters

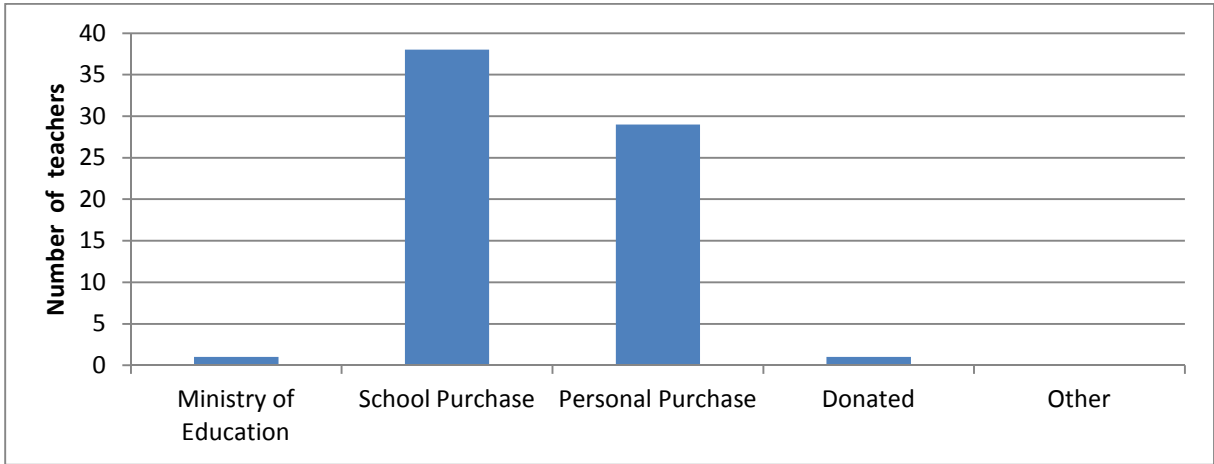
Around 80% of the teachers indicated that they have charts and/or posters in their departments (Figure 4.6(a)) with most teachers using them either daily or as frequently as possible (Figure 4.6(b)). No teachers indicated the non-use of posters that were available. Schools were responsible for 55% of the purchases while 42% of the posters/charts were bought personally by teachers (Figure 4.6(c)).



**Figure 4.6(a)** Availability vs. non-availability of charts/posters.



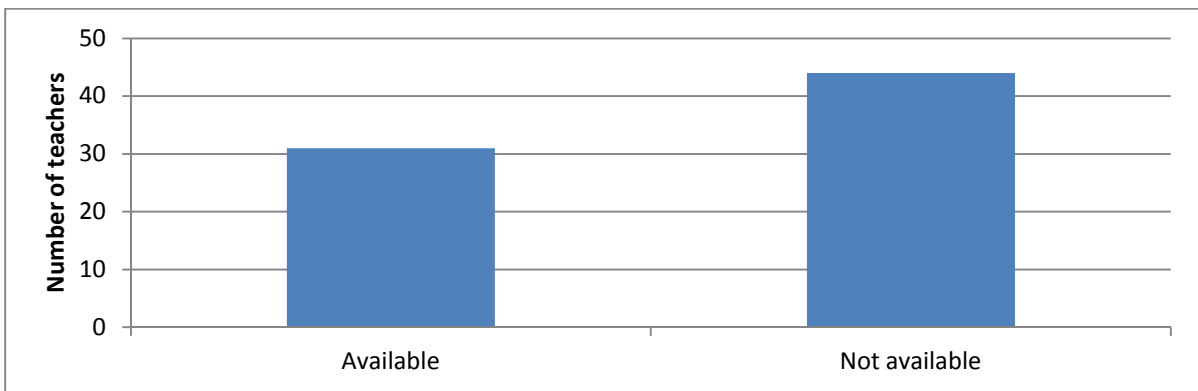
**Figure 4.6(b)** Frequency of use of charts/posters.



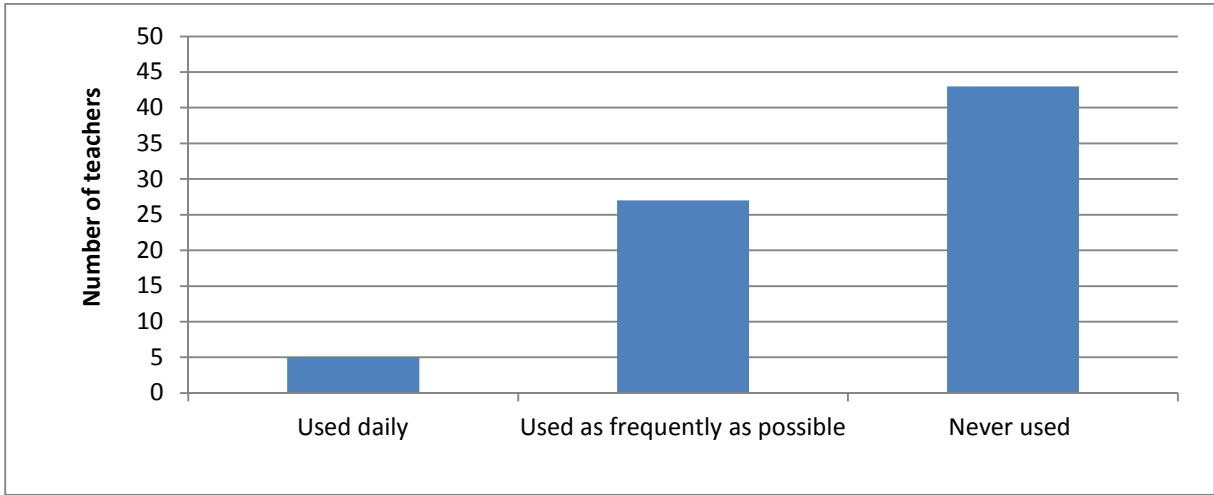
**Figure 4.6(c)** Source of charts/posters.

**4.2.2.4 Physical objects (other than geometric models)**

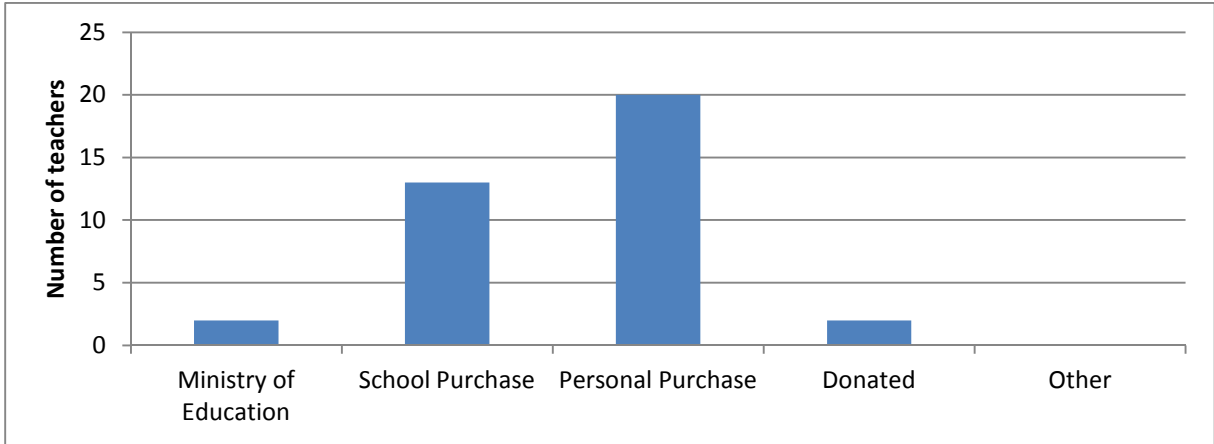
In the schools that were surveyed only 41% of the teachers indicated that physical objects (other than geometric models) were available in their classrooms (Figure 4.7(a)). Of this 41%, five teachers made use of these objects on a daily basis with the remaining 27 using the items as frequently as possible (Figure 4.7(b)). Most of these physical objects (54%) were purchased using teachers’ personal funds, with school budgets being used for approximately 35% of the purchases (Figure 4.7(c)).



**Figure 4.7(a)** Availability vs. non-availability of physical objects (other than geometric models).



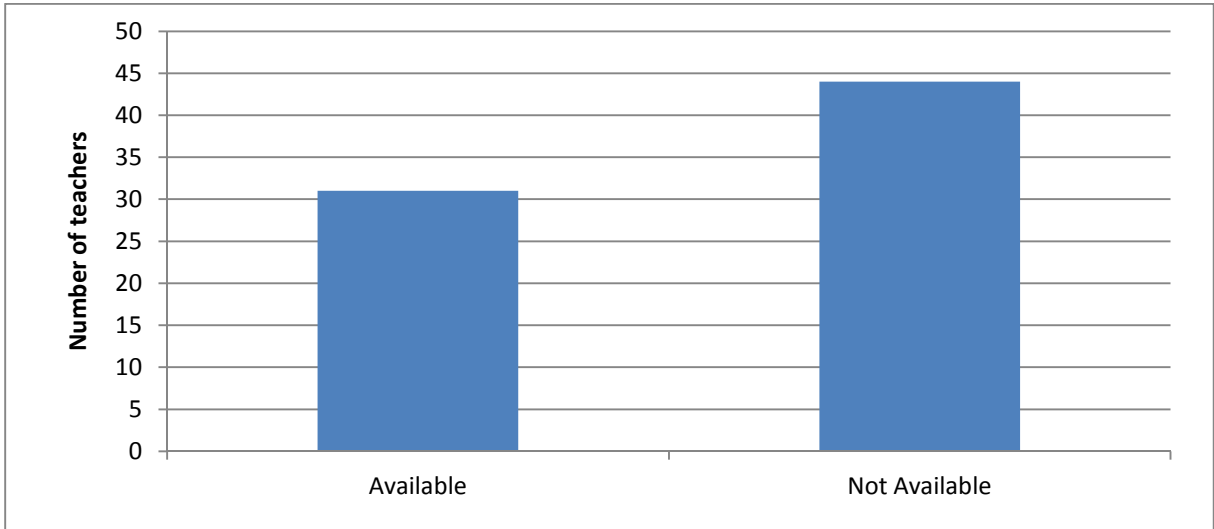
**Figure 4.7(b)** Frequency of use of physical objects (other than geometric models).



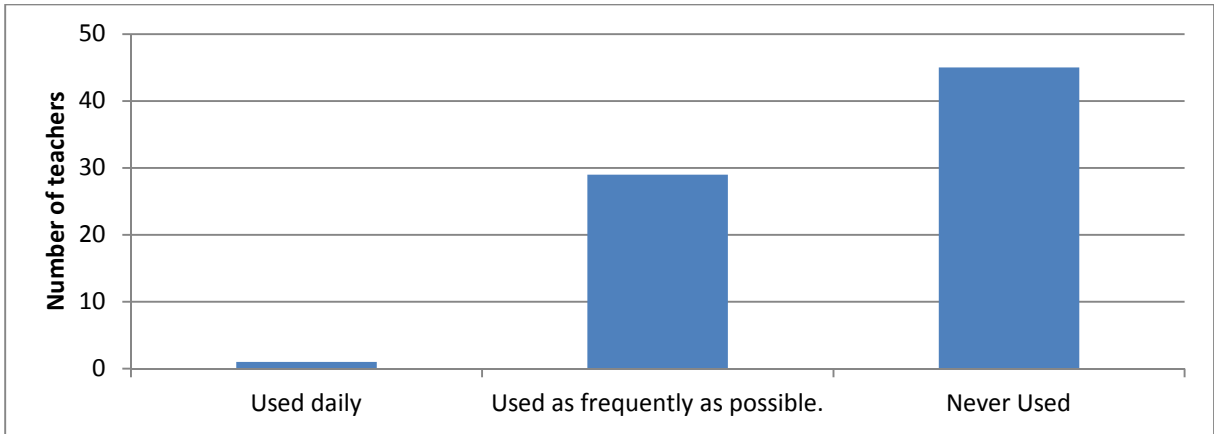
**Figure 4.7(c)** Source of physical objects (other than geometric models).

**4.2.2.5 Geometric models/shapes**

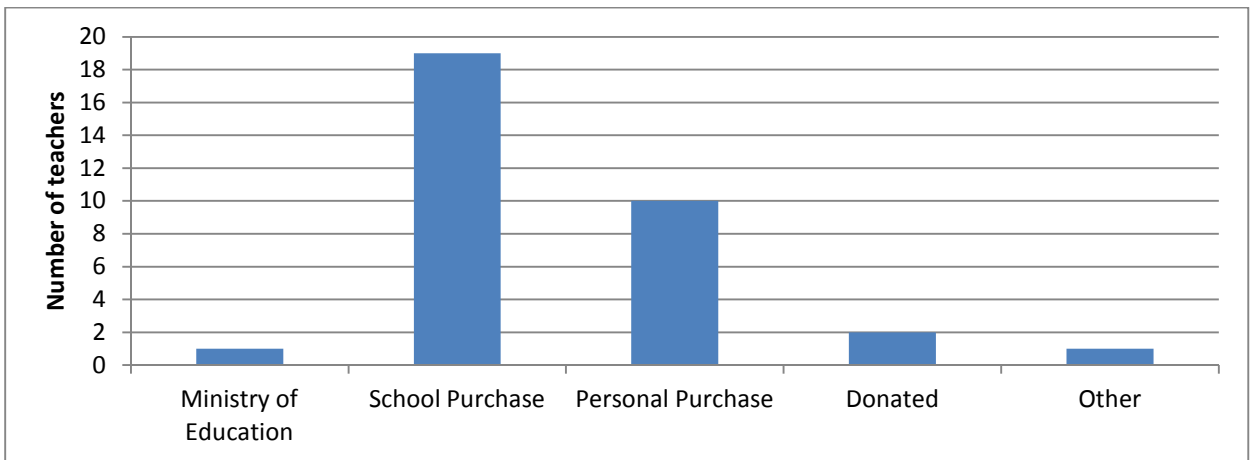
Around 59% of participants indicated that geometric models were not available (Figure 4.8(a)). 29 of the 75 teachers indicated that they used geometric models as frequently as possible, with only one teacher using such models on a daily basis (Figure 4.8(b)). A 54.5% response from teachers showed that schools sourced most of the available geometric models (Figure 4.8(c)).



**Figure 4.8(a)** Availability vs. non-availability of geometric models/shapes.



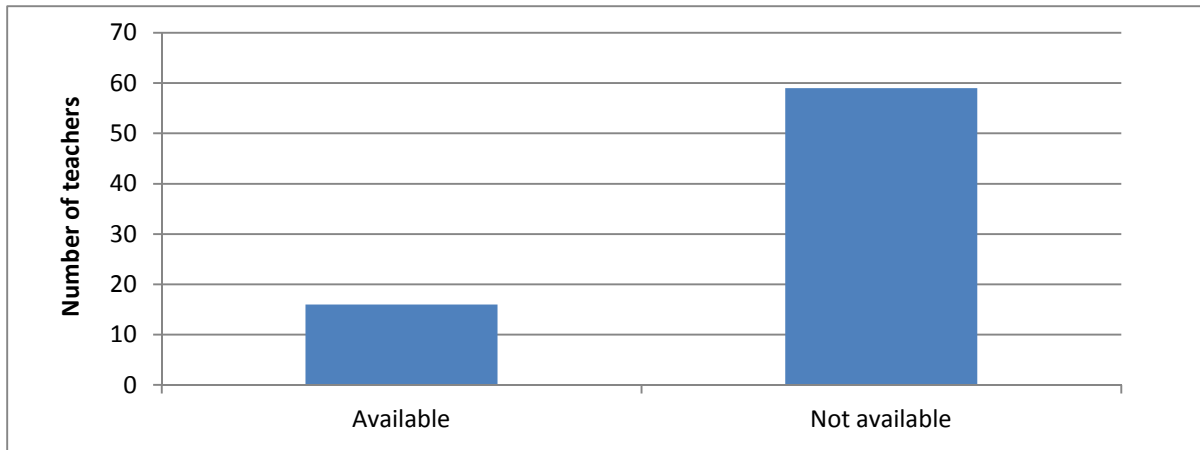
**Figure 4.8(b)** Frequency of use of geometric models/shapes.



