PRIMARY TEACHERS' MATHEMATICAL BELIEFS AND PRACTICES IN THE MALDIVES

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A four-paper thesis submitted in partial fulfilment of the requirements for the degree of Master of Education

Victoria University of Wellington

2012

Abstract

Recent reforms in mathematics education have been influenced by such theoretical perspectives as constructivism, which have reconceptualised teaching and learning. Mismatches between teachers' beliefs about teaching and learning, and ideas underpinning reform are often viewed as major obstacles to implementing educational reforms. This study examined the mathematical beliefs and practices, and factors affecting practices, of eight primary teachers selected from four schools in two different regions of the Maldives.

The research used a multiple case study approach within a qualitative methodology. A questionnaire, semi-structured interviews, and observations were used to collect data about teachers' beliefs and practice. Teachers' lesson notes, worksheets, samples of student work, and test papers were used to understand teachers' practice. Data were analysed within and across cases using a thematic approach.

Teachers demonstrated a range of beliefs that included both constructivist and traditional elements to different degrees. In general, teachers' observed practice was more traditional than their beliefs about teaching and learning mathematics. The teachers' practice showed some consistency with their beliefs about the nature of mathematics, mathematics teaching and learning; however, the degree of consistency between beliefs and practice differed from teacher to teacher. Overall, the findings indicated there are several factors affecting teachers' practice, including methods of assessment, teacher accountability for students' results, limited time to cover the curriculum, lack of resources, and parental pressure to use textbooks. National assessment practices, affecting many factors found to limit practice, emerged as being particularly influential on the teachers' instructional behaviour.

The study suggests the need to change the nature of national assessment, and remove other barriers if teachers are to be best placed to implement their constructivist beliefs and the Maldives mathematics curriculum. The findings also have implications for professional development and teacher education programmes.

Acknowledgements

All Praise unto Allah, Lord of the worlds

It is an honour for me to thank all those who helped, and contributed to the successful completion of this thesis.

First and foremost, I would like to express my sincere gratitude to Dr. Michael Drake and Dr. Robin Averill for their continuous support, guidance, patience, encouragement, wisdom, humour, and excellent supervision. I am heartily thankful to you, Michael and Robin.

I am truly indebted and thankful to the participant teachers and the students for their time, contribution, willingness to share their thoughts, and allowing me to visit their classes. My sincere thanks also go to Ministry of Education of Maldives, the principals of participating schools for their keenness, warm welcome, and support. I also thank those who contributed in trialling the questionnaire and observation schedule. Many thanks to you all.

I express my sincere gratitude to Laura van Peer for proof reading, and Dr. Steve Perrin at Student Learning Support Service of Victoria University for his advice and guidance.

My sincere thanks also go to all my friends who asked about the progress of my study and offered words of encouragement. I was very fortunate to have some friends working on their research at the same time as mine. I appreciate you, my friends, for the meetings held periodically to discuss our research projects. It was a tremendous help. Thank you.

I would like to thank the New Zealand International Aid and Development Agency (NZAID) for awarding me a scholarship to study at Victoria University of Wellington for my master's degree. I appreciate the continuous support provided by the NZAID team at Victoria University, in particular Julia Harrison for her help.

Finally, I owe my deepest gratitude to my wife Zimna, and sons, Dhanish and Dhaniyaal for their support, uncomplaining patience, and love. Thank you also to my Mum, Dad, sisters, and brothers for their encouragement and love. I love you all.

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CHAPTER ONE

Introduction

As a mathematics teacher and Head of Department (HOD) of mathematics in one of the schools in the Maldives, later as an assistant lecturer at the Faculty of Education of Maldives National University, I had many opportunities to observe other teachers teaching mathematics in the country. Similar to what Adam (2004) found in her Maldives study, I observed that teachers often relied on "chalk-and-talk" techniques to teach mathematics.

I am concerned about Maldivian students' low achievement in mathematics examinations, their lack of interest in learning mathematics, and their belief that mathematics is difficult to understand. As the finding of Adam (2004) indicates, to help foster students' learning, and to improve their motivation, teaching may have to change. However, as a result of my observations I realised that despite efforts to improve teaching – such as reforms in curriculum and professional development for teachers – teachers seem to have rarely changed their instructional practices.

The resistance to changing practice may be partially due to the beliefs teachers hold about teaching and learning mathematics, or there may be other factors influencing teachers' instructional practice. The idea of this study originated from my desire to understand teachers' mathematical beliefs and contextual factors affecting instructional practice of teachers in the Maldives.

The following sections of this chapter summarise the research problem (Section 1.1), the research context (Section 1.2), the focus of the study (Section 1.3), the significance of the topic (Section 1.4), and the organisation of the thesis (Section 1.5).

1.1 The research problem

Research on teachers' educational beliefs and the influence these have on instructional behaviour has increased in recent years (Fives, Buehl, & Bendixen, 2010). Some of the research has shown that teachers have well-articulated beliefs concerning teaching and learning, and these beliefs play an important role in shaping teachers' instructional practice regardless of their pedagogical knowledge or the curriculum guidelines they follow (Barkatsas & Malone, 2005). In addition, research has shown teachers' beliefs are not always congruent with their practice, because there are a number of other factors influencing teachers' instructional practice (Bolden & Newton, 2008).

Understanding teachers' beliefs and practice is important for improving their instructional practice, and to help teachers implement reform agendas. Reform efforts for improving or promoting instructional practice often need teachers to abandon some of their established beliefs and current practices (Little, 1993). Teachers' beliefs and practices need to be compatible with the ideas behind the curriculum or with ideas underlying the reform effort; once they believe in it, they "will lead the way in implementing it" (Battista, 1994, p. 462). According to Handal (2003), even if teachers' beliefs match the ideas underlying the reform, often the traditional nature of educational systems makes it difficult for teachers to translate their beliefs into practice, making studies on teachers' beliefs and instructional practices very important to consider when implementing reform agendas.

Most of the research on teachers' beliefs and practice has been conducted in developed countries. There is strong need to explore the beliefs and practice of teachers in developing countries because many of these countries are going through reforms in education that have been influenced by learning theories such as constructivism (Bimbola & Daniel, 2010; Chiu & Whitebread, 2011).

Exploring teachers' beliefs and practice is particularly important to the Maldives as the country is undergoing a major reform in education and the curriculum. Despite the Maldives Government's effort to improve the quality of education, many believe that there is, to date, no satisfactory improvement in students' performance, and there are good reasons, as discussed later in the chapter, to believe that instructional practices of teachers in the Maldives are inadequate. The number of students passing lower secondary examinations is far below 50 percent in most subjects including mathematics (data provided by Ministry of Education). This is a serious issue. There is also doubt about whether children are able to apply most of the mathematics they learn in school to real-life situations.

Initiated in 2008, curriculum reform in the Maldives is expected to play a key role in enhancing the quality of education in schools and to help teachers to provide students with meaningful, lasting, and useful knowledge. However, the success of implementing curriculum reforms is largely in the hands of teachers, and how the teachers practice reform ideas is based on how much they believe in them:

> Teachers are viewed as important agents of change in the reform effort … however, teachers are also viewed as major obstacles to change because of their adherence to outmoded forms of instruction that emphasize factual and procedural knowledge at the expense of deeper levels of understanding. (Prawat, 1992, p. 354)

Child-centred pedagogy, or a constructivist approach, to teaching plays an important role in the current Maldivian Curriculum (Educational Development Centre, 2000a; Educational Development Centre, 2000b) and the new curriculum[1] reform (Educational Development Centre, 2011a). However, it is not clear whether Maldivian teachers believe in a constructivist approach to teaching and learning mathematics, and whether they will implement the curriculum as intended.

Little is known concerning mathematics teachers' instructional practice in the Maldives. A study conducted in two schools in the Maldives to investigate the implementation of an ethnomathematical unit in a mathematics classroom shows that the mode of instruction in "Maldives classrooms relies heavily on the transmission of knowledge model" (Adam, 2004, p. 65). The study highlighted that, to confirm the results, there was a need for more studies on the mathematical practice of teachers. Moreover, how strongly teachers believed in the effectiveness of traditional or student-centred approaches, and the factors affecting their practice remain to be explored.

1.2 The Maldives context

The Republic of Maldives is a small island nation of 1192 islands, grouped in a double chain of 26 atolls, located in the Indian Ocean. The islands are small with an average size of less than a one square kilometre. According to the census of 2006, of these, 196 islands are inhabited, with a total population of 298,968 (Department of National Planning, 2010). One third of the population, 103,693, lives in the capital, Male' and

[1] The government expects the new curriculum to be implemented from 2012.

more than 65% of the inhabited islands (133) have less than 1000 people. Only four islands have a population of more than 5000. Furthermore, more than one third of the population, 132,941, is under 20 years of age. The geographical features of the Maldives have a tremendous influence on the education. There are many challenges to providing equal access to quality education for the small, scattered population living on tiny islands separated by sea.

Traditionally education was based on mostly religious teaching, and it was the responsibility of the religiously educated people to transmit their knowledge (Mohamed, 2006). Children went to houses of these learned persons called *edhuruge*. There were no formal schools until 1927 (Ministry of Education, 2008a), and the teaching was mostly based on one-on-one tutorials (Mohamed, 2006). Apart from religious teachings, the early schools of the Maldives provided a curriculum of writing, reading, and arithmetic (Ministry of Education, 2008a). The Western style of schooling was introduced in 1960 (Mohamed & Ahmed, 2005). According to Mohamed and Ahmed, this was the beginning of a public school system, and was “patterned after the British system in terms of organization of curriculum and methods of instruction” (p. 91). However, until 1978, formal education was concentrated in Male’. In 1978 the government decided to move to a unified, national system of education and to provide universal primary education for all.

Today, the country spends about 15% to 20% of its income on education (Ministry of Education, 2008a). However, due to the dispersion of the student population in 196 islands, schools are generally not well resourced. Due to insufficient numbers of classrooms and teachers, the majority of the schools run in two sessions[2]. A significant number of untrained teachers with only lower or higher secondary level qualifications are employed to teach in schools. According to a government report, 59% of pre-school teachers, 36% of primary teachers, and 15% of lower secondary teachers employed in 2005 were untrained (Ministry of Education, 2008a). Figures are similar today; according to government statistics, 35% of Maldivian primary teachers are untrained (Ministry of Education, 2010).

[2] Some year levels and teachers teaching to these levels come in the morning while others come in the afternoon. In most of the schools the morning sessions starts at 6.45 and ends at 12.30, and the afternoon sessions runs from 12.45 to 5.30pm

A teacher education centre, now called the Faculty of Education of the Maldives National University, was first established in 1984 as the Institute for Teacher Education. It trains most of the country's national teachers. Until recently, primary teachers were trained at certificate rather than degree level. The Faculty of Education has started various teacher training programmes at Diploma and Bachelor levels in order to train quality teachers.

In the Maldives, primary education begins for children at the age of six and comprises two key stages, with three years in each key stage. Key Stage One consists of Grades one to three, and the students are between the ages of six and eight. Key Stage Two consists of Grades four to six with students between the ages of nine and eleven.