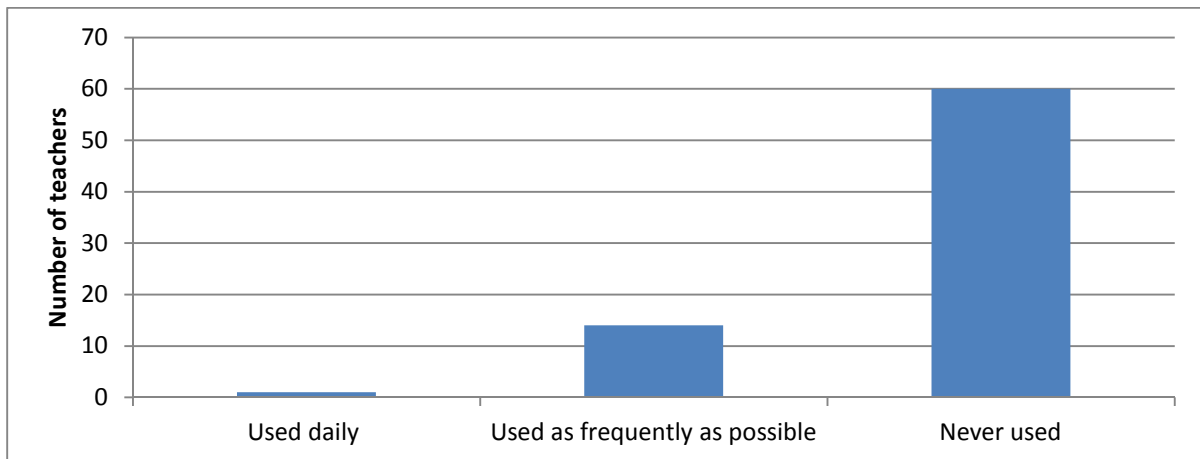
**Figure 4.8(c)** Source of geometric models/shapes.

#### 4.2.2.6 Graph boards

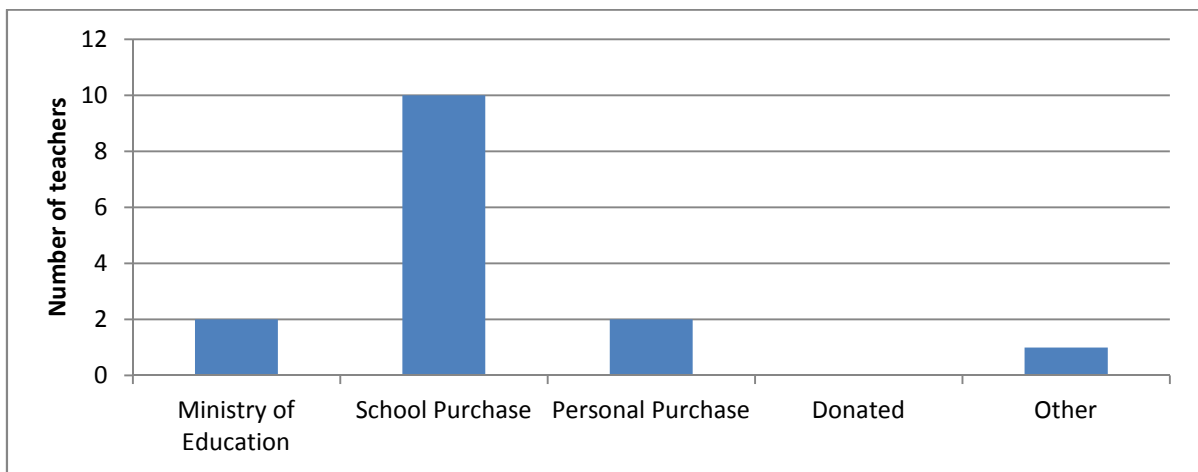
Almost 79% of the participants indicated that they do not have graph boards in their Mathematics departments (Figure 4.9(a)), a figure which is similarly reflected by 80% of the participants (60 teachers out of the cohort of 75) indicating that they never make use of graph boards in their classrooms (Figure 4.9(b)). Of the 16 teachers who have graph boards at their schools, 10 of them indicated that the schools purchased these boards (Figure 4.9(c)).



**Figure 4.9(a)** Availability vs. non-availability of graph boards.



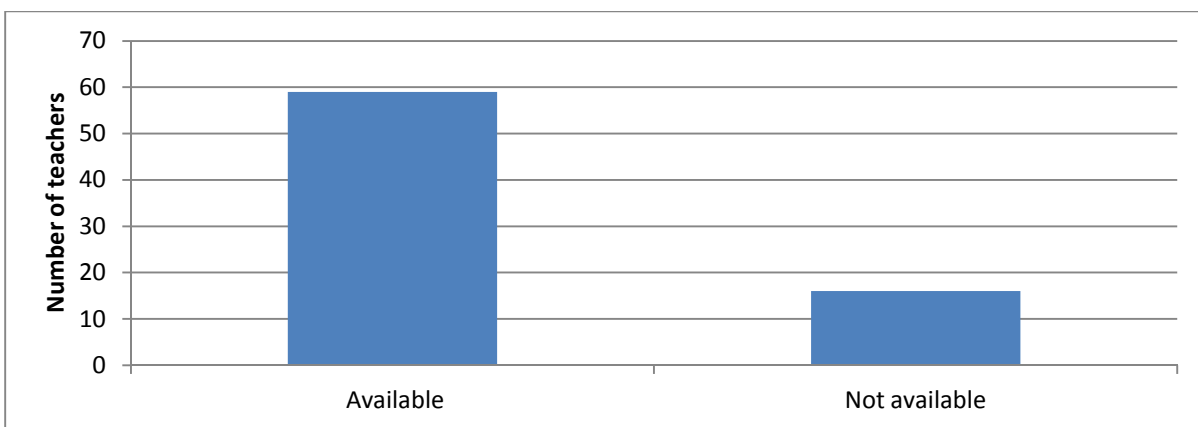
**Figure 4.9(b)** Frequency of use of graph boards.



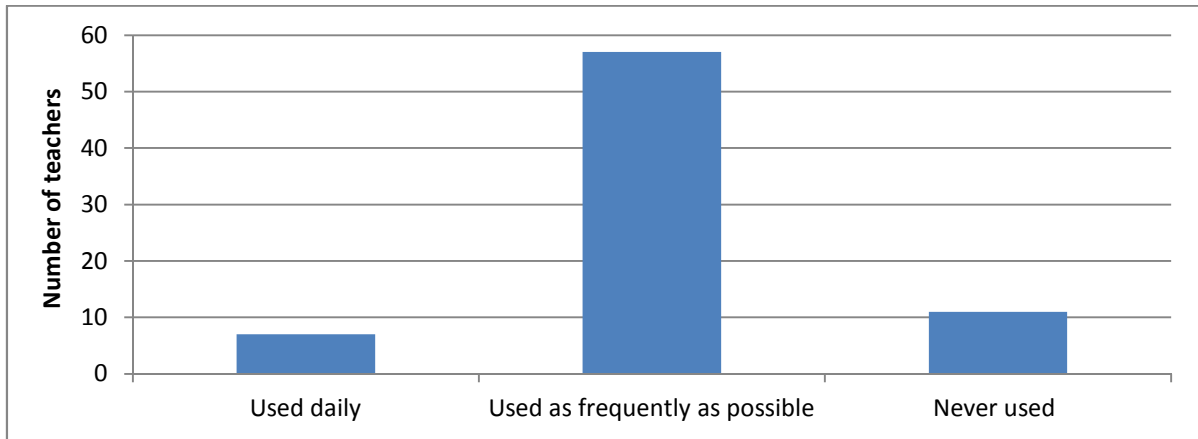
**Figure 4.9(c)** Source of graph boards.

#### 4.2.2.7 Mathematical instrument sets for learners

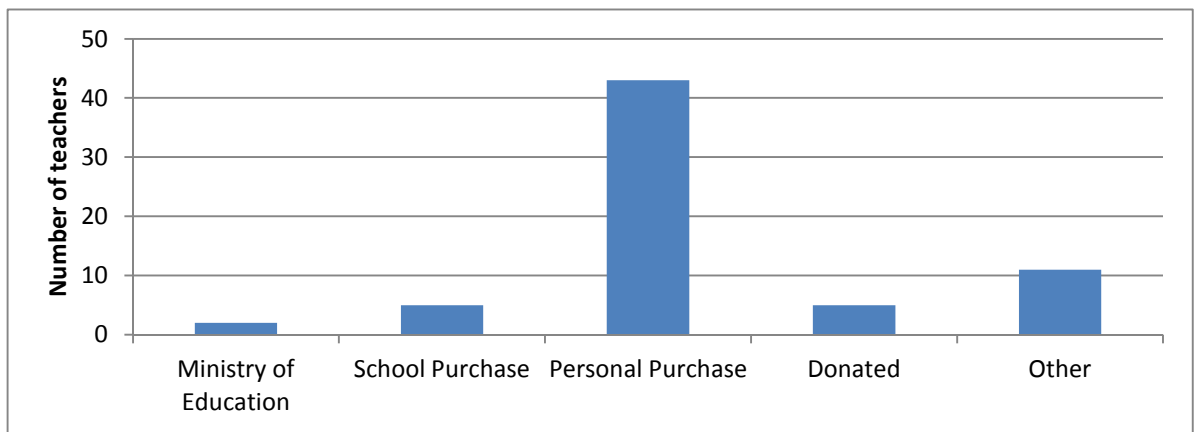
Almost 79% of teachers indicated that mathematical instrument sets were available for their learners (Figure 7.10(a)) and 76% of the teachers indicated that they made use of these mathematical sets as frequently as possible (Figure 7.10(b)). Around 14% of the teachers never used the mathematical sets as a result of their non-availability in the classroom. With respect to the source of the mathematical instrument sets, more than half of the teachers (57%) indicated that the learners had to personally purchase their instrument sets. A small percentage of the teachers (6.7%) indicated that their schools sourced the mathematical instrument sets for their learners (Figure 4.10(c)).



**Figure 4.10(a)** Availability vs. non-availability of mathematical instrument sets for learners.



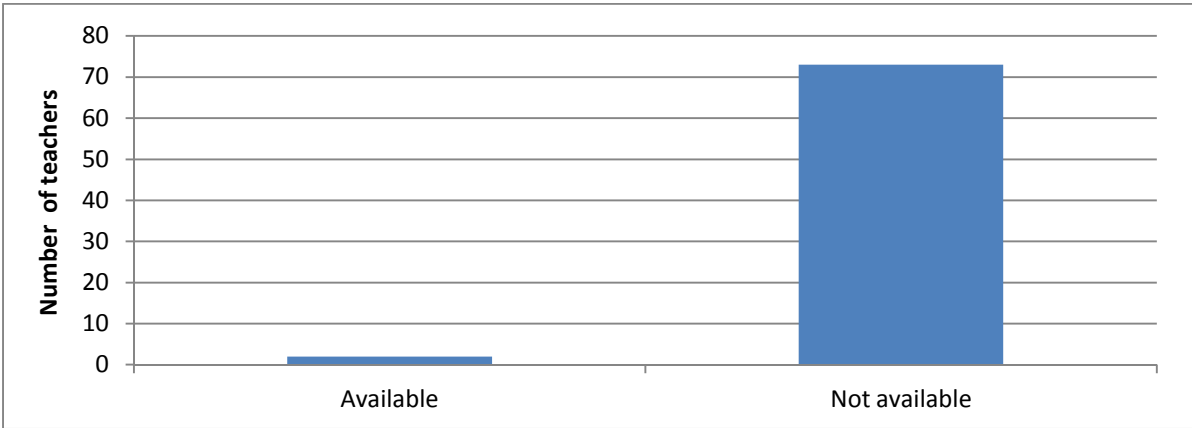
**Figure 4.10(b)** Frequency of use of mathematical instrument sets for learners.



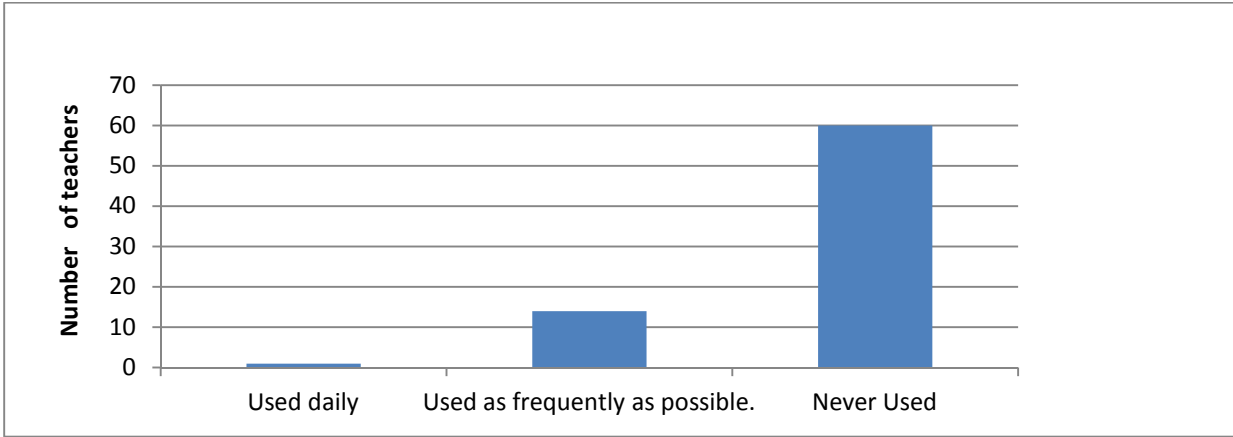
**Figure 4.10(c)** Source of mathematical instrument sets for learners.

#### 4.2.2.8 Geoboards

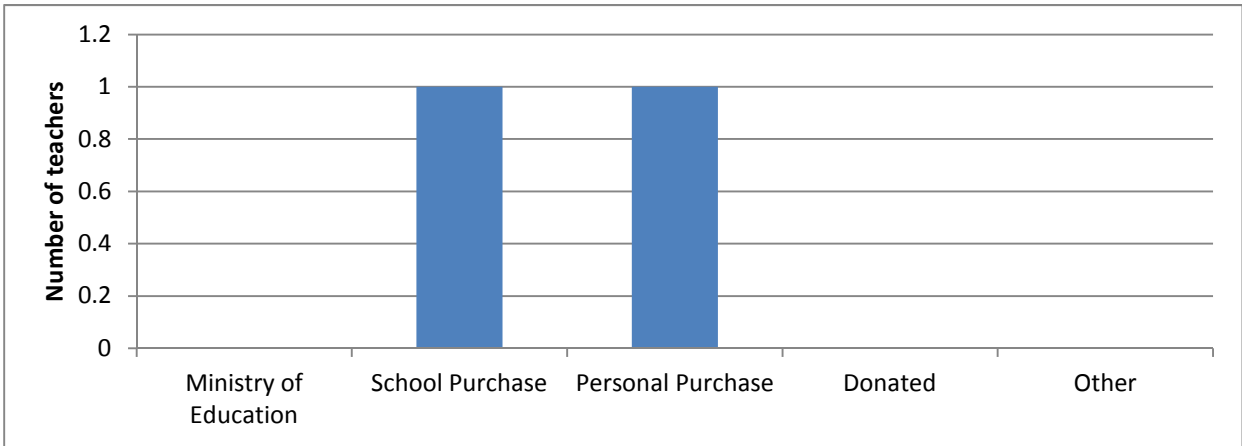
Geoboards are not readily available in the schools surveyed. Only two of the 75 teachers have geoboards available in the classrooms. This is surprising since this useful instrument can easily be improvised and is a simple but effective means of engaging with topics in geometry (e.g. transformations). 60 of the 75 teachers (80%) indicated that they never use a geoboard in the teaching and learning of Mathematics. Of the two geoboards that were available, one was bought by the school while the other was personally bought by the teacher (Figure 4.11(c)).



**Figure 4.11(a)** Availability vs. non-availability of geoboards.



**Figure 4.11(b)** Frequency of use of geoboards.



**Figure 4.11(c)** Source of geoboards.

#### 4.2.2.9 Overhead projectors

63% of the Mathematics teachers indicated that they have overhead projectors in their Mathematics departments, with 37% of the teachers not having access to them (Figure 4.12(a)). Only 8% of teachers use an overhead projector on a daily basis, with 31% using them as frequently as appropriate and around 61% never using an overhead projector in their Mathematics lessons (Figure 4.12(b)). Of the 46 teachers who indicated that they had access to overhead projectors, the majority of them (72%) indicated that the schools purchased this equipment with the Ministry of Education accounting for 15 % (Figure 4.12(c)).

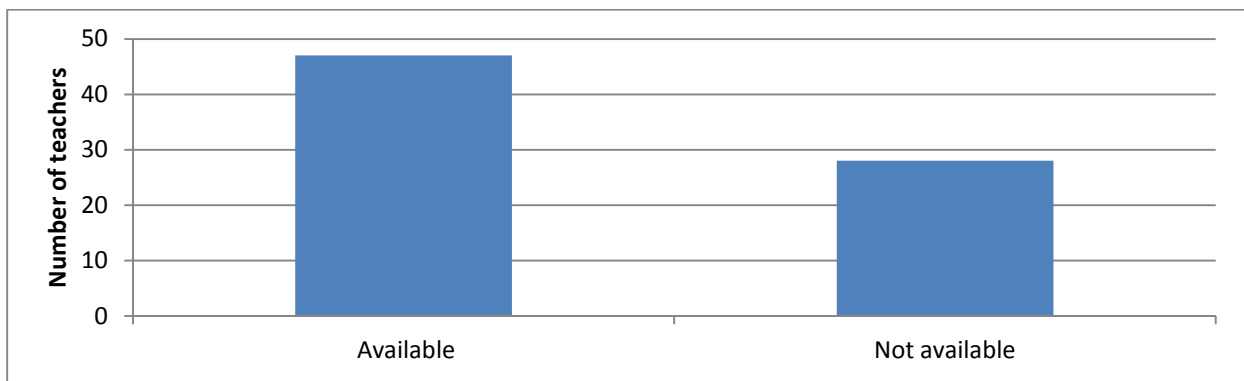


Figure 4.12(a) Availability vs. non-availability of overhead projectors.

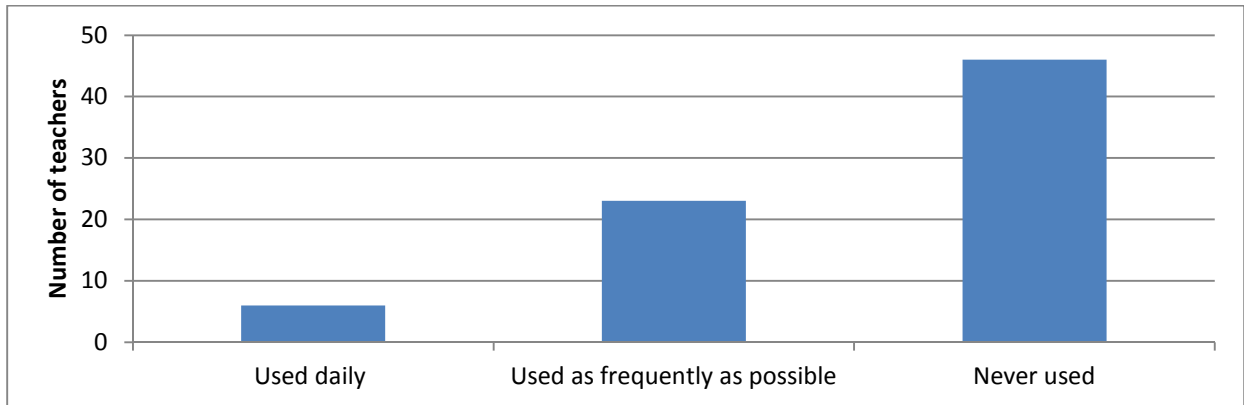
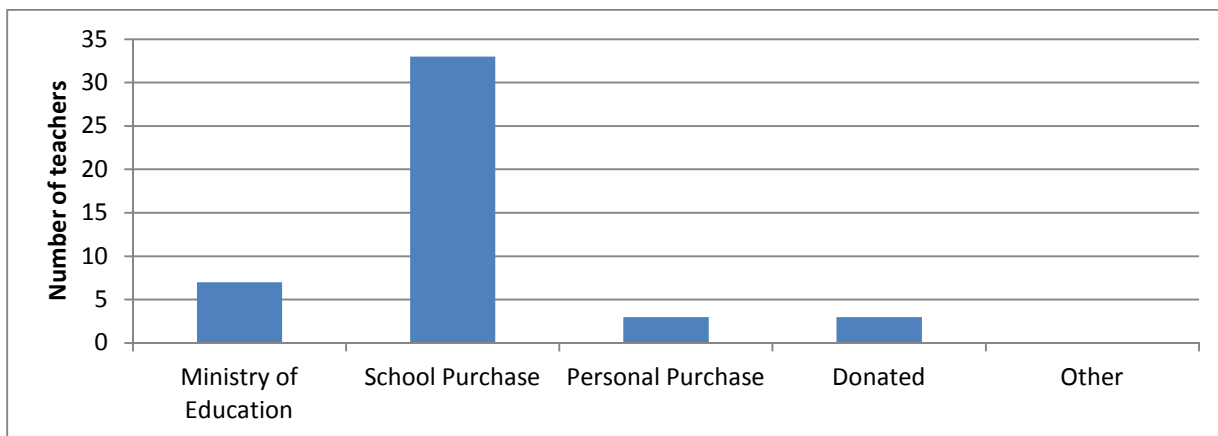


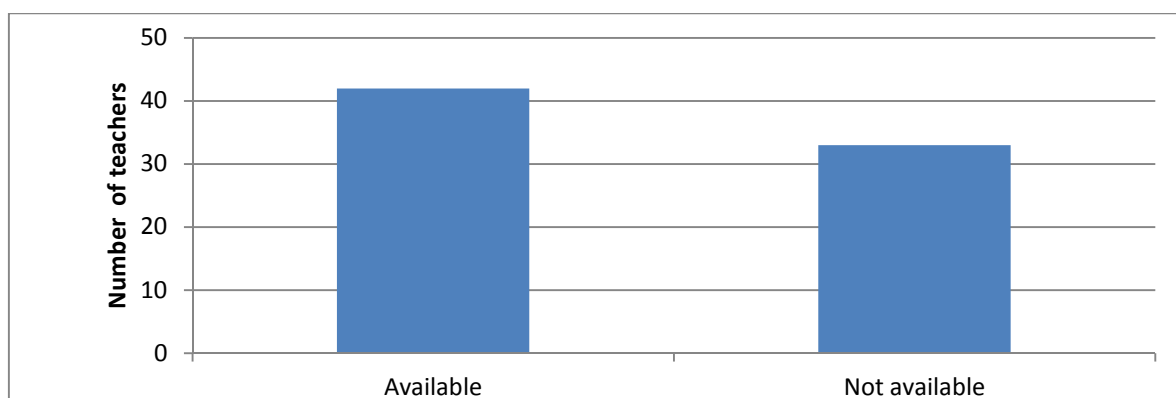
Figure 4.12 (b) Frequency of use of overhead projectors.



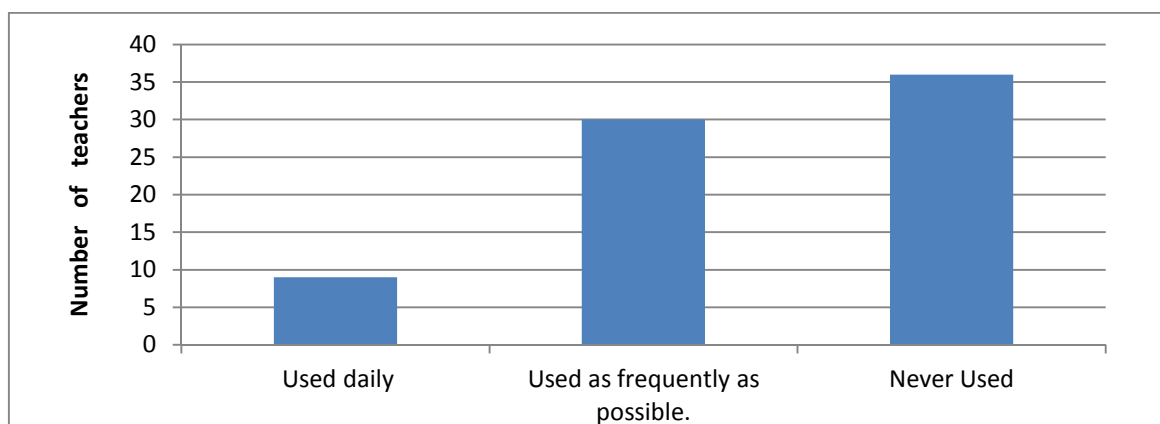
**Figure 4.12(c)** Source of overhead projectors.

#### 4.2.2.10 Computers and/or laptops

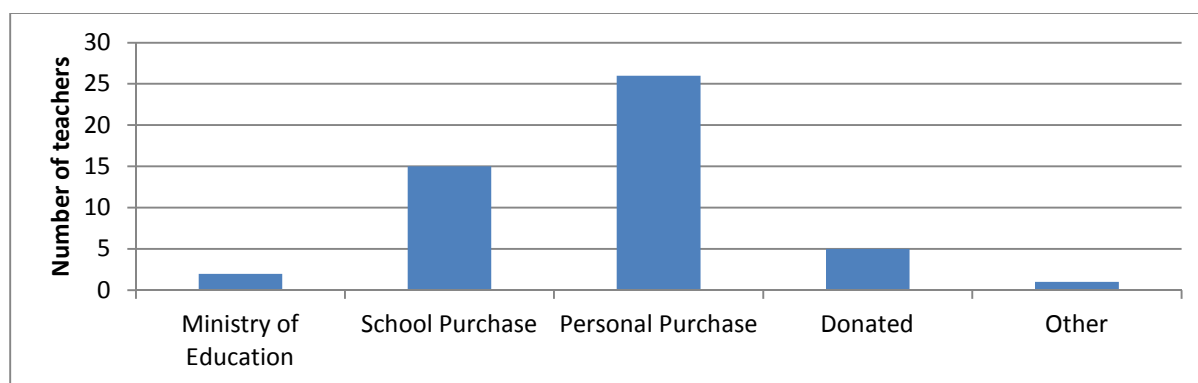
56% of the 75 teachers indicated that computers or laptops are available in their schools (Figure 4.13(a)). Around 48% of the teachers revealed that they never use computers or laptops in the learning and teaching of mathematics (Figure 4.13(b)). Only five of the 75 teachers use computers in their lessons on a daily basis (Figure 4.13(b)), while around 40% of the teachers indicated that they used computers in their lessons as frequently as possible depending on the appropriateness of the topic being taught and the availability of suitable software. Figure 4.13(c) shows the source of computers in the surveyed schools. The data suggests that Mathematics teachers in these schools value the importance of using modern technology in their lessons since 53% of them personally purchased these devices. Only two of the 75 teachers indicated that the computer(s) they use in their lessons were provided by the Ministry of Education, while 15 of the teachers cited school purchases as the source of their computers.



**Figure 4.13(a)** Availability vs. non-availability of computers/laptops.



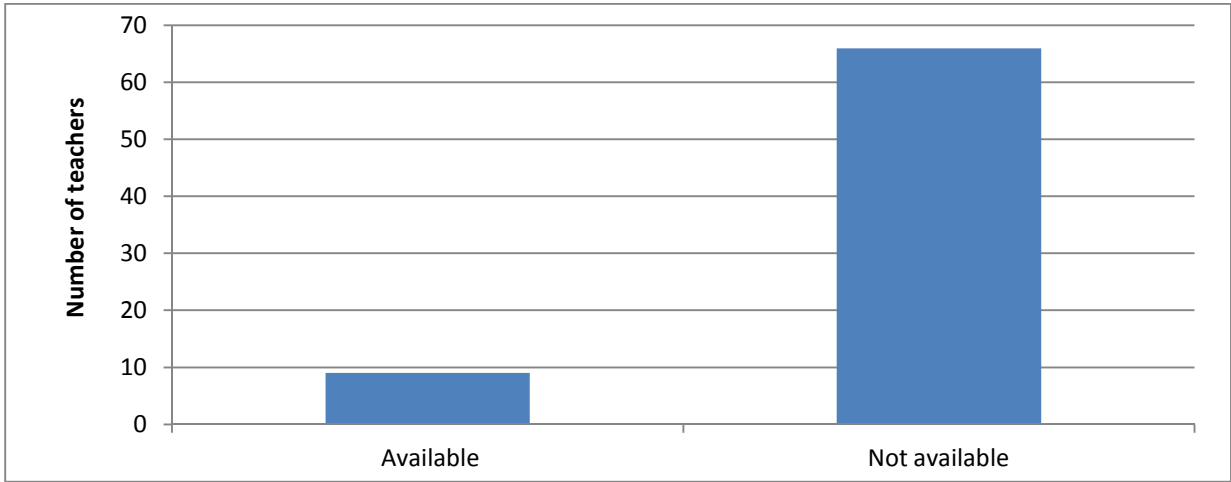
**Figure 4.13(b)** Frequency of use of computers/laptops.



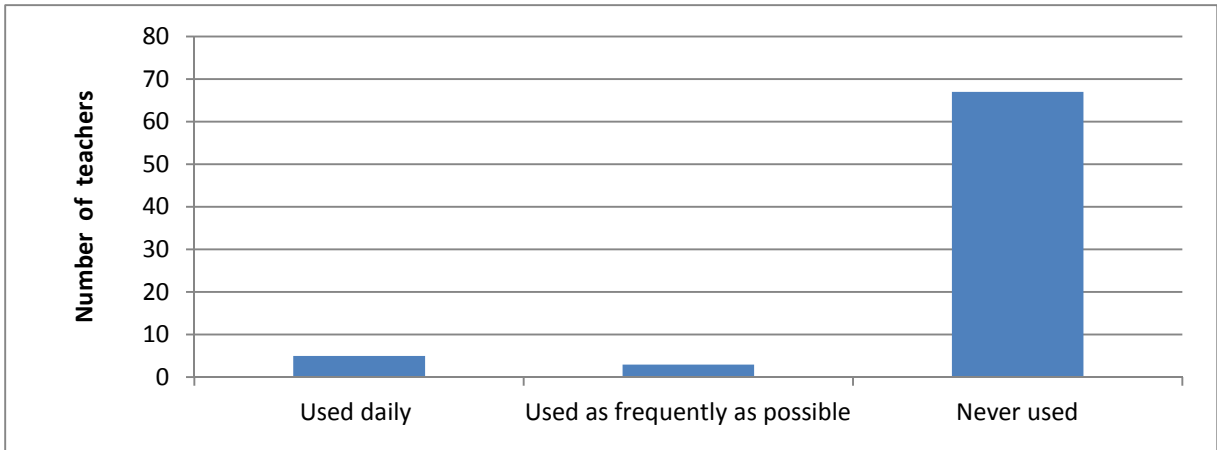
**Figure 4.13(c)** Source of computers/laptops.

#### 4.2.2.11 Interactive whiteboards

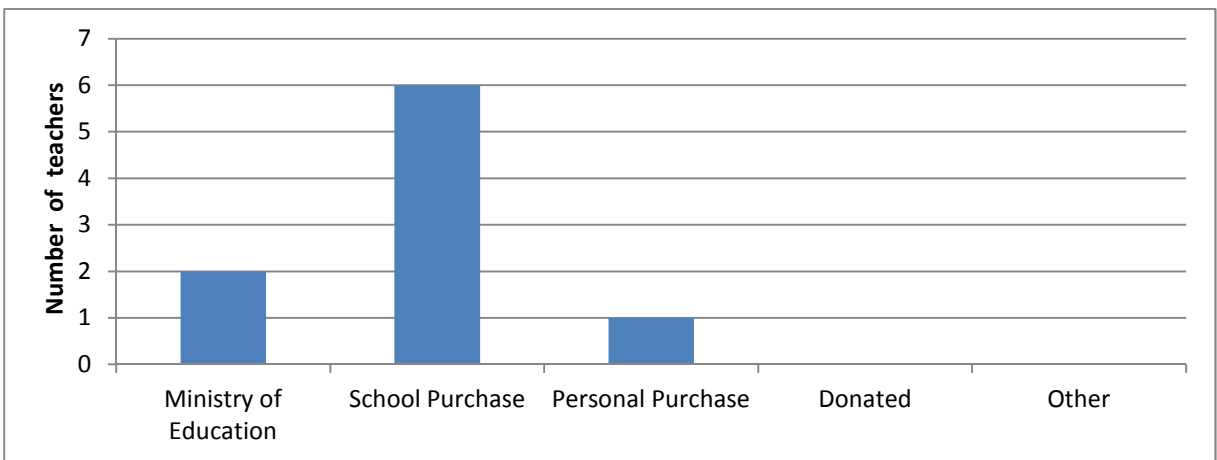
Interactive whiteboards are not readily available in the 25 secondary schools surveyed, with only 9 teachers indicating that they had access to such technology (Figure 4.14(a)). Figure 4.14(b) illustrates that almost 90% of surveyed teachers never use interactive whiteboards in their lessons. Of the nine teachers indicating that they had access to interactive whiteboards, two-thirds indicated school purchases as the source (Figure 4.14(c)).