The Ministry of Education does not allow students to repeat a year level except for special reasons. Therefore, the transition rate for students moving from primary to lower secondary is 96 percent (Ministry of Education, 2008a).

1.2.1 The curriculum

The Maldives Ministry of Education introduced a curriculum for primary education for the first time in 1984 (Ministry of Education, 2008a). The Education Development Centre (EDC) of the Ministry of Education revises the curriculum periodically, with a significant revision taking place in 2000 (Ministry of Education, 2008a). At secondary school level, the curriculum consists of syllabuses for internationally recognised examinations such as the Cambridge International General Certificate of Secondary Education (IGCSE) and The General Certificate of Education (GCE) examination syllabuses (e.g., University of Cambridge International Examinations, 2008).

Another major curriculum reform process commenced in 2008, and the first draft of the curriculum was developed at the end of 2009 (EDC, 2011b). It defines learning experiences for children aged four to 18 (preschool to higher secondary). Since 2009 the draft curriculum has gone through number of revisions, and implementation, which will take place in phases, will begin in 2012 in some schools (EDC, 2011b). According to the EDC, all schools will be teaching the new curriculum by 2015.

Both the 2000 revised curriculum (EDC, 2000a) and the new draft curriculum encourage a constructivist approach to teaching and learning. Regarding teaching and learning mathematics, the 2000 revised curriculum states that "teachers, students and parents should be aware that mathematics cannot be understood by memorising facts or by rote-learning" (EDC, 2000b, p. 1). The new draft curriculum "envisions the development of successful individuals who are motivated to learn and explore; who are inquisitive and eager to seek, use and create knowledge …" (EDC, 2011a, p. 12). According to this draft, mathematics plays an important role in the development of such individuals. It emphasises that mathematics should "develop students' problem solving, reasoning, creative, logical and critical thinking skills" (p. 18). The draft curriculum states that "students should be encouraged to try new things and explore every concept through a wide variety of experience and learning activities …" (p. 66).

The primary mathematics curriculum requires students in Grade five and below to have six periods of a minimum 35 minutes, and students in Grade six, seven periods per week.

1.2.2 Mathematics teaching

Primary teachers are trained as generalist teachers to teach all subjects. However, in general, teachers in upper primary teach specific subjects. For example, a teacher may teach only mathematics across several classes. Teachers teaching primary mathematics are not required to have a high mathematics qualification. They generally enter the profession with a lower secondary school qualification, and having completed a one or two year teacher training programme.

Maldivian teachers teaching mathematics rely heavily on textbooks. The EDC publishes a set of textbooks for each grade, and it is expected the teachers and students will use them. For example, in 2010 Grade four students had two mathematics textbooks (Naseer & Adam, 2007a; Naseer & Adam, 2007b). For teachers teaching parallel classes, it is common practice to have weekly "coordination meetings", often with a grade coordinator, to decide the content to be covered that week and textbook and workbook activities that will be given to students during the week. During that week teachers are expected to cover the content materials decided in the meeting.

1.2.3 Assessments and students' performance in exams

In the Maldives, students in Grades one, two, and three (Key Stage One) are assessed through observation by the teacher and through continuous assessment[3]. In Grades four to 12, students are assessed by a number of unit tests given at the end of each unit and a term test at the end of each term[4]. Tests are based on the textbook materials, and are developed internally by the teachers teaching parallel classes and subject coordinators/HODs. In general, the teachers contribute questions and the subject coordinator/HOD assembles and edits them. The results are reported to parents at the end of each term.

The students in secondary grades also sit IGCSE and GCE Ordinary Level (OL) examinations after the completion of Grade 10, and GCE Advanced Level examination at the end of Grade 12. In addition, there are two levels of national examinations offered at the end of Grades 10 and 12, and these examinations assess Dhivehi Language and Islamic Studies. As the students are offered international exams in English for all subjects except Dhivehi Language and Islamic Studies, the medium of instruction in schools for all but these two subjects is English.

The issue of the large numbers of students failing IGCSE and GCE OL examinations and the GCE Advanced Level examination has been debated in the Maldivian education sector over many years. Students' mathematics results are of specific concern. The numbers of students who pass have remained well below 40 percent. Figure 1.1 shows the percentage of students who passed mathematics in the GCE OL examination from 2005 to 2009 (data supplied by the Ministry of Education).

[3] Students are assessed after each unit, normally by pencil and paper tests.
[4] The academic year consists of two terms. In 2011, the first term was from 9 January to 2 June, and the second term was from 12 June to 17 December. The last two weeks in each term were allocated for school exams.

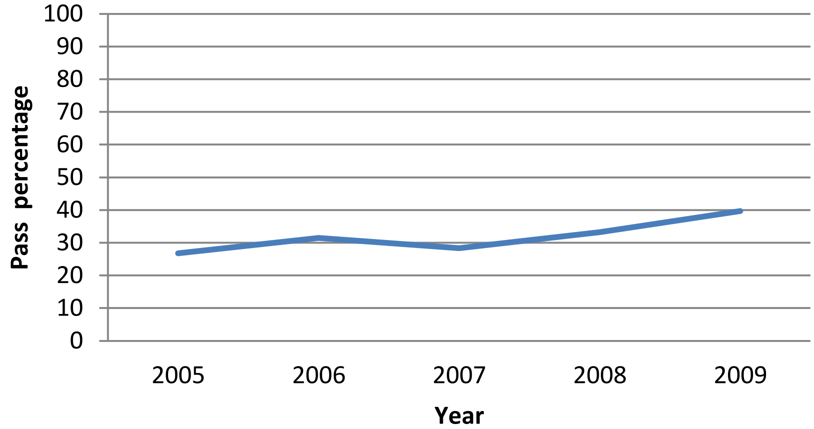


Figure 1.1 Percentage of candidates passing GCE OL mathematics (2005 – 2009).