**Figure 4.14(a)** Availability vs. non-availability of interactive whiteboards.



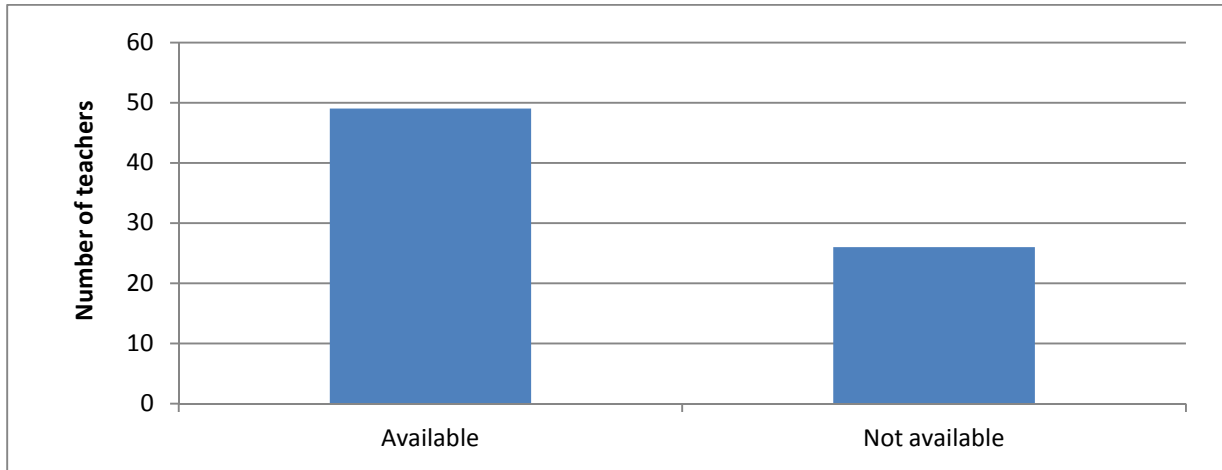
**Figure 4.14(b)** Frequency of use of interactive whiteboards.



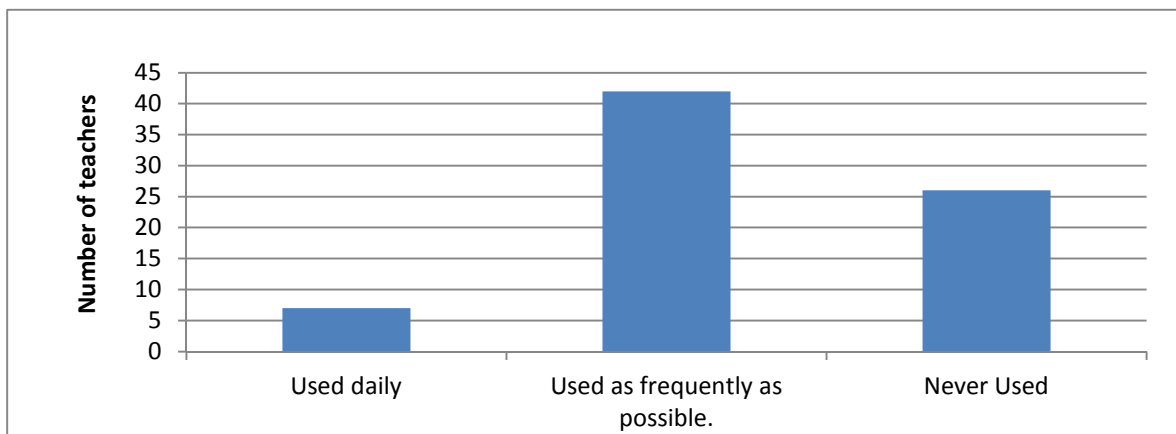
**Figure 4.14(c)** Source of the interactive whiteboards.

#### 4.2.2.12 Improvised teaching aids

65% of the teachers indicated the availability of improvised teaching aids in their schools (Figure 4.15(a)) with 9% indicating that they used such resources on a daily basis (Figure 4.15(b)). 35% of the teachers indicated that they have never used improvised teaching aids in their lessons.



**Figure 4.15(a)** Availability vs. non-availability of improvised teaching aids.



**Figure 4.15(b)** Frequency of use of improvised teaching aids.

#### 4.2.2.13 Any other teaching aids

This category aimed to assess whether there were any other mathematics teaching aids that are used in the 25 surveyed schools but were not cited as specific categories in the questionnaire list. Only 5 teachers indicated the availability of teaching aids other than those on the list provided.

Some of the items missing from the questionnaire list but which were indicated by the teachers as teaching aids include calculators, worksheets and electronic devices such as audio-visual gadgets.

### **4.2.3 Discussion**

The types of mathematical teaching aids most readily available in the 25 secondary schools surveyed in the Windhoek metropolitan area include: charts and posters; chalkboard 30° & 60° set squares; chalkboard rulers, protractors and compasses; mathematical sets for learners; overhead projectors; and improvised teaching aids. For each of these teaching aid categories teachers indicated a greater than 60% availability. The availability of physical objects (other than geometric models), geometric models and computers/laptops was calculated as being in the 60% to 40% range, and such teaching aids can be classified as being moderately available. Graph boards, interactive whiteboards and geoboards were the least available items with availability scores of 21%, 12% and 3% respectively.

Teaching to achieve mathematical proficiency (Kilpatrick, et al., 2001) involves “consistently helping students learn worthwhile mathematics content” (p. 369) through the provision of adequate learning resources such as teaching aids to enable learners to actively participate in the mathematics activities and further promote their learning experiences. Graph boards, geoboards and geometric models, which have been identified as being largely unavailable (or only moderately available in the case of geometric models) are not only important for the teaching and learning process but can be readily improvised at most schools nationwide. According to Obara and Jiang (2011), the use of well-designed teaching tools such as hands-on geometric artefacts has the potential to “develop clear images of the two- and three-dimensional geometric objects, which are not easily constructed otherwise, and of their mathematical properties and relationships” (p. 109). In their study on the need for improvisation of teaching aids in Science lessons, Onasanya and Omosewo (2011) observed that “teachers have been depending on excessive use of words to convey facts in the learning and teaching of science” (p. 70). In this study it was noted that although 49 teachers indicated that improvised teaching aids were available, only 7 of the 75 teachers used such tools on a daily basis.

In examining the aggregate responses for all 13 categories of teaching aids provided in the questionnaire, only 100 instances of particular teaching aids being used on a daily basis were identified. While there were just over 350 instance of particular teaching aids being used as frequently as possible, the almost 450 instances of specific teaching aids never being used is somewhat worrying. As a developing nation it is clear that teaching and learning resources are insufficiently provided for in many Namibian secondary schools. Although the major source of teaching aids was indicated as being school purchase (47% of the total responses), it is interesting to note that personal purchases accounted for a surprising 35%. This makes personal purchase the second-highest source of teaching aids in the schools surveyed. This highlights the readiness and willingness of some teachers to take responsibility for sourcing and financing personal teaching aids for their classroom teaching and learning. By contrast, the Ministry of Education was indicated as being responsible for only 11% of the teaching aids audited. Research in Mathematics education has given credence to the importance of having a variety of teaching aids as such resources are likely to promote learners' understanding of mathematical concepts. As Nool (2012) remarks, the use of teaching aids "has indeed been found to yield positive outcomes for learners' understanding in different levels of Mathematics learning from elementary to college levels" (p. 309).

Research on the importance of using teaching aids has shown that learners develop visualisation skills through hands-on experiences in Mathematics lessons (Obara & Jiang, 2011, p. 103). The use of different strategies and teaching aids in approaching mathematics problems "helps students become stronger and more flexible in working in various problem situations" (Obara & Jiang, 2011, p. 109). The use of computer related teaching and learning resources is also likely to encourage learners to actively participate in lessons thereby promoting learner-centred education. According to Cornelius-White and Harbaugh (2010), learner-centred instruction is an approach to teaching and learning that "prioritizes facilitative relationships, the uniqueness of every learner, and the best evidence on learning processes to promote comprehensive student success through engaged achievement" (p. 174). Teaching aids can be used to promote not only active participation of learners in lessons but also to support multiple representational access to mathematical concepts thereby foregrounding the goals of Learner-Centred Education.

White (2003) argues that “productive classroom discourse requires that teachers engage all students in discourse by monitoring their participation in discussions and deciding when and how to encourage each student to participate” (p. 37). The need to motivate learners to develop a positive attitude towards Mathematics is highlighted by Reys (1971) who explain that teaching aids with “favourable physical characteristics will frequently stimulate the learners’ imagination and interest” (p. 553).

Clements and McMillen (1996) observed that “computers might supply representations that are just as personally meaningful to students as are real objects; that is they might help develop integrated concrete knowledge” (p. 271). The computer has proved to be a powerful resource for modern teachers especially if both the teachers and learners have internet access at their schools. The schools in this survey encompassed both public and private secondary schools in an urban centre environment. There are some schools with more than four Mathematics classes per grade, with around 35 learners per class. Given that 33 of the 75 teachers surveyed indicated that they had no access to computers for teaching, this translates to a very high number of young learners who are not being exposed to computers and modern technology in their everyday Mathematics lessons.

While some teaching aids are readily available and are regularly used (e.g. charts and posters; chalkboard  $30^\circ$  &  $60^\circ$  set squares; chalkboard rulers, protractors and compasses; mathematical sets for learners; overhead projectors; and improvised teaching aids), this survey highlighted the poor availability of other teaching aids. While physical objects (other than geometric models), geometric models and computers/laptops were moderately available, graph boards, interactive whiteboards and geoboards were available in only a handful of schools. The non-availability of interactive whiteboards in the vast majority of schools is an area of potential concern, particularly considering that the survey was carried out in an urban/metropolitan environment. The study unearthed that only two out of 75 secondary school teachers indicated that they possess a geoboard at their school, despite the fact that geoboards can be cheaply and easily manufactured from very simple materials. An encouraging finding of the survey was the teachers in many instances have gone an extra mile to contributing to the supply of teaching aids by personally financing resources. It is noteworthy that the Ministry of Education is responsible for supplying far fewer teaching aids

than those that are personally financed by teachers. Computer use in the classroom is still far from ideal with 33 teachers indicating that they have never used computers in their lessons.

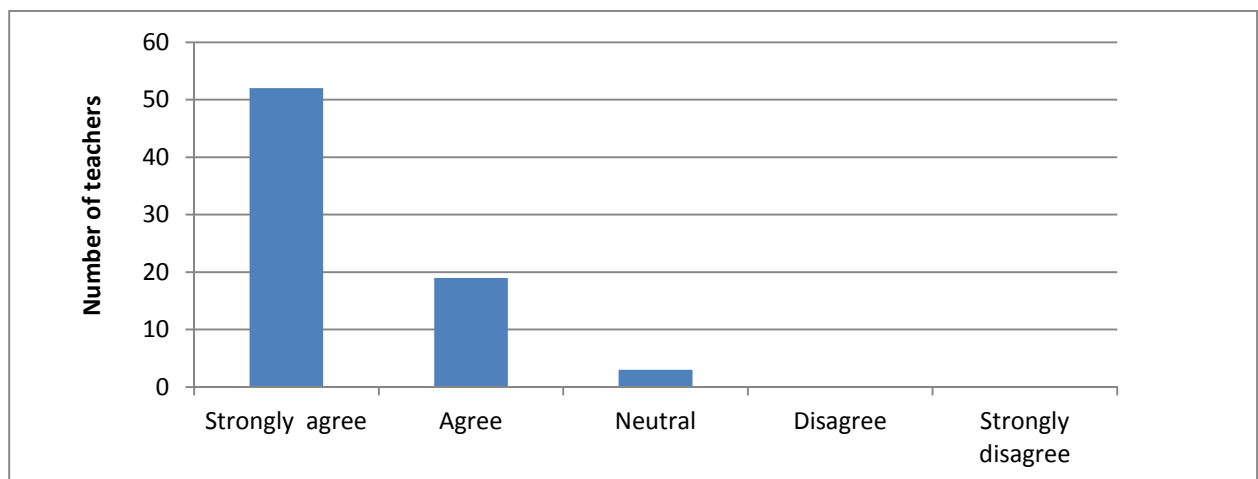
### 4.3 LIKERT SCALE DATA

This section presents and discusses teacher responses to the ten closed questions posed in the second part of the survey questionnaire carried out in Phase 1. The Likert scale was used to gather teachers' opinions on broader issues related to the use of teaching aids in Mathematics lessons in their schools.

#### 4.3.1 Responses to individual questions

##### **Question 1: The use of teaching aids in Mathematics classes at secondary school level promotes learners' participation and interest in Mathematics.**

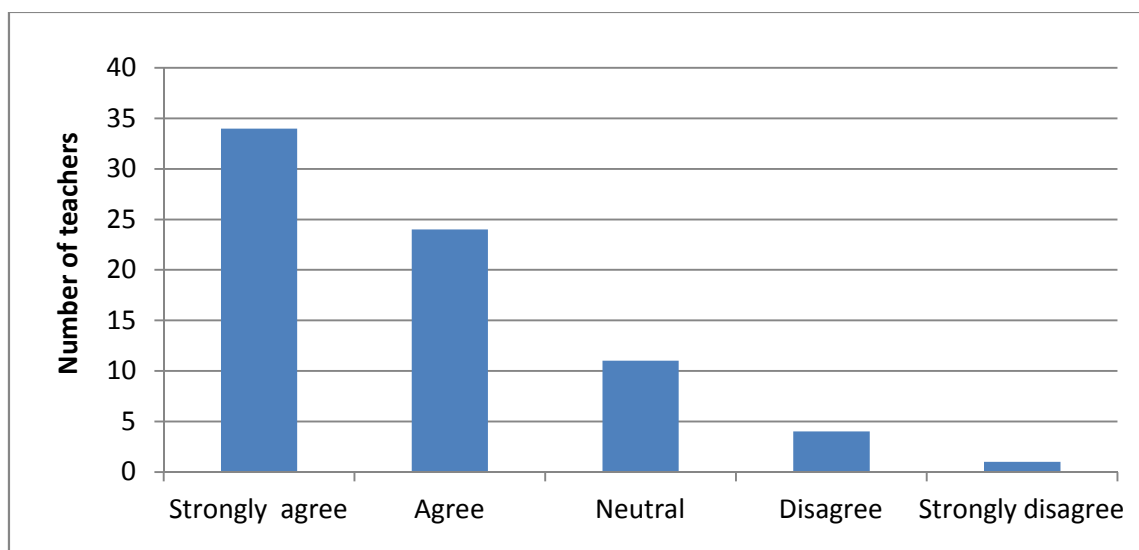
The purpose of this question was to ascertain whether teachers believe that the use of teaching aids in Mathematics lessons contributes towards learners' active participation and general interest in the subject. 96% of all respondents agreed (25.6% strongly so) that the use of teaching aids in Mathematics classes promotes learners' participation and interest in the subject (Figure 4.16).



**Figure 4.16** *The use of teaching aids in mathematics classes promotes learners' participation and interest in Mathematics.*

**Question 2: Teaching can only be effective when adequate and relevant teaching resources are used in Mathematics lessons.**

This question aimed to investigate whether Mathematics teachers felt that inadequate resources compromised the effectiveness of their teaching activities at secondary school level. Approximately 78% of the participants agreed (46% strongly so) that availability of relevant and adequate resources was necessary for effective delivery of Mathematics lessons at secondary school level (Figure 4.17). Only 6.8% of the participating teachers were of the opinion that using teaching aids was not a necessary prerequisite to effective teaching and learning of Mathematics at secondary level. There was thus an implicit consensus among teachers that teaching aids not only promote active participation and interest among the learners but also promote teaching for mathematical proficiency.