Figure 1.1 shows the numbers of students passing GCE OL has increased slightly since 2007. However, this apparent improvement in performance is under question since many schools have recently not permitted some of their students to sit the exam due to concerns that these students' marks may lower their overall school results.

Many educators in the Maldives believe that to improve students' performance in secondary school examinations, students need to be given a quality primary education. For example, a daily newspaper reported an educational expert as saying "primary education standards in Maldives need to be improved in order to improve the overall standards" of secondary school examinations (Hamdhoon, 2004). Students' mathematics performance in the Ministry of Education's *diagnostic test*[5] supports this claim. In 2008 the test was conducted in Grades four and seven in all schools in the Maldives. Five thousand, six hundred, and eighty six (5686) students in Grade four and eight thousand, one hundred, and forty (8140) students in Grade seven participated in this test (Ministry of Education, 2008b). Only 29% and 13% of Grade four and Grade seven students respectively passed.

1.2.4 Professional development for teachers

To provide professional assistance to teachers, Teacher Resource Centres were established in 2008 in each of 20 atolls, and schools are encouraged to conduct school-based professional development programmes for the teachers. The Ministry of

[5] Diagnostic testing started in 2003. In 2003 the test was piloted in the capital. The test was conducted in selected schools in the capital in 2004, and in 2006 and 2007 the sampling was extended to other island schools. In 2008 the test was administered in all the schools in the Maldives.

Education introduced a professional development policy for the first time in 2009 (Centre for Continuing Education, 2010). This policy requires teachers to have fifteen hours professional development every year, and the ministry allocates three non-teaching days during every academic year for school-based professional development (Ministry of Education, 2009). However, given the dispersed nature of islands and the lack of qualified professional developers, it is a challenge to provide adequate and effective professional development for teachers. Mohamed (2006) notes that only a few "organized professional development" opportunities are available for teachers (p. 12). According to Mohamed, the Ministry of Education occasionally conducts one- or two-day workshops as a series of theory sessions in lecture format, but no follow-up activities are conducted. No systematic research has been conducted into the implementation of this policy or the effectiveness of the professional guidance.

1.3 The study focus

This study aims to explore the beliefs and practices of teachers teaching at the upper primary level - Key Stage Two - and the factors affecting teachers' practice. The study focuses on primary teachers, because these teachers are locally trained and, therefore, the study has implications for teacher education programmes in the country. Furthermore, mathematics content and assessment differ at different key stages, possibly affecting teachers' beliefs about what mathematics is and how it should be taught. Key Stage Two is selected for the study because, unlike Key Stage One, students are assessed by a number of unit tests during each term and also by a term test at the end of each term.

The study is guided by the following questions:

1. What beliefs do upper primary teachers hold about teaching and learning mathematics?
2. How are the Maldivian upper primary teachers' beliefs and practices regarding teaching and learning mathematics consistent with the constructivist approach?
3. Are there inconsistencies between upper primary teachers' mathematical beliefs and their instructional practice?

4. What are the factors that inhibit or promote upper primary teachers' translation of beliefs into practice?

1.4 The significance of the study

Understanding teachers' beliefs and practice in the Maldives has implications for implementing reforms in the curriculum. Numerous scholars believe that understanding the beliefs of teachers is essential to improving teachers' professional preparation and their practice (e.g., Beswick, 2005; Muis & Foy, 2010; Pajares, 1992). Changing teachers' beliefs and practice is a major challenge in implementing reforms (Battista, 1994; Prawat, 1992). Therefore, teacher education and professional development programmes need to focus on changing teachers' beliefs rather than only focusing on methodology (Cross, 2009).

Thompson (1984) argues that the relationship between beliefs and practice is weakened as a result of constraints teachers face in their daily practice. Understanding factors that influence teachers' practice is essential for educational providers and school leaders to help teachers to improve their practice (Bolden & Newton, 2008; Leong & Chick, 2011). Therefore, this study was not only designed to explore teachers' beliefs and practice, but also to identify factors influencing their practice.

1.5 Organisation of the thesis

This introductory chapter has provided the context of the research, the significance of the study, and the researcher's background. Chapter Two presents a review of literature relevant to the study. Chapter Three details and justifies the methodology practised in the study, describes the research design, data collection tools, and analysis approach. The findings are presented in Chapters Four and Five. Chapter Four provides a thick description of individual cases. Findings of cross case analysis are given in Chapter Five. Finally, Chapter Six focuses on findings and their implications, and provides the study's conclusion. Chapter Six also discusses limitations of the findings and identifies areas for future research.

CHAPTER TWO

Literature review

This chapter presents an overview of literature related to the study. Most of the literature discussed is from developed countries as few empirical studies related to the topic have been conducted in the Maldives.

This review begins with an overview of epistemology in relation to mathematics education (Section 2.1), followed by a brief description of constructivism and constructivist teaching (Section 2.2). Section 2.2 highlights the role of the constructivist teacher (Section 2.2.1), and the principles and elements of constructivist teaching (Section 2.2.2). The chapter then describes traditional models of teaching, outlining their characteristics (Section 2.3). Next, it proceeds to examine and discuss teachers' mathematical beliefs and practice. The beliefs about teaching and learning in general are briefly presented first (Section 2.4), followed by teachers' mathematical beliefs (Section 2.5), and the relationship of these beliefs to instructional practice (Section 2.6). In addition, the significance of teachers' beliefs and practice in professional development programmes (Section 2.7), and role of assessment practice in teaching are outlined (Section 2.8). The chapter closes with a brief summary (Section 2.9).