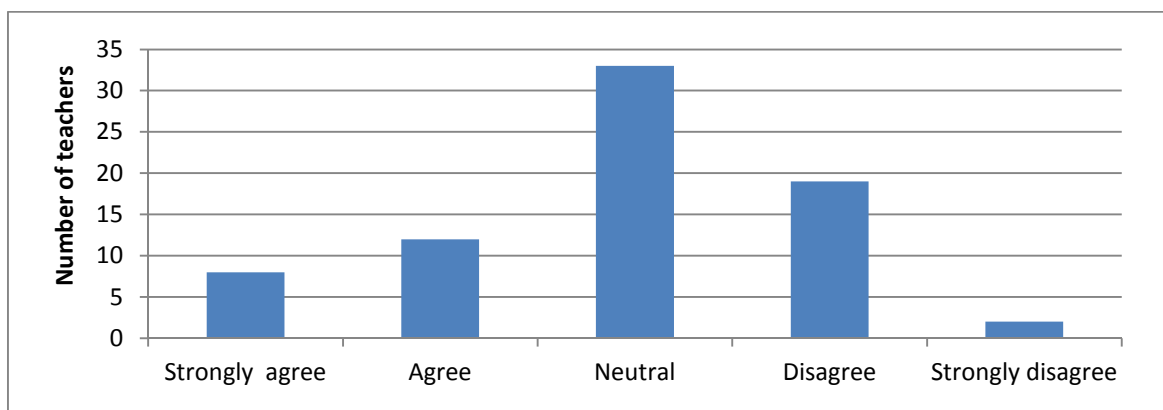


**Figure 4.17** *Teaching can only be effective when adequate and relevant teaching resources are used in mathematics lessons.*

**Question 3: Mathematics teachers have enough time to prepare teaching aids for most of their lessons.**

Questions 1 and 2 aimed at eliciting the general perception of teachers towards the importance of using teaching aids. If teachers value the importance of using teaching aids in their everyday teaching, the question arises as to whether or not they have sufficient time to devote to the preparation of teaching resources. In response to Question 3, close to half of the participants (44.6%) responded neutrally while 28.4% indicated that they did *not* have

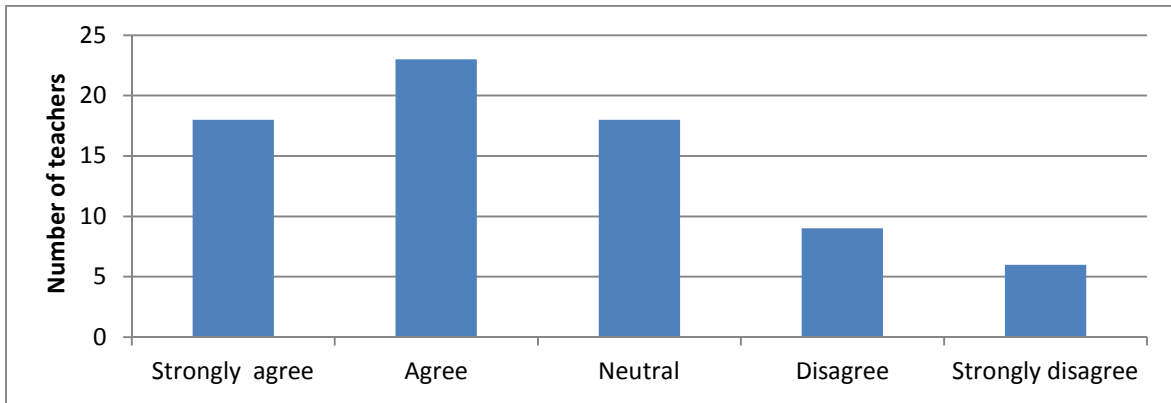
enough time to prepare teaching aids. Only 27% of the teachers indicated that they had sufficient time to prepare teaching aids (Figure 4.18). This suggests that the value and importance that many teachers attach to the use of teaching aids is being compromised by the unavailability of preparation time.



**Figure 4.18** *Mathematics teachers have enough time to prepare teaching aids for most of their lessons.*

**Question 4: Using teaching aids in Mathematics lessons promote the teacher’s programme to complete the syllabi in time.**

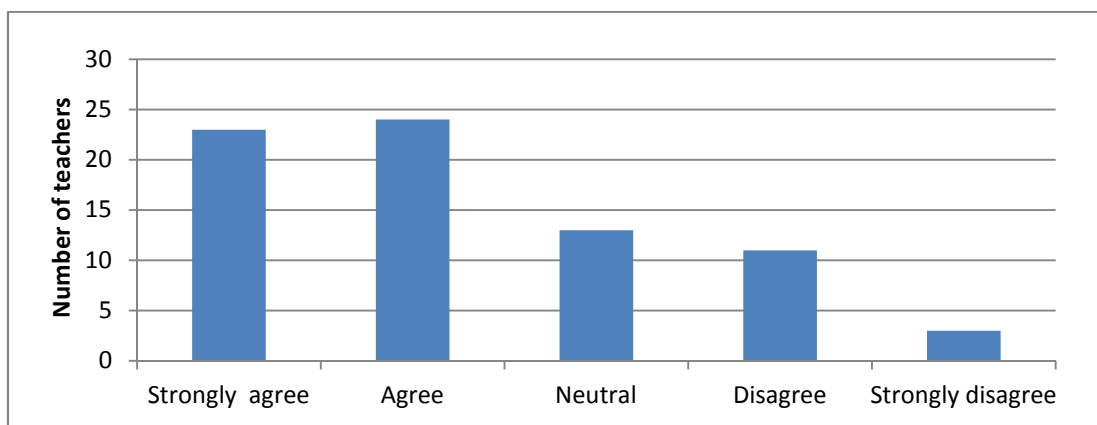
55% of the teachers were of the opinion that the use of teaching aids in their Mathematics lessons contributed to allowing them to complete the prescribed syllabus according to schedule. Only 20% of the teachers felt that teaching aids did not assist in the process of completing the syllabus in time (Figure 4.19). This raises an important question: Why would Secondary School teachers fail to create time to prepare teaching resources (Question 3) if their general opinion is that the use of such resources promotes learners’ active participation (Question 1), assists with effective lesson delivery (Question 2) as well as aiding the process of finishing the school syllabus in a timely fashion (Question 4)?



**Figure 4.19** *Using teaching aids in mathematics lessons promote the teacher's programme to complete the syllabi in time.*

**Question 5: The use of teaching aids in Mathematics is made difficult because resources are not available in schools.**

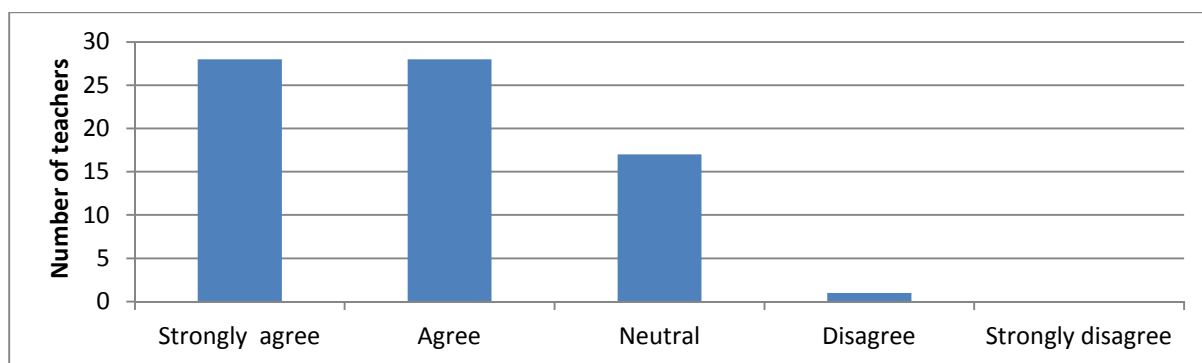
This question focuses on the in-school availability of teaching resources for Mathematics and in part was meant to triangulate the information extracted from Part 1 of the questionnaire where teachers' aggregate responses to the availability versus non-availability of teaching aids were analysed. In terms of the availability of the teaching aids there were a total of 911 responses, 47% of which indicated that the particular teaching aid was not available. In response to the Likert scale questions 63.5% of the teachers agreed (3.1% strongly so) that resources are not adequate, and that the use of teaching aids is made difficult by lack of resources in schools (Figure 4.20). These two pictures of availability seem to correlate well.



**Figure 4.20** *The use of teaching aids in mathematics is made difficult because resources are not available in schools.*

**Question 6: The use of teaching aids promotes good academic performance of learners in end of year Mathematics examinations.**

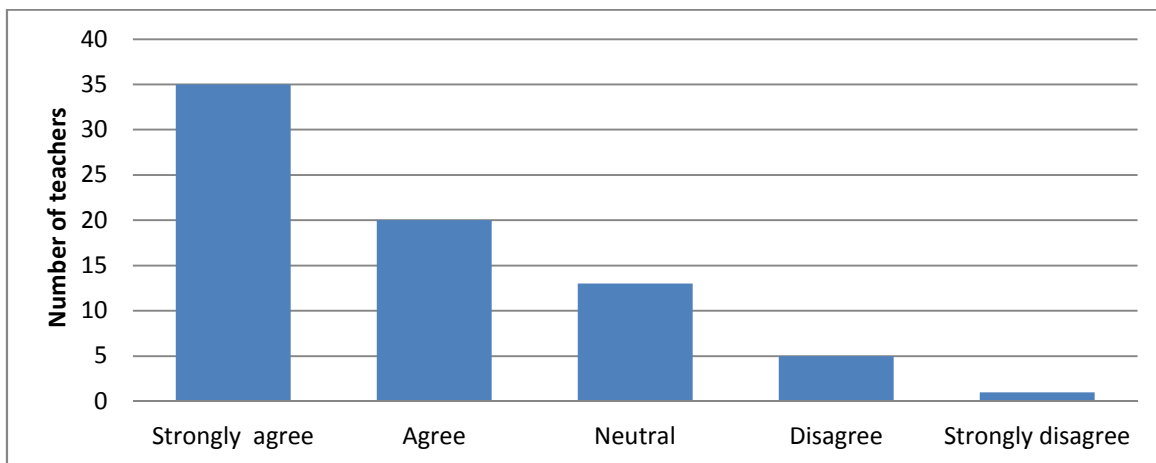
75.6% of the teachers were of the opinion that teaching aids promote good academic performance in year-end Mathematics examinations (Figure 4.21). None of the participants fell in the “strongly disagree” category while only one teacher disagreed with the notion that teaching aids contributed to learners’ academic performance in examinations. 17 teachers were neutral in their response.



**Figure 4.21** *The use of teaching aids promotes good academic performance of learners in end of year mathematics examinations.*

**Question 7: Teachers should be given more in-service training on the use of teaching aids in Mathematics.**

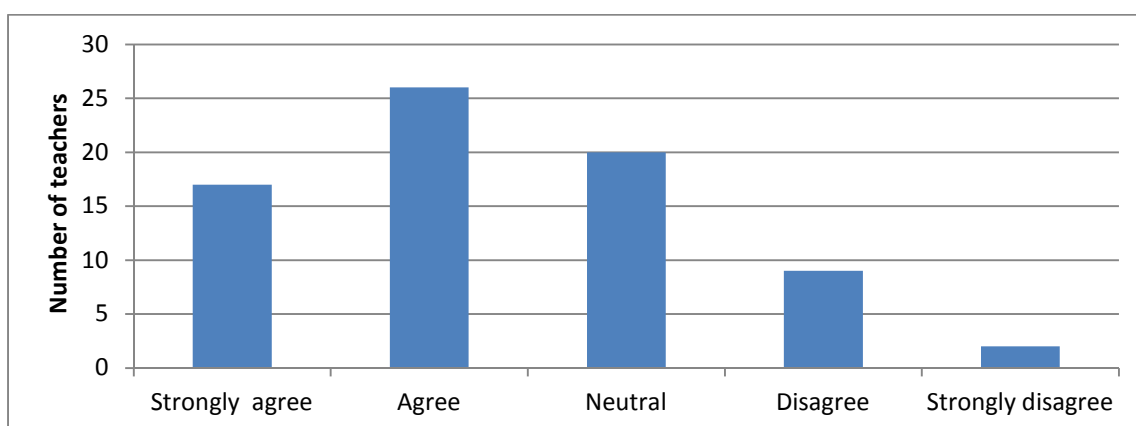
What do teachers say about the pedagogical and didactical skills taught and acquired while trainee teachers? Are skills and theories acquired at the time of training relevant and sufficiently useful to enable them to design effective teaching aids for their everyday classroom experiences? An overwhelming 74% of the teachers felt that they required more in-service training on the use of of teaching aids in Mathematics. 47% of the teachers strongly agreed with this sentiment (Figure 4.22). Only a handful of teachers felt that additional in-service training on the use of teaching aids was unnecessary.



**Figure 4.22** Teachers should be given more in-service training on the use of teaching aids in Mathematics.

**Question 8: Mathematics teachers can easily improvise effective teaching aids that help learners grasp important concepts using scarce resources available.**

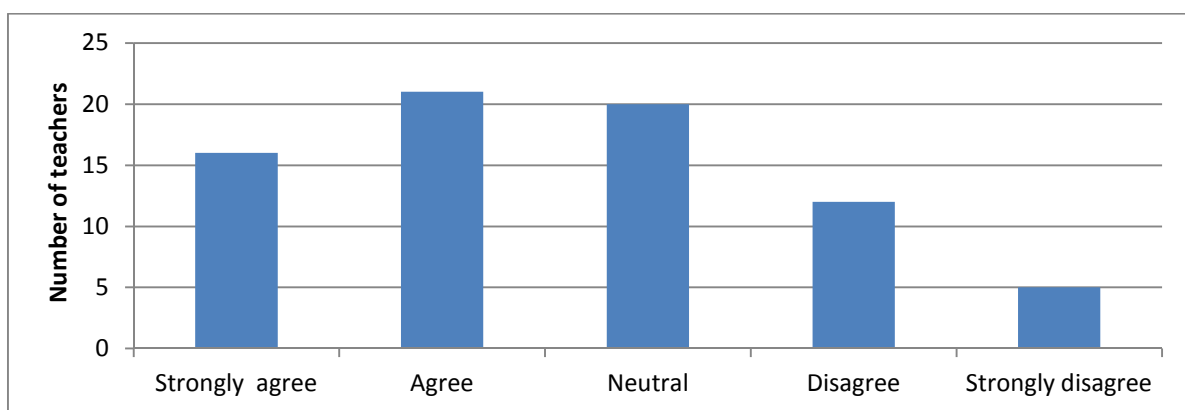
In under-resourced schools there is a pressing need for teachers to be able to take the initiative and come up with simple but innovative ways of improvising appropriate teaching aids. Approximately 58% of the participants agreed (23% strongly so) that Mathematics teachers were in a position to easily improvise effective teaching aids from limited resources. Only 15% of the participants disagreed with this position (Figure 4.23). This correlates well with the availability of improvised teaching aids (Section 4.2.2.12) where 65% of the teachers indicated the availability of improvised teaching aids in their schools.