2.1 Epistemology and mathematics education

Hofer and Pintrich (1997) define epistemology as "an area of philosophy concerned with the nature and justification of human knowledge" (p. 88). It is about the beliefs or theories associated with knowledge and knowing. In mathematics education "there is an increasing awareness of the significance of epistemological and philosophical issues for important traditional areas of inquiry" (Ernest, 1994, p. xi) and, as a result, the number of papers on personal epistemology and its relation to issues in mathematics education has increased (Muis & Foy, 2010). Ernest argues that there is a strong link between epistemology and educational issues, and states that even theories of learning are epistemologically oriented.

Until the 1980s, mathematics was believed to be “fully informed and perfectly finished knowledge”. In this view, teaching and learning mathematics only requires “effective transmission of mathematical knowledge” (Ernest, 1994, p. 1). This is similar to the behavioural model of teaching and learning (Cathcart, Pothier, Vance, & Bezuk, 2005; Scheurman, 1998) whereby knowledge is believed to be acquired through teacher centred instruction (Bolden & Newton, 2008), with drill exercises being a major component of the teaching and learning process (Cathcart, et al., 2005). The focus, therefore, is on outcomes rather than meaning making and understanding. In some recent literature about personal epistemology this view of mathematics and knowing is regarded as the traditional approach (Barkatsas & Malone, 2005; Brooks & Brooks, 1993).

Clements and Ellerton (1996) argue that in the 1970s the failure of teaching and learning practices based on the traditional approach led educators to view mathematics differently. In recent years, mathematics education has been influenced by the view that mathematics is actively constructed by individuals, which is generally known as constructivism. Within constructivism, there are a variety of different forms, such as radical and social constructivism (Ernest, 1994). Radical constructivism emphasises the individual aspect of learning, whereas in social constructivism the learner is believed to acquire knowledge as a result of social interactions. In this literature review, the term constructivism refers to constructivism in general and includes both radical and social constructivist aspects of learning.

2.2 Constructivism and teaching

Constructivism is a philosophy and a theory of knowing that argues human knowledge results from one’s experiences (Marlowe & Page, 2005; von Glasersfeld, 1989). Constructivism is also used as a learning theory and educational strategy (Muijs & Reynolds, 2005), according to which knowledge is constructed as the learner connects new experiences with the existing knowledge (Pritchard & Woollard, 2010). The theories of Piaget and Vygotsky serve as a basis for constructivist learning theories (Fosnot, 1996). Their fundamental argument is that humans have no access to objective reality as they construct their own version of knowledge (Fosnot, 1996).

Constructivism can be used to guide one's instructional strategies. It describes how students come to know and understand, but does not "prescribe specific methods for helping students construct knowledge" (Draper, 2002, p. 523). There are no specific strategies or step-by-step procedures that lead to constructivist teaching (Brewer & Daane, 2002).

Although the literature on constructivist teaching does not prescribe specific practices, it provides detailed descriptions and elements of such practice. Authors on constructivist teaching make comparisons between constructivist and traditional teaching models to show the differences in the two teaching approaches (Richardson, 2003). The main difference is constructivist teaching's emphasis on students' active participation in the learning process. Constructivist teaching, therefore, does not focus on content and the teacher, but emphasises the students and the process.

A number of studies of constructive teaching strategies have shown that they are effective. For example, research conducted in Washington (Abbott & Fouts, 2003) which involved 669 classrooms from 34 schools including 15 elementary and 8 middle schools found that constructivist teaching had a positive impact on student achievement. The subjects in this study included mathematics, social studies, science, and language arts. Another study (Kim, 2005) conducted in Korea with 76 sixth-grade students shows that in teaching mathematics, a constructivist approach was more effective in terms of students' academic achievement than a traditional approach. In this study students' were divided into two groups; one was taught using a constructivist approach while the traditional approach was used with the other group.

2.2.1 The role of the teacher and students

A constructivist teacher acknowledges the learner as an active knower, and the role of the teacher is to guide, coach, and facilitate learning, but not to transmit knowledge (Davis, Maher, & Noddings, 1990; Pelech & Pieper, 2010). The teacher provides opportunities to participate in activities that enable students to create their own understanding, and to discuss, demonstrate, and explain their ideas to others (Marlowe & Page, 2005). The teacher believes that students learn best through working, listening, and comparing their own perspectives with others.

In teaching mathematics, constructivist teachers believe that for students to think, they need to be presented with problems, questions, and activities with relevant and adequate information (Hiebert, et al., 1996). Hiebert and colleagues believe that too little information or too much information hinders learning. They argue that without relevant information students would progress very slowly, and too much information would undermine students' inquiries. According to Reynolds and Muijs (1999), effective teachers give students relevant information in brief presentations prior to letting students work on problem solving.

In constructivist mathematics classrooms, the teacher assists students as they construct understanding (Draper, 2002). Students share the responsibility of creating a learning community in which they discuss, explain, and justify their solutions to inquiries (Sapkova, 2011; Simon, 1995). They appreciate learning is not only from the teacher, and they listen to fellow students' ideas with the intention of learning from them (Hiebert, et al., 1996). In constructivist teaching students take responsibility and ownership in the learning process.