**Figure 4.23** Mathematics teachers can easily improvise effective teaching aids that help learners grasp important concepts using scarce resources available

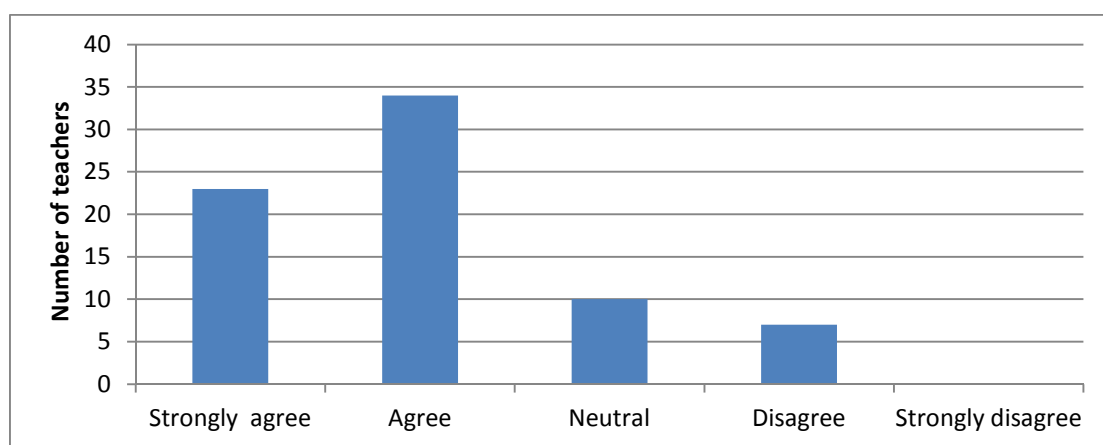
**Question 9: Teachers graduate from university and college with adequate knowledge on the use of teaching aids in Mathematics.**

50% of the teachers felt that graduate teachers leave training institutes with adequate knowledge on the use of teaching aids in Mathematics (Figure 4.24). This is surprising considering that an overwhelming 74% of the teachers felt that they required more in-service training on the use of of teaching aids in Mathematics (Question 7). Only 23% of the teachers felt that students graduate from the colleges with insufficient preparation on the use of teaching resources.



**Figure 4.24** *Teachers graduate from university and college with adequate knowledge on the use of teaching aids in mathematics.*

**Question 10: The use of teaching aids in mathematics promotes the ministry’s policy of learner-centred education in schools.**



**Figure 4.25** *The use of teaching aids in mathematics promotes the ministry’s policy of learner-centred education in schools.*

77% of teachers agreed (31% strongly so) that using teaching aids helps them in delivering learner-centred Mathematics lessons. Interestingly, seven teachers felt that the use of teaching aids was not in line with the Namibian Ministry of Education's policy of learner-centred education.

#### **4.3.2 Discussion of Likert scale attitudinal responses**

A holistic analysis of the general opinions elicited from the teachers indicates that the majority of teachers value and appreciate the role that teaching aids play in teaching for mathematical proficiency at secondary school level. 95.5% of the teachers believed that teaching aids promote learners' active participation and interest in Mathematics while 75.6% agreed that using teaching aids leads to better academic performance. There was also a 77% teacher consensus that using teaching aids helps in delivering learner-centred lessons in Mathematics.

Teachers were of the opinion that using teaching aids helps create a conducive learning environment where all learners participate actively, while the teacher can take on a role of providing scaffolding and support. According to the Namibian Ministry of Education (MoE, 2007), the approach to "teaching and learning of mathematics is based on a paradigm of learner-centred education" (p. 4). The Mathematics school syllabus points out that Mathematics teachers should encourage active participation of learners in their lesson activities.

Research has shown that teachers' perceptions influence the selection of instructional strategies when delivering lessons (Ball, 1996, p. 501). The teaching of Mathematics for proficiency (Kilpatrick, et al., 2001) at secondary school level should promote both conceptual understanding and procedural fluency of topics being taught in schools. According to Uribe-Flórez and Wilkins (2010) teaching for Mathematical understanding is very important at elementary school level and teaching aids are "tools that teachers can use to help students build understanding" (p. 369). The general attitude of the research participants clearly demonstrates a positive perception towards the use of teaching aids in their lessons. Teaching aids have the potential to help teachers promote and stimulate mathematical thinking among the learners as they become active participants in the learning process.

Teaching aids seem to encourage effective interactions between the learners and the content being taught. The use of appropriate and relevant teaching resources has been highlighted as a means of ensuring that learners engage themselves actively in the learning process as they can “meaningfully touch and move the concrete materials to make visual representations of mathematical concepts” (Nool, 2012, p. 310). Nool (2012) further suggests that teachers should “explore effective materials and methods of helping students, especially low performers, to comprehend mathematics concepts” (p. 310). The need for teaching for conceptual understanding was stressed by Reys (1971) who stated that “in teaching Mathematics we are primarily concerned with concept formation as opposed to the memorisation of facts” (p. 551).

Uribe-Flórez and Wilkins (2010) maintain that “elementary school teachers were found to use manipulatives more often than middle school teachers [while] high school teachers were found to use manipulatives the least” (p. 364). The availability of time to prepare teaching aids appears to be a problem for the teachers who participated in this study, all of whom teach at a secondary school level. Only 23% of the teachers who participated in the survey agreed that they have time to make teaching aids despite of the fact that the majority acknowledged the importance of using such tools in their classes.

50% of the teachers said that they left teacher training institutions with sufficient and appropriate knowledge with respect to the use of teaching aids. However, 74% of the participants felt that they needed in-service training on the use of teaching aids to supplement the skills acquired at training institutions. It is clear that additional in-service training on the use of mathematical teaching aids would not go amiss.

#### **4.4 QUALITATIVE DATA**

The second phase of data analysis involved reading through the teachers’ opinions in response to the open-ended question which was Part 3 of the questionnaire (See Appendix A). The views that were articulated by the 75 participants centred on their general perceptions towards the use of teaching aids in Mathematics at secondary school level. During the analysis of this qualitative data, common themes gradually emerged through repeated engagement with the data. Related responses were colour-coded and grouped under common themes.

Additional qualitative data was also obtained from the semi-structured interviews carried out with teachers in Phase 2 of the study. This interview data was transcribed, coded in terms of emerging themes, and integrated with Phase 1 qualitative data.

The themes that emerged relate to: hands-on nature of concrete objects; reality and visualization; enhanced teaching of concepts; active participation and interest; inadequate resources and the need to improvise; motivation and learner performance; and time and support from the ministry. Although these themes are presented individually, it is however acknowledged that they are interrelated and overlapping.

#### **4.4.1 Hands-on nature of concrete objects**

Clements (1999) defines concrete objects as “objects that students can grasp with their hands” (p. 46) while Reys (1971) explains that manipulatives (viewed as teaching aids in this study) are “objects that a learner is able to feel, touch, handle and move” (p. 551). The teachers who participated in this study were of the opinion that the use of teaching aids in Mathematics lessons at secondary school should be encouraged because their use provides learners with concrete examples to explain concepts. The teachers felt that the use of tangible, hands-on objects in their Mathematics lessons help them to explain abstract mathematical ideas more effectively. Some teachers felt that this hands-on physical contact with manipulatives was particularly beneficial for weaker learners. Teachers occasionally referred to the advantages of using teaching aids to teach concepts of probability at secondary level where learners find it difficult to follow the repeated random selection of objects from a group without replacement. Another specific area that was mentioned related to calculating areas and volumes of 3-dimensional shapes where the use of teaching aids would enable learners to physically engage with the 3-dimensional shapes. Some teachers also felt that learners are provided with an opportunity to explore the nature of a mathematical problem if they work with concrete models because such activities promote empirical reasoning.

During the semi-structured interviews, one of the participants from a selected school that does not have an adequate supply of teaching aids was asked to comment on whether learners enjoyed learning Mathematics. Teacher<sup>3</sup> C<sub>1</sub> answered:

*Yes, for those learners who are interested in Mathematics, you give them something which they will touch and they will not forget while on the other hand we have others who want wars when you ask them to produce something as teaching aids. Those who enjoy mathematics have ample time to do research if you give them a project and when they come back to discuss in class, they do learn a lot. As you might know, we have some learners who are partially visually impaired, so with the use of teaching aids you allow them not rely on hearing only but you involve all their senses and if one sense is stimulated then one never forgets. (lines 937-946)*

Teacher C<sub>1</sub> illustrates that the use of teaching aids in Mathematics lessons not only has the potential to create interest among learners but also benefit the partially impaired learners who might get an opportunity to get hands-on experience through the use of concrete objects in class activities. The teachers also pointed out that concrete teaching aids develop the learners' thinking skills through practical activities. According to McKinney & Frazier (2008), mathematics through a constructivist approach has been advocated by many researchers because it “provides a more hands-on, student oriented method and allows them to make connections with prior learning and personal experiences” (p. 203). In support of this, Uttal, et al. (1997) argue that “concrete objects provide a way around the opaqueness of written mathematical symbols” (p. 38). A significant number of teachers believed that providing hands-on objects as teaching aids help learners make sense of Mathematics activities.

#### **4.4.2 Reality and visualization**

Teachers were unanimous in their view that teaching aids provide learners with experiences with reality that support the visualisation of mathematical concepts. Reflecting on the importance of visual tools in the classroom, Naidoo (2012) indicated that Mathematics teachers “used visual tools with the intention of assisting learners to grasp abstract concepts in order to support and improve mathematical conceptual knowledge development” (p. 2) and further observes that through the use of the visual teaching aids “the learners were not merely

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<sup>3</sup> Five teachers were interviewed in Phase 2 of the research. Teacher A<sub>1</sub> and Teacher A<sub>2</sub> are from schools which had adequate resources and showed good practice in the use of teaching aids. Teacher B was from a school with a moderate supply of teaching aids. Teacher C<sub>1</sub> and Teacher C<sub>2</sub> are from schools where the availability of teaching aids was a great challenge.

passive recipients, but active participants” (p. 8). Teachers in this study held the opinion that teaching aids assist learners to relate real-world situations to the mathematics being taught, and visual teaching aids are therefore important during the learning and teaching process. The issue of promoting teaching of realistic mathematics at secondary schools was clearly voiced by one of the participants who had more than 30 years of teaching experience, Teacher A<sub>2</sub>, who works at one of the selected schools that had adequate resources and showed good practice in the use of teaching aids. On commenting on the need for teachers to avoid relying on textbooks alone when teaching Mathematics, Teacher A<sub>2</sub> said:

*We need to go to reality. If for instance we have taught something from the textbook, then where is the worksheet? If it's about water or electricity bills then let us go to reality and do actual or real calculations. We should do calculations of the tariffs, the total electricity consumption and look for the previous meter readings and so on. (lines 370-375)*

It is clear from the teacher's argument that she advocates the use of resources other than a textbook to help learners relate Mathematics content with real life. The issue that using teaching aids brings reality into lessons was echoed by a significant number of participants during Phase 1 of the study, which resulted in this issue being followed up in the semi-structured interviews in Phase 2. Teacher B who hails from a school with a moderate supply of teaching resources expressed similar sentiments on how teaching aids bring reality into his Mathematics lessons. In responding to the interview question (line 649-650: “How do you describe the use of teaching aids in the Mathematics classroom?”) Teacher B responded briefly:

*The use of teaching aids in Mathematics brings reality to the classroom! (lines 651-652)*

Upon being probed to explain in more detail what he meant, Teacher B elaborated as follows:

*If you only teach the child about the gradient while he/she does not have a clear picture of the real object, s/he will not understand but if you use something like a hill or you take them outside, they will understand the concepts. I sometimes take the learners outside because not all teaching aids are mobile. I take them outside when I am teaching about area and show them bricks to illustrate the surface area of solid shapes. We measure the dimensions of the solid bricks and calculate the areas of the cuboids. (lines 654-661)*

During the course of the interview Teacher B was asked another probing question (line 687-688: “What would you say about someone who would tell you that the use of teaching aids in

Mathematics is a waste of time?”). The response of Teacher B again stressed the issue of reality and visualisation:

*Wow! That means that particular teacher is depriving the visual learners their right to learn. Teaching aids as I said earlier bring reality into the classroom, which is why we can remember things we saw when we were young and that vision from teaching aids is likely to remain in our memory for a long time. (lines 689-693)*

Teacher B’s reference to “visual learners” is striking, and shows a sensitivity towards the notion that different learners learn in different ways (Presmeg, 1986, p. 42). Some learners may be more visual (as opposed to analytic) in terms of their cognitive processing and reasoning, and the use of teaching aids that promote visual reasoning would resonate very strongly with such learners. To deprive such learners of appropriate teaching aids is, in Teacher B’s opinion, tantamount to constraining their learning potential.

The views from both the open-ended question and semi-structured interviews confirm that the teachers strongly believe that teaching aids promote visualisation and reality in Mathematics lessons. However, on a cautionary note, Rivera, Knott and Evitts (2007) remind teachers that “the fact that some students have developed the misconception that Mathematics is all about manipulating numbers and numerical expressions and applying algorithms” (p. 73) could make it difficult for some secondary school learners to see and/or appreciate the real-life relevance in the content being taught. Thus, the use of teaching aids in and of themselves should not be seen as a useful teaching strategy. A skilled teacher is still required to guide the learners to make appropriate and meaningful links between the teaching aids and the mathematical concepts being taught.

#### **4.4.3 Enhanced teaching of concepts**

Wood (1988, p. 23) emphasizes that when teaching Mathematics to children it is important not only to focus on practical activity, problem solving and developing skills but also to focus on conceptual understanding. Wood (1988) further argues that the popularity of Piaget’s theory on intellectual development “was the reassurance it seemed to offer in identifying children’s natural capacities to construct the fundamental conceptual basis for mathematical thinking” (p. 183).

The majority of the teachers in this study were of the opinion that the use of teaching aids at secondary school level promotes long-term understanding of mathematical concepts, and that teaching aids enhance the learning and teaching of Mathematics because the learners build a better understanding of the topic. In teaching for Mathematical proficiency, Kilpatrick, et al. (2001, p. 313) propose that there must be a mutual triangular instructional relationship among the teachers, content and the learners to enhance conceptual understanding. Onasanya and Omosewo (2011) expressed that "it is important to note that students require information through many instructional materials so as to bring better understanding of what they are being taught" (p. 74). Teachers felt that the use of teaching aids enhances the understanding of difficult topics, especially topics related to geometry where learners struggle to follow theoretical explanations on 3-dimensional shapes in the absence of physical objects as a reference point. Asked to comment on what he felt about the use of teaching aids and the development of mathematics concepts, Teacher B had this to say:

*Teaching aids are supposed to be used correctly to make learners understand. When you construct the triangular prism for example, you need to dismantle the whole solid shape for the learners to see the net and discover how it has been constructed. (lines 704-707)*

Teacher B was asked to expand on whether there were any differences that one could easily notice in a classroom where teaching aids were not used:

*In a classroom where you use teaching aids, you are likely to experience more questions. Teaching aids do actually in one way or the other help the teacher to explain concepts and sometimes the learners can easily guess what you will be focusing on in your lessons by just seeing the teaching aids. What happens is that if you do not have the teaching aids, the lesson becomes boring. It is also difficult to explain when you only use theoretical explanations. Mathematics is a practical subject because it is used in everyday and every topic that we teach should have teaching aids. (lines 761-769)*

According to McKinney and Frazier (2008) there has been much research which advocates the use of a constructivist approach in the teaching of Mathematics through "student-centred, active learning that promotes conceptual understanding" (p. 208). Constructivism is about social relationships and promotes the construction of learners' knowledge through the use of teaching aids in Mathematics lessons. Palincsar (1998) suggested that "as learners participate in a broad range of joint activities and internalize the effects of working together, they acquire new strategies and knowledge of the world and culture" (pp. 351-352). The Mathematics teachers in the Namibian environment where LCE is strongly advocated by the

education policy are encouraged to ensure that their teaching methods promote “the active participation of the learners in the learning process” (MEC, 1993, p. 60). Teaching aids might enhance the teaching of concepts in Mathematics if correctly and effectively used in lessons.

#### **4.4.4 Active participation and interest**

The approach to teaching and learning of Mathematics in Namibian schools is focused on learner-centred education (Ministry of Education, 2007) whose roots are found in social constructivism. The social constructivist perspective of learning posits that “learning involves the active construction of knowledge through engagement and personal experience” (von Glasersfeld, as cited in Kaminski, 2002, p. 133). There was moderate response from the participants indicating that teaching aids enhance interest towards the subject and that they encourage learners to participate actively in lessons. Interested learners already enjoy doing the subject and therefore the basic objectives of attaining a learner-centred lesson are easily attained since the use of teaching aids typically increases the participation of such learners even further.

Pintrich (1999) views interest to be the “individual’s general attitudes or liking of the task that is somewhat stable over time and a function of personal characteristics” (p. 465). The concept of interest has numerous features and one of them is that “interest is a content-specific concept...related to specific topics, tasks or activities” (Schiefele, 1991, p. 301). According to Nool (2012), research studies carried out to assess the effectiveness of teaching aids (manipulatives) in improving learners’ understanding of mathematical concepts discovered that learners described Mathematics as a “boring and terrifying subject because of the difficulty to visualize and understand its underlying symbolic concepts and processes” (p. 310). Since concrete teaching aids have the potential to promote conceptual understanding through visualization and hands-on engagement, they should also have the potential to encourage learners’ active participation and engagement. When Teacher A<sub>1</sub> from a school with an adequate supply of teaching aids was asked the question “Based on your experience, how do you find the use of teaching aids in the Mathematics lesson?” (line 118-122), she replied:

*They are quite helpful, because when the kids see you using other stuff in the lesson, they become interested in the lesson but if it is any normal lesson and there are no teaching aids, they are less interested. So I think for capturing learners’ interests, teaching aids are very helpful. (lines 123-129)*

Similar sentiments were expressed by teachers responding to the open-ended question in Phase 1. It was also indicated that teaching aids promote the *co-operation* of learners in Mathematics because learners enjoy lessons where teaching aids are used. These remarks about active participation resonate with Sawyer (2004) who observed that in social constructivist theory “new knowledge emerges from collaborative, exploratory discussions among learners” (p. 199).

A classroom environment where learners are not interested in learning presents a huge challenge in terms of teaching for mathematical proficiency. When asked to describe the attitude of the learners in classrooms where teaching aids are used, Teacher A<sub>2</sub> had this to say:

*Learners are more positive. I feel that if you can offer more and give more learning experiences, you will see that a child who has been exposed to learning experiences will become more curious to learn. They are interested in finding more and in a way it reflects your attitude. If the learners see that you are positive about teaching something new, they will follow suit. (lines 340-345)*

Teacher A<sub>2</sub>, who has over 30 years of teaching experience and who works at a school with adequate teaching resources and had demonstrated their good use, was further probed to provide examples of mathematics topics which she had taught using teaching aids and which had been successful in heightening the interest of her learners:

*You cannot do without teaching aids. If you introduce 3-dimensional figures as a topic, then learners will be interested in exactly finding what it is, how many facets does it have, what shape is it, what is each facet constructed of, is it an isosceles triangle or an equilateral? If you offer the learners an opportunity to construct their own nets, to create their own tetrahedron then such a learner will have a richer experience than the learner that only looked at the picture of a polyhedron. When we calculate the area of surfaces of all facets of the tetrahedron you actually enlarge the learning area of the learners and one can easily connect the learning material to the real life. (line 348-357).*

According to Weiss (as cited in Schiefele, 1991), the poor attitude of learners towards Mathematics as a subject cannot be solved simply by improving teachers’ qualifications. Rather, the focus should be on increasing their knowledge pertaining to instruction and motivation. In-service training for teachers on effective ways of using teaching aids in Mathematics is likely to go some way to addressing this need.

To summarize, teachers were of the opinion that the use of teaching aids promotes interest among learners and this encourages the promotion of learner-centredness where all learners are encouraged to participate meaningfully.

#### **4.4.5 Inadequate resources and the need to improvise**

An analysis of the quantitative data (Sections 4.2 & 4.3) showed that many schools are under-resourced when it comes to teaching aids. In spite of this, the vast majority of teachers in this study acknowledge the potential benefits that teaching aids can bring to the classroom. The juxtaposition of these two observations raises an important question: How do teachers who do not have adequate teaching resources in their schools operate?

Some teachers found a partial solution to the problem by borrowing important pieces of equipment from neighbouring schools. As Teacher C<sub>2</sub> elucidated:

*It's like some teachers are going out of their way to borrow those [materials] from neighbouring schools. I am just waiting to finish this chapter on transformation and come back to bisecting lines because I also need the big chalkboard compass. I will go to friends at the neighbouring schools to borrow one. (lines 1126-1130)*

Although this is not an ideal scenario, and certainly not a long-term solution, it does nonetheless show a level of collegiality amongst teachers from different schools, and the mutual sharing of teaching aids thus seems to be one way of increasing access to important pieces of equipment and other scarce teaching resources.

Despite the dire lack of resources in some schools, there is also evidence to suggest that some teachers have tackled this problem by improvising and making their own teaching aids. When asked the question (“How do you describe the availability of teaching aids in this school?” (line 853) Teacher C<sub>1</sub> replied:

*Our school is a project school and I would say that the use of teaching aids at our school is very, very minimal and the availability is non-existent. We are aiming at having some basic teaching aids like the measuring tapes, protractors, whatever... those few things, otherwise when we talk of the advanced items such as the electronic Overhead Projectors (OHP) you find that their application is lacking here. We are depending on what we can produce by ourselves. I would not say that we really do not have anything but we have the basics. (lines 854-861)*

Teacher C<sub>1</sub> was asked to expand on the use of home-made teaching resources to complement the serious shortage of resources in his Mathematics department:

*Yes! It is more useful making your own teaching aids than using what has been prepared by someone because when you make your own – you already have an idea of how you are going to use it in the lesson. It is more useful and beneficial to the learners than the already prepared teaching aids. (lines 921-925)*

According to Sawyer (2004), creative teaching should enable knowledgeable and expert teachers to have “creative autonomy to improvise in their classrooms” (p. 18), and this relates to the making and using of improvised teaching aids as well. This finds particular import in those schools that are under-resourced in terms of teaching aids. Furthermore, involving learners in the making of teaching resources not only increases the number of items that can be produced, but there are a number of important aspects to the production process itself that can be capitalized on. When Teacher B was asked the question: “Are there any advantages of involving learners in the making of their own teaching aids?” (lines 594-595), a detailed explanation was provided:

*Yes! A lot of advantages! First of all they learn to work as a team doing group work because when one learner draws, the other one cuts while the others could put the glue. That’s team work already! They are groomed to become team players. Another reason is that when they are making teaching aids, they learn to communicate with each other. They also learn to carry out instructions because if there is a learner who encounters difficulties in carrying out instructions, they can learn from each other. They also learn time management because when you give them such an activity you set time for them.....they do not have to do it the whole day which means they learn to stick to time limits. (lines 596-606)*

When Teacher A<sub>2</sub> was asked to comment on what advice she would give to teachers in under-resourced schools, she responded as follows:

*Resources! When I had my teacher training, we had a lecturer who used to say that a teacher should be like a vulture on a box because a box is an important tool to store things. Boxes are wonderful objects because you can create 3-dimensional objects we have been talking about. We underestimate the everyday ordinary newspaper. (lines 389-393)*

When asked to expand on what she meant by “we underestimate the everyday ordinary newspaper”, Teacher A<sub>2</sub> became quite passionate in her response:

*Have you seen recently how many pie charts they print, the graphics, etc. in the newspaper? We get wonderful classroom teaching aids. We just do not realise that for instance that if we look at the Nictus adverts you get*

*cupboards prices on hire purchase. You can hand in the newspaper advert and tell [one's learners] in groups to buy different items such as vacuum cleaner, refrigerator, the bed and the cupboard. You ask them to calculate hire purchase price, the cash price, the percentage increase or the interest the company charges. That's teaching aid! (lines 395-403)*

Despite many schools being under-resourced in terms of teaching aids, the analysis revealed that some teachers were prepared to take ownership of this problem and either borrowed resources from neighbouring schools or improvised with home-made teaching aids. Such creativity and resourcefulness needs to be shared more broadly within the Namibian context as examples of best practice and as examples of what is possible with limited resources.

#### **4.4.6 Motivation and learner performance**

According to Sowell (1989), studies on the effectiveness of the use of teaching aids revealed that learners' academic performance in Mathematics "is increased through the long term use of concrete instructional materials and that students' attitudes toward mathematics are improved when they have instruction with concrete materials provided by teachers knowledgeable about their use" (p. 498). Köller, Baumert and Schnabel (2001) further underscore that "mathematics is often seen as a very difficult subject in which motivational factors are particularly important for the enhancement of learning" (p. 452). It is further argued that learners with low levels of interest would normally "lack the motivation to learn, with subsequent negative effects on their achievement" (Köller, et al., 2001, p. 464).

The general response from participants was that teaching aids tend to encourage motivation as well as positive attitudes towards the teaching and learning of Mathematics. In addition, many teachers felt that the use of teaching aids contributed to good academic performance in examinations. Teachers were also of the opinion that teaching aids have the potential to motivate bored learners to engage more in the Mathematics classroom. Teaching in a learner-centred environment should be made easier if learners are not only interested in the mathematics activities but are self-motivated, and there is an acknowledgement that appropriate teaching aids have the potential to do just that.

During Phase 2 of the study the teachers were asked the general question "What would you say about the academic performance of learners versus the use of teaching aids in the

mathematics classroom?" Their various responses highlight a sensitivity to the complex nature of the learning process:

Teacher A<sub>1</sub>: *That's a very complex question. I cannot just say that teaching aids alone promotes or leads to good academic performance. There are other factors that contribute to good results at the end, not just teaching aids!* (lines 148-151)

Teacher A<sub>2</sub>: *I think for sure that teachers that use resources more abundantly in their lessons will abundantly have a better performance of their learners.* (lines 406-408)

Teacher B: *Yes, with the use of teaching aids, the learners who listen in class will not have to go back to their notes given or textbooks because once they have experienced the teaching, they are likely to remember what they have been taught and will answer examination or test questions correctly.* (lines 728-729)

Teacher C<sub>2</sub>: *I can say that it helps the learners to understand and remember in examinations if you are using teaching aids and the concept remains there and it is very difficult for them to forget rather than for example just give a formula for surface area on the board and ask them to substitute – later when you ask them they will take time to remember.* (lines 1181-1185)

These comments reveal that teachers believe that the use of teaching aids has the potential to contribute towards academic achievement in Mathematics. For some teachers the comments also show sensitivity to the complexity of the teaching and learning process, and that the use of teaching aids is but one facet of a multi-faceted process. One critical aspect which a number of teachers highlighted is that teaching aids provide learners with tangible referents that assist learners with remembering key concepts or information.

#### **4.4.7 Time and support from the Ministry**

A common theme running through the data related to the time commitment needed to prepare teaching aids. Many teachers felt that the preparation of teaching aids, as well as their subsequent use in lessons, takes a lot of time. One teacher remarked that "*The packed mathematics school syllabus leaves teachers with less time to make teaching aids especially at grade 10 and 12 levels*". Nonetheless, there were also some teachers who felt that the use of teaching aids has the potential to save time in the long run by allowing for the timely completion of school syllabi.

Closely linked to these comments relating to time constraints was a general feeling amongst the participants that the Ministry of Education needed to take responsibility for supplying teachers with appropriate teaching aids. This was an unexpected theme, and it is interesting that it featured so prominently in teachers' responses. Some of the teachers' responses selected from the open-ended question in Phase 1 are provided below:

- ✓ *Ministry of education is not doing enough in the area of teaching aids as schools are poorly equipped.*
- ✓ *Not all important teaching aids are available in schools. Ministry of Education should provide teaching aids to all schools.*
- ✓ *Ministry must seriously consider supplying all schools with teaching aids to ensure quality education.*
- ✓ *Teaching aids should be made available at all schools in the country.*
- ✓ *Teachers should receive further training on use of teaching aids.*

Teacher C<sub>1</sub> expanded on this theme as follows:

*I think first of all you tutors or lecturers at university and colleges you should go to the Ministry of Education and request them to provide teaching aids to schools. Currently we do not have cohesion in schools because everyone is doing his own way on the use of teaching aids. (line 371)*

In summary, while teachers value the importance of using appropriate resources and teaching aids in their lessons, time constraints prevent many teachers from preparing their own teaching aids. There is a widespread expectation from teachers that the Ministry of Education should take responsibility for supplying schools with appropriate resources.

## **4.5 CONCLUSION**

This chapter presented the results of the survey on the availability and use of teaching aids at secondary schools in the Windhoek metropolitan area. The quantitative data derived from the Phase 1 questionnaire identified the types of teaching aids that are available in each Mathematics department, the frequency of their use as well as their source. This was followed by a discussion of teacher responses, using a Likert scale, to the ten closed questions posed in the second part of the survey questionnaire carried out in Phase 1. This aimed at gathering teachers' opinions on broader issues related to the use of teaching aids in Mathematics lessons in their schools. Finally, qualitative data obtained from both the Phase 1 questionnaire as well as the Phase 2 semi-structured interviews was presented in terms of emerging themes that included the hands-on nature of concrete objects, reality and visualization, enhanced

teaching of concepts, active participation and interest, inadequate resources and the need to improvise, motivation and learner performance, and time and support from the ministry.

In the final chapter the findings of this study are drawn together with specific reference to the original research questions set out in Section 3.2.

## **CHAPTER 5**

### **FINDINGS & CONCLUSION**

#### **5.1 INTRODUCTION**

This chapter provides a summary of the main ideas of the study and presents the research findings. It encompasses a brief review of the research questions, an overview of the contextual backdrop to the study along with the research process, and summarises the findings and significance of the study. The chapter concludes with recommendations for future research.

#### **5.2 REVIEW OF THE OBJECTIVES**

This study focused on assessing the availability and usage of teaching aids in Mathematics at secondary schools (both public and private) located in Namibia's capital city of Windhoek. The study also aimed at developing a more nuanced and in-depth understanding of the use of teaching aids at purposefully selected schools, as well as teachers' perceptions towards the use of these teaching resources in their Mathematics lessons. The study was guided by the following research questions:

- 1) What type of teaching and learning aids are available for Mathematics teachers in the private and public secondary schools in Windhoek?
- 2) What is the nature or character of the use of the available teaching aids?
- 3) What are the teachers' general perceptions on the availability and use of teaching aids in Mathematics at secondary school level?

#### **5.3 OVERVIEW OF THE CONTEXT**

Learner-Centred Education (LCE) was introduced in 1991 as a foundation policy for the new educational system of Namibia after attainment of Independence. Intricately associated with such a learner-centred approach is the importance of learners' active participation in and meaningful contribution to the learning process. The Mathematics teacher in the Namibian

educational context is encouraged to embrace a learner-centred approach in the teaching and learning process by developing a culture of curiosity and eagerness to learn amongst the learners through the use of teaching aids. The effective use of teaching aids in a LCE environment is meant to encourage active participation and to help learners discover and build co-operative skills and to promote problem solving skills and foster creative thinking. Although the importance of teaching aids as promoters of learner-centred education at secondary school level is strongly emphasized in the teacher training curriculum, evidence from the field has suggested that many teachers are not comprehensively implementing the use of teaching aids in secondary school Mathematics lessons. This was the initial impetus for the present study.

For the purposes of this study, “teaching aids” is used an umbrella term meant to refer to a variety of teaching resources, teaching materials, teaching media, or manipulatives that are found and used in the Mathematics classroom to facilitate teaching and learning. The types of teaching aids that were focused on in this study include graph boards, interactive whiteboards, geoboards, mathematical instruments for the chalkboard, mathematical sets for learners, charts and posters, geometric models, overhead projectors, computers, as well as any improvised teaching aids made using available resources. The study explored the current situation in Mathematics classrooms with respect to the use of teaching aids as well as the general perceptions of qualified teachers towards the use of such resources in their lessons at secondary school level.

## **5.4 OVERVIEW OF THE RESEARCH PROCESS**

The study was grounded in an interpretive paradigm and employed a mixed methods approach to generate both quantitative and qualitative data in two sequential phases. The first phase of the research process, which involved 75 Mathematics teachers, took the form of an audit of the availability and usage of teaching aids at 25 secondary schools in Windhoek. In addition to this quantitative data, qualitative data was derived from the open-ended questions in the Phase 1 questionnaire as well as subsequent Phase 2 semi-structured interviews that were informed by Phase 1 data. A case study methodology was adopted in Phase 2 which focused on five purposively selected schools that displayed different characteristics in terms of the availability of teaching resources.

## **5.5 FINDINGS OF THE STUDY**

The findings of this study are summarised here in response to the three guiding research questions.

### **5.5.1 What types of teaching aids are available for Mathematics teachers in the private and public secondary schools in Windhoek?**

The types of mathematical teaching aids most readily available in the 25 secondary schools surveyed in the Windhoek metropolitan area include: charts and posters; chalkboard 30° & 60° set squares; chalkboard rulers, protractors and compasses; mathematical sets for learners; overhead projectors; and improvised teaching aids. For each of these teaching aid categories teachers indicated a greater than 60% availability. The availability of physical objects (other than geometric models), geometric models and computers/laptops was calculated as being in the 60% to 40% range, and as such can be classified as being moderately available. Graph boards, interactive whiteboards and geoboards were the least available items with availability scores of 21%, 12% and 3% respectively. While there were nine teachers who indicated that they had access to an interactive whiteboard there were only two out of 75 teachers who indicated that they had a geoboard. The poor availability of graph boards and geoboards, and the relatively poor availability of geometric models, is somewhat disturbing since not only are these items useful and effective tools for the teaching and learning process, but they can be easily and cheaply manufactured from available raw materials.