Constructivist teaching is often criticised in terms of the role of the teacher. For example, Kirschner, Sweller, and Clark (2006) label constructivist teaching as a *no guidance* or *minimal guidance* approach. However, advocates argue that such interpretations are not valid:

> If constructivist approaches are characterised as 'unguided', that is, as setting students up to rediscover, through unguided exploration, those abstract and counter-intuitive ideas that people like Newton, Curie, Einstein, Meitner, Darwin and others discovered as a result of many years of full-time study and collaboration … then it seems pretty obvious that this is not an effective way of helping students to understand canonical scientific knowledge. Indeed, far from it. (Taber, 2011, p. 260)

2.2.2 Constructivist principles and strategies

Marlowe and Page (2005, pp. 7-9) suggest four principles that are useful in differentiating constructivist and traditional learning:

1) Constructivist learning is about constructing knowledge, not receiving it.
2) Constructivist learning is about understanding and applying, not recalling.
3) Constructivist learning is about thinking and analysing, not accumulating and memorizing.
4) Constructivist learning is about being active, not passive.

By comparison Brooks and Brooks (1993, p. 33) propose five guiding principles of teaching that encourage this type of learning:

1) Posing problems of emerging relevance to students,
2) Structuring learning around main concepts or primary concepts,
3) Seeking and valuing learners' points of view,
4) Adapting curriculum to students' suppositions, and
5) Assessing students' learning in the context of teaching.

According to Brooks and Brooks (1993) teachers should "organize information around conceptual clusters of problems, questions, and discrepant situations" rather than giving exercises to practise isolated skills (p. 46). They advise providing students with manipulative, interactive, and physical materials. They emphasise that teachers should provide students with opportunities to express their points of view, and adapt curriculum activities to address students' understanding of the concept. Brooks and Brooks argue that, *talking* to students, *listening* to them, encouraging them to have *dialogue with each other*, and *seeking to elaborate* their responses are essential aspects of constructivist teaching.

By comparing and contrasting various ideas, views, and principles about constructivist teaching (Brooks & Brooks, 1993; Marlowe & Page, 2005; Pelech & Pieper, 2010; Simon, 1995; Simon & Schifter, 1991) the overall themes that emerged are:

1) Constructivist teaching promotes understanding,
2) Constructivist teachers help students connect new experiences to their existing knowledge,
3) In constructivist classrooms students work with others and share their ideas,
4) Constructivist teachers provide interactive and manipulative materials for students to investigate mathematical ideas, and
5) Constructivist teachers provide their students with problem solving activities and real-life tasks.

The literature regarding these themes is further reviewed in subsequent sections.

Constructivist teaching promotes understanding: Advocates for constructivist teaching argue that teaching for understanding should be the main focus for mathematics teachers as it is through understanding that knowledge becomes meaningful, useful, and applicable (Cobb, Wood, Yackel, & McNeal, 1992; Kulm, Capraro, & Capraro, 2007).

Understanding acts as a catalyst for generating new knowledge by making it easier to learn and remember, and also enhances the transfer of learning (Hiebert & Carpenter, 1992; Skemp, 1976).

Although mathematics is based on rules and symbols that must be learned, for many, understanding is not simply a matter of recalling mathematical procedures, rules, and symbols, and using them without knowing the reasons (Kulm, et al., 2007). The purpose of acquiring mathematical knowledge is to apply it in real-life contexts; hence many believe that mathematical instruction should be modelled in such a way that the knowledge students acquire will be useful in real life (Hiebert, et al., 1996). Today, there is a growing body of research that suggest that mathematical understanding is built as the outcome of an active process, and teaching and learning is considered as a social interaction (Ben-Hur, 2006; Prawat, 1992; Voigt, 1994). This approach to teaching and learning provides students with knowledge that is more meaningful and useful for real-life contexts (Battista, 1994; Clements & Ellerton, 1996; Yackel, 1995).

Students' prior knowledge and experience: Constructivist teachers help students to make sense of what they learn by helping them to connect new knowledge to existing knowledge and ideas (Muijs & Reynolds, 2005; Pelech & Pieper, 2010). Constructivist teaching is based on the assumption that students come to school with experiences, ideas, and conceptions, and learning takes place when new knowledge is related to already existing knowledge structure (Baviskar, Hartle, & Whitney, 2009). Hiebert and Carpenter (1992) argue that a mathematical concept is "understood thoroughly if it is linked to existing networks with stronger or more numerous connections" (p. 67). If teachers force children to learn new knowledge, and if children cannot link it to existing knowledge structure, the information can only be learnt by memorisation (Orton, 1992). According to Orton, such learning can easily be forgotten, and may not promote students' mathematical thinking.

Constructivist teachers "allow student responses to drive lessons, shift instructional strategies, and alter content" based on the needs of students (Brooks & Brooks, 1993). According to Brooks and Brooks, this does not mean the teacher needs to abandon a topic if students are interested in discussing other issues, but instead to be flexible with plans and curriculum materials. Research has shown that when teacher instruction is based on students' prior knowledge the learning is more effective than the traditional approach of teaching. For example, Hewson and Hewson (1983) conducted a study in which an experimental group was taught using instructional strategies and materials based on students' prior knowledge, and the control group was taught using the traditional approach. The study revealed that learning is more effective when instructional strategies and learning materials are based on what students already know. Orton (1992) states that if a teacher can determine what the students already know, then he or she can decide what and how to teach.