Specifically focusing on technology, the computer has proven to be a powerful resource for modern teachers. Some of the schools that formed part of the survey had more than four Mathematics classes per grade, with around 35 learners per class. Given that 33 of the 75 teachers surveyed indicated that they had no access to computers for teaching, this represents a very high number of young learners who are not being exposed to computers and modern technology in their Mathematics lessons. Furthermore, bearing in mind that the schools taking part in this audit were located in an urban centre environment, the situation for rural or remote schools is no doubt significantly worse.

### **5.5.2 What is the nature or character of the use of the available teaching aids?**

The findings of this study show that although some of the audited teaching aids were readily available, only a small number of teaching aids were used on a daily basis. While approximately 40% of the responses indicated that a particular teaching aid was used as frequently as possible, the almost 450 instances (49% of the responses) of specific teaching aids never being used is somewhat worrying. As a developing nation it is clear that teaching and learning resources are insufficiently provided for in many Namibian secondary schools.

In terms of the source of teaching aids, although the major source was indicated as being school purchase (47% of the total responses), it is interesting to note that personal purchases accounted for a surprising 35%. This makes personal purchase the second-highest source of teaching aids in the schools surveyed and highlights the readiness and willingness of some teachers to take responsibility for sourcing and financing personal teaching aids. By contrast, the Ministry of Education was indicated as being responsible for only 11% of the teaching aids audited.

### **5.5.3 What are the teachers' general perceptions on the availability and use of teaching aids in Mathematics at secondary school level?**

General perceptions of teachers towards the use of teaching aids in secondary schools are summarized here in relation to emergent themes.

**Hands-on nature of concrete objects:** Teachers were of the opinion that the use of teaching aids at secondary school should be encouraged because the use of tangible, hands-on objects in their Mathematics lessons helps them to explain abstract mathematical ideas more effectively. Some teachers felt that this hands-on physical contact with manipulatives was particularly beneficial for weaker learners.

**Reality and visualization:** Teachers believed that teaching aids provide learners with real-life experiences which support in the visualisation and conceptualization of mathematical

ideas. Teaching aids were also believed to provide an invaluable link between the real world and the mathematics being taught.

**Enhanced teaching of concepts:** Teachers were generally of the opinion that the use of teaching aids at secondary school level enhances the learning and teaching of Mathematics by promoting long-term understanding of mathematical concepts.

**Active participation and interest:** Teachers were of the opinion that teaching aids promote learners' active participation and interest in Mathematics, thereby promoting the notion of learner-centred education as advocated by the Ministry.

**Inadequate resources and the need to improvise:** Despite many schools being under-resourced, some teachers took the initiative of either borrowing resources from neighbouring schools or improvising with home-made teaching aids.

**Motivation and learner performance:** Teachers believed that teaching aids have the potential to encourage motivation as well as a positive attitude towards the teaching and learning of Mathematics. In addition, many teachers felt that the use of teaching aids contributed to good academic performance in examinations.

**Time and support from the Ministry:** While teachers value the importance of using appropriate resources and teaching aids in their lessons, it became evident that time constraints prevent the majority of teachers from preparing their own teaching aids. There was also a widespread expectation from teachers that the Ministry of Education should take responsibility for supplying schools with appropriate resources.

In addition to these themes it is worth highlighting that although 50% of the participants felt that graduate teachers leave training institutes with adequate knowledge on the use of teaching aids in Mathematics, almost three quarters of the participants felt that they required more in-service training on the use of teaching aids.

## **5.6 LIMITATIONS OF THE STUDY**

The research focus for this study was on the availability and use of mathematics teaching aids in both government and private secondary schools in Windhoek with an ultimate aim of gaining an in-depth characterization of their usage. The greatest limitation of the study is that the situation in the city of Windhoek should not be expected to be the same as in remote or rural districts, and as such the findings of this study are not generalisable. Although the purpose of a case study is to develop a rich understanding of the case under scrutiny, this study can nonetheless be seen as a useful step towards an increasingly refined picture of the broader Namibian educational landscape.

The process of distributing questionnaires and obtaining swift responses from the participating schools was a great challenge. Principals were not eager to allow the teachers to be disturbed by completing the research questionnaire during the researchers' presence. Questionnaires were thus left at the respective schools with follow-up appointments being made to collect the completed questionnaires at a later date. Despite this, the teacher response rate for completed questionnaires was 75%.

## **5.7 SIGNIFICANCE OF THE STUDY**

This study provides data that can assist policy makers at both ministerial level as well as institutes of higher learning with respect to key issues that impact on learners' participation and understanding of mathematics concepts at secondary school level. The pedagogical significance of the study is that it re-emphasizes the crucial role that teaching aids can have in promoting the attitude and performance of learners in Mathematics as well as helping learners value the importance of the subject. The study is also important because it highlights critical gaps that educational planners may need to address to ensure an equal distribution of teaching resources across all secondary schools. Finally, it is seen as a strength that this study provides data that is of practical relevance to teachers, teacher educators and ministerial officials.

## **5.8 RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER STUDY**

Based on the results of this study, the following recommendations are put forward:

- The Ministry of Education should be encouraged to strengthen the teaching and learning of Mathematics at secondary schools by providing adequate teaching resources in the form of teaching aids.
- The institutes of higher learning tasked with producing secondary school teachers should work in collaboration with the Ministry of Education to provide in-service support on the use of teaching aids to practicing teachers.
- Instances of teacher creativity and resourcefulness need to be shared more broadly within the Namibian educational landscape as examples of best practice and as examples of what is possible with limited resources.

In addition, the following suggestions are put forward as possible future research avenues to explore:

- Since this study focused on the Windhoek metropolitan area, there is a need to carry out similar research in secondary schools situated in more remote or rural contexts.
- It would be worth considering extending this study to other countries in the SADC region.
- It would also be interesting to carry out a study on learners' perceptions on the use of teaching aids in secondary schools, not only in Mathematics but across the whole secondary school curriculum.

## **5.9 CONCLUSION**

The teaching and learning process requires teachers to use teaching resources that help learners grasp underlying mathematical concepts and skills. The use of teaching aids in Mathematics has been shown by numerous studies to have a positive impact on promoting active participation and meaningful construction of knowledge. Teaching aids promote learner-centredness which lies at the heart of the Namibian educational system. This study has shown that the majority of teachers at secondary schools in Windhoek have a positive

attitude towards the importance and role of teaching aids in Mathematics. However, in many instances schools are under-resourced with respect to teaching aids. While steps need to be put in place to ensure widespread and equal distribution of teaching aids, and while the need for appropriate in-school support on the use of teaching aids has been highlighted, it is hoped that teachers will nonetheless draw inspiration from the findings of this study and that creative improvisation and resourcefulness with respect to teaching aids will become positive drivers for change.

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## Appendix A - Questionnaire

(a)		(b) ITEM				(c) FREQUENCY			(d) SOURCE				
Types of Teaching Aids		Availability of the teaching aids		Is the Item being used?		Frequency of use			Source of teaching aids				
		Yes √	No X	Yes √	No X	Used on a daily basis	Used as frequently as possible wherever possible	Never used	Ministry of Educ.	School Purchase	Personal (Own)	Donated	Other
1	30° & 60° Set squares for the chalkboard												
2	Ruler , protractors & compasses for the chalkboard												
3	Charts/Posters												
4	Physical objects (other than geometric models)												
5	Geometric Models /Shapes												
6	Graph board												

<b>7</b>	<b>Mathematical instrument sets (for learners)</b>												
<b>8</b>	<b>Geoboards</b>												
<b>9</b>	<b>Overhead projector</b>												
<b>10</b>	<b>Computers and/or laptops</b>												
<b>11</b>	<b>Interactive whiteboards</b>												
<b>12</b>	<b>Improvised teaching aids</b>												
<b>13</b>	<b>Any other teaching aids</b>												

**Part 2.** You are asked to tick in the box that matches with your opinion towards the use of teaching aids in mathematics at your school.

		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
		5	4	3	2	1
1.	The use of teaching aids in mathematics classes at secondary school level promotes learners' participation and interest in lessons.					
2.	Teaching can only be effective when adequate and relevant teaching resources are used in mathematics lessons.					
3.	Mathematics teachers have enough time to prepare teaching aids for most of their lessons					
4.	Using teaching aids in mathematics lessons promote the teacher's programme to complete the syllabi in time.					
5.	The use of teaching aids in mathematics is made difficult because resources are not available in schools.					
6.	The use of teaching aids promotes good academic performance of learners in end of year mathematics examinations					
7.	Teachers should be given more in- service training on the use of teaching aids in mathematics.					
8.	Mathematics teachers can easily improvise effective teaching aids that help learners grasp important concepts using scarce resources available.					
9.	Teachers graduate from university and college with adequate knowledge on the use of teaching aids in mathematics.					
10.	The use of teaching aids in the mathematics promotes ministry's policy of learner centred education in schools.					

**Part 3**

You are a Mathematics teacher at a secondary school level.

What is your general opinion towards the use of teaching aids in mathematics at secondary school level?

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Thank you for your co-operation.

## **Appendix B - Request to Regional Director to conduct research in Khomas Educational Region**

P. Bag 13317, Windhoek.  
Phone 061 270 3243  
Mobile 081 210 6379  
E-mail [tdzambara@yahoo.co.uk](mailto:tdzambara@yahoo.co.uk)

13 September 2011

The Regional Education Director  
Ministry of Education (Khommas Region)  
P. Bag 13 263. Windhoek

Dear Sir

### **Ref: Request for permission to conduct an educational research in Windhoek Secondary schools**

I do hereby request the permission from your office to conduct an educational study at secondary schools in Windhoek metropolitan area in the field of Mathematics Education. The purpose of the study is first to do an analysis on the availability and usage of teaching aids in mathematics in all the secondary schools in Windhoek.

If permission is granted, the first stage of the proposed study will be a Questionnaire to be completed by mathematics teachers at secondary schools on voluntary basis. The whole process of ticking responses on the questionnaire will take approximately 15-20 minutes per teacher to complete. This study should take place in October 2011 and I shall personally take the Questionnaires to the schools. The second part of the study will take place in 2012 with a focus on 5 secondary schools chosen on the basis of the quantitative results of the first phase. A case study will be then done on the selected schools to get a deeper understanding on the impact of the use of teaching aids.

I am a part- time student studying for a Masters Degree in Mathematics Education with Rhodes University of South Africa. I am also an Assistant Lecturer with the University of Namibia (Khomassdal Campus) – Faculty of Education currently teaching mathematics to BETD 3<sup>rd</sup> year student teachers. I hope that the results of this study will positively contribute towards improving the teaching of mathematics in our secondary schools by promoting the good use of aids thereby complementing the Ministry's policy of learner centred education approach. The study could also contribute towards strengthening the teaching methodology courses in mathematics at teacher training institutions of higher learning.

Hope to receive your cordial consideration.

Yours faithfully

Tobias M. Dzambara

## Appendix C - Regional Director's permission to conduct research



**REPUBLIC OF NAMIBIA**  
**KHOMAS REGIONAL COUNCIL**  
**DIRECTORATE OF EDUCATION**

Private Bag 13236, Windhoek, Tel. 264 61 2934329/231948, Fax. 264 61 248251

Enq: Josia S Udjombala  
E-mail: tatemadala@yahoo.com  
Ref: 11/2/1

Mr Tobias M Dzambara  
University of Namibia (Khomasdal Campus)  
Private Bag 13317  
Windhoek

October 5, 2011


Dear Mr Dzambara

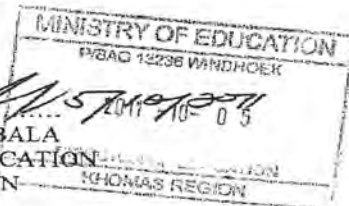
**RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT SCHOOLS IN THE KHOMAS REGION**

I write to refer to your letter on the above subject matter, dated September 30<sup>th</sup> instant. I am pleased to inform you that permission has been granted for you to do a research in the Khomas Region, at schools of your choice. Authorization is granted on the understanding that normal school programmes are in no way to be disrupted and participation by subjects will be voluntary.

I wish you success.

Thank you.

  
JOSIA S UDJOMBALA  
DIRECTOR: EDUCATION  
KHOMAS REGION



## Appendix D - Request to principals to conduct research at their schools

P .O. Box 96376  
Windhoek  
Phone 061 270 3295  
Mobile 081 210 6379

E-mail tdzambara@yahoo.co.uk  
06 February 2012

The Principal  
.....Secondary School  
Windhoek

Dear Sir/Madam

**Ref: Request for permission to conduct an educational research at your secondary school.**

I do hereby request the permission from your office to conduct an educational study at your secondary school in the field of Mathematics Education. The purpose of the study is to do an **analysis on the availability and usage of teaching aids in mathematics** at secondary school level.

If permission is granted, the first stage of the proposed study will be a **Questionnaire** to be completed by **mathematics teachers** at secondary schools on voluntary basis. The whole process of ticking responses on the questionnaire will take approximately **15-20 minutes** per teacher to complete. All the information gathered will be kept confidential. The Regional Director (Khomas Region) granted me permission to conduct the research at schools in Windhoek. This study should take place in February 2012 and there are no foreseeable risks to teachers who will be participating in the study

I am a part- time student studying for a Masters Degree in Mathematics Education with Rhodes University of South Africa. I am also an Assistant Lecturer with the University of Namibia (Komasdal Campus) – Faculty of Education currently teaching mathematics education. I hope that the results of this study will positively contribute towards improving the teaching of mathematics in our secondary schools by promoting the good use of aids thereby complementing the Ministry’s policy of learner centred education approach. The study could also contribute towards strengthening the teaching methodology courses in mathematics at teacher training institutions of higher learning.

Hope to receive your cordial consideration.

Yours faithfully

Tobias. M. Dzambara

**Appendix E- Principals' consent form authorising interviews to be conducted**

Rhodes University- Grahamstown, South Africa

Department of Education: Course - MEd (Mathematics Education 2011-12)

**Student's Name: Tobias M. Dzambara**

**SCHOOL PRINCIPAL'S CONSENT FORM**

I ----- in my capacity as the **Principal** of ----- School in Windhoek metropolitan area hereby give a written **consent** to Mr. Tobias Dzambara (student no g11D3691) in his capacity as an MEd [Mathematics Education 2012] student at Rhodes University (South Africa) to conduct a Research interview with one of our **Mathematics teacher** Mr./Mrs./Ms. \_\_\_\_\_ as explained in the attached application letter for permission. The interview to be done with the teacher's consent will focus on the use of teaching aids in mathematics at secondary school level. If the teacher decides to participate in this interview he/she reserves the right to withdraw, without explanation, at any point.

Thank You

**Principal's Name** \_\_\_\_\_

Signature \_\_\_\_\_ Date \_\_\_\_\_

**Date Stamp:**

--

## Appendix F - Teacher's consent form to take part in an interview

Rhodes University- Grahamstown. South Africa  
Department of Education: Course- MEd (Mathematics Education 2011-12)

### **PHASE 2: RECORDED INTERVIEW WITH MATHEMATICS TEACHER** **RESEARCH PARTICIPANT CONSENT FORM**

I ----- in my capacity as a Mathematics teacher of ----- School in Windhoek metropolitan area hereby give a written **consent** to participate in the research study Part 2 to be conducted by Mr. Tobias Dzambara (student no g11D3691) in his capacity as an MEd [Mathematics Education 2012] student at Rhodes University (South Africa) as explained in the attached application letter for permission.

I agree to take part in this **recorded interview** which will basically focus on the use of teaching aids in mathematics at my school. I have read and understood the information above outlining the conditions and procedures of this particular interview. I am fully aware that I retain the right to withdraw from the interview process at any point without explanation.

Thank You.

**Teacher's Name** \_\_\_\_\_

Signature \_\_\_\_\_ Date \_\_\_\_\_

**Rhodes University MEd student's full name:**

Tobias M. Dzambara (No: g11D3691)

Signature \_\_\_\_\_ Date \_\_\_\_\_