Sharing ideas and working with others: "Social interaction" is a key element of a constructivist philosophy of teaching and learning (Jones, Jones, & Vermette, 2010). In constructivist teaching students are provided with opportunities to discuss what they learn, and share their ideas with each other and with the teacher. "Constructivists rely on teaching practices that are rich in conversations" and it is through conversations the "teacher comes to understand what the learner is prepared to learn and how to orchestrate" further learning activities (Draper, 2002, p. 3). Working with others and sharing ideas in groups help students to construct meaningful and useful knowledge (Boaler, 2006).

Explaining to each other their personal solutions to mathematical problems is important for the development of children's mathematical thinking (Cobb et al., 1992). Students also need to think about and discuss similarities and differences between mathematical rules and procedures in order to construct relationships (Hiebert & Carpenter, 1992). The role of the teacher, therefore, is to help students build networks of relationships by establishing a learning environment that encourages discussion, inquiry, and collaborative problem solving (Yackel, 1995). In classrooms where students share knowledge and understanding they actively engage in learning mathematics and are motivated (Fraivillig, Murphy, & Fuson, 1999). In a number of research projects, Boaler (1998, 2002, & 2006) has shown that students who learned mathematics through activities that required them to work in groups, share ideas, and engage in discussions developed deeper understanding.

Manipulative materials: The use of manipulative material is another important strategy often used in the constructivist teaching of mathematics. Students' own use of manipulative materials enhances their understanding. Hiebert and Carpenter (1992) argue that the appropriate use of concrete materials in elementary mathematics instruction helps students to build links among mental or internal representations and their external environment. They suggest that the proper use of manipulative materials help students build relationships between mathematical symbols and physical materials. However, the use of manipulative material does not guarantee meaningful learning (Baroody, 1989; Thompson, 1994).

The research on the effective use of concrete materials shows mixed results (Fennema, 1972; Friedman, 1978; Hiebert, Wearne, & Taber, 1991). The inconsistency in these findings shows that manipulative materials are not enough to promote students understanding (Clements & McMillen, 1996; Clements, 1999; P. W. Thompson, 1992). Clements (1999) argues that students may manipulate physical objects meaningfully without understanding the concept, and sometimes the meanings students construct using manipulatives may not be what teachers intend students to learn. For example, they may use manipulative materials in a rote manner without understanding the concept behind the procedure (Clements & McMillen, 1996; Hiebert & Carpenter, 1992). Effective use of manipulative material involves students' discussion as an integral part of it (Kosko & Wilkins, 2009). Manipulation of physical objects and mathematical symbols "without reflection is unlikely to stimulate construction of the relationship that leads to understanding" (Heibert & Carpenter, 1992, p. 73).

Problem solving: Students' engagement in problem solving is the "most suitable way for the learner to construct actively the new knowledge" (Voskoglou, 2011, p. 95). Problem solving enables students to use their existing mathematical knowledge, experience, and skills, and construct new knowledge through exploring and reflecting (Fox & Surtees, 2010). It helps students to think about mathematical ideas, connect the mathematical knowledge to real-life situations, and make sense of the knowledge (Hiebert et al., 1996; Hiebert & Carpenter, 1992; Kahan & Wyberg, 2003; Sweller, 1988).

Problem solving is not simply doing mathematical exercises that require students to apply known procedures (Ben-Hur, 2006). Problem solving requires learners to think, analyse, and reason through a situation; unlike a traditional practice-based mathematical exercise, in problem solving learners cannot immediately see how to resolve it (Killen, 2003). According to Flores (2010), in problem solving, students should go through three steps: 1) identify what to do to solve the problem, 2) communicate the solution to others, and 3) explain the validity of the solution.

Hiebert et al. (1996) argue problem solving strategies exhibited by students depend more on the culture of the classroom than the task itself. They assert that "tasks are inherently neither problematic nor routine" (p. 16). The classrooms should have a culture and environment that encourage students to engage in mathematical investigation, teacher-to-student interaction, as well as student-to-student discussion that focus on mathematical issues (Davis et al., 1990). Students should be encouraged to learn from each other.

2.2.3 Discussion

The literature identifies guiding principles and suggests strategies that help students actively construct knowledge. The literature has shown that the effective use of such strategies promotes students' understanding. However, it should be noted, constructivist teaching is not a specific set of strategies. It is the classroom environment and students' active participation in constructing their own understanding that distinguishes constructivist teaching from a traditional approach. The strategies often attributed as constructivist strategies can be used in the traditional manner. For example, Clements and McMillan (1996) note that students and teachers can use manipulative materials in a rote manner without understanding the concept. Similarly, students working together in groups does not guarantee the teacher is using the strategy effectively. For instance, a rote learning exercise to practise a procedure already demonstrated by the teacher may not be a suitable group task as it may not facilitate discussion and interaction of students. Such exercises can be completed by a single student without involving others. The use of strategies that are often labelled as constructivist does not mean the teacher is using them in a constructivist way. Therefore, it is not the use of particular strategies, but the classroom culture in which the strategies are used and interaction between teacher and students that determine whether the teacher is using a constructivist approach.

2.3 Traditional models of teaching

In traditional approaches to teaching, students are seen as blank sheets or empty containers the teacher can fill with content or knowledge (Brooks & Brooks, 1993). In traditional approaches, mathematics is viewed as a fixed discipline and an established set of concepts (Perry, Howard, & Tracey, 1999). Teachers focus on procedural rather than conceptual understanding (Bolden & Newton, 2008) and provide their students mainly with drill exercises to practise isolated skills (Roehler & Cantlon, 1997). This approach to teaching is described thus:

> [The teacher] lecturing or explaining to the entire class and then assigning "seat work" for the students to complete individually at their desks. Any questions the teacher asks the students are likely to be direct, factual questions whose answers can be produced from rote memorization. And the depth of the teacher's evaluation of students' answers is that the answers are either "right" or "wrong". (Gregg, 1995, p. 442)

Gregg (1995) describes a traditional classroom as one where the teacher routinely checks students' homework, demonstrates some of the homework on the board, explains new materials, and then assigns students "seat work". The students spend most of their time learning by rote, working in silence, and completing whole pages of practice sums from textbooks; teachers tell them the right answers with the expectation that it will be learned (Pritchard & Woollard, 2010). The teachers rely heavily on textbooks and workbooks with emphasis on basic skills, and "seek correct answers to validate students learning" (Brooks and Brooks, 1993, p. 17).

In the literature, the traditional approach has also been labelled as the transmission model, teacher-centred, subject matter oriented, or subjected-centred model, and the constructivist approach has been labelled as student-centred or a non-traditional approach (Boz, 2008; Bramald, Hardman, & Leat, 1995; Perry et al., 1999; Prawat, 1992; Raymond, 1997).

2.4 Teachers' beliefs

There is no generally agreed definition of the term "belief" in educational psychology (Beswick, 2005; Cross, 2009; Pajares, 1992). In describing the inconsistencies in definitions of the term Pajares writes, "defining beliefs is at best a game of player's choice ... They travel in disguise and often under alias" (p. 309). In the literature the term is used interchangeably with epistemological beliefs (Bromme, Kienhues, & Porsch, 2010; Schommer-Aikins, 2004), epistemological theories (Hofer & Pintrich, 1997), personal epistemology (Rule & Bendixen, 2010), and reflective judgement (King & Kitchener, 2004), "principles of practice", "perspectives", "practical knowledge", or "orientations" (Kagan, 1992, p. 66). This continued use of different terms results in inconsistency in definitions of beliefs (Torner, 2002).

Cross (2009) defines beliefs as "embodied conscious and unconscious ideas and thoughts about oneself, the world, and one's position in it, developed through membership in various social groups; these ideas are considered by the individual to be true" (p. 65). According to Kagan (1992), a teacher's beliefs are often described as "teachers' implicit assumptions about students, learning, classrooms, and the subject matter to be taught" (p. 66). Pajares (1992) argues that definitions of beliefs that include a number of constructs are too broad to be useful for specific research. He suggests that a more specific definition, such as beliefs about particular subject content and teaching and learning, would be more useful. According to Pajares, defining beliefs on specific constructs rather than a general definition would move towards consensus about definition of teacher beliefs.

Despite the irregularity in defining beliefs, a number of studies have shown quite consistent findings about the nature of beliefs. Beliefs are shown to be deeply personal, stable, and resistant to change (Kagen, 1992; Pajares, 1992); consciously or unconsciously held (Cross, 2009; Kagan, 1992; Thompson, 1984); to influence individuals' cognitive processes and behaviour (Muis & Foy, 2010), but they do not always reflect behaviour as there may be a number of other factors affecting behaviour (Kagen, 1992).

Beliefs can be formed as a result of intensive experience or a succession of events, or even by chance (Pajares, 1992). Teachers' beliefs about teaching and learning may have originated from their schooling through their experience of learning and observations of teaching of their former teachers (Thompson, 1984). When pre-service teachers enrol in teacher education programmes they already have strong beliefs about how to teach and learn (Kagen, 1992).These beliefs are then shaped by their own practice of teaching and learning experiences (Beswik, 2005).

Researchers conceptualise beliefs as systems of more or less independent sets of beliefs (e.g., Green, 1971; Schommer-Aikins, Bird, & Bakken, 2010). The belief systems "are dynamic in nature, undergoing change and restructuring as individuals evaluate their beliefs against their experience" (A. G. Thompson, 1992, p. 130).

Green (1971) identifies three dimensions of a belief system. The first dimension describes that beliefs are not held in total isolation of one another, and some "beliefs are related to others in the way that reasons are related to the conclusions" (p. 44). In any given system of beliefs, there may be some primary beliefs, and some beliefs that are derived from these primary beliefs. This means people can hold some beliefs (primary) without understanding the reasons for having them.

Green's second dimension describes the psychological strength of beliefs: those held most strongly are called psychologically central, and others are called psychologically peripheral. According to Green, peripheral beliefs are easy to change, while central beliefs are not.

The third dimension tells that "beliefs are in clusters, as it were, more or less in isolation from other clusters and protected from any relationship with other set of beliefs" (p. 48). According to Green (1971), people can hold inconsistent beliefs. This is because beliefs are organised in clusters with a "protective shield that prevents any cross-fertilization among them or any confrontation between them" (p. 47). A number of authors (e.g., Beswick, 2006; A. G. Thompson, 1992) acknowledge Green's (1971) framework is still useful for understanding beliefs and the relationship between them.

2.5 Teachers' mathematical beliefs

A number of researchers (e.g., Ernest, 1989; Handal, 2003; Kuhs & Ball, 1986; Perry et al., 1999; Raymond, 1997) agree that the key components of teachers' beliefs about mathematics include beliefs about the nature of mathematics, beliefs about mathematics learning, and beliefs about mathematics teaching. Teachers' beliefs about the nature of mathematics refer to teachers' views regarding the discipline of mathematics as a whole (Ernest, 1989). Beliefs about mathematics learning include perceptions about students' roles and how students learn effectively (A. G. Thompson, 1992). Thompson describes beliefs about mathematics teaching as teachers' view about their own role in the classroom, and their choice of classroom activities, and instructional strategies they prefer.

According to Ernest (1989), the most important of these three categories is the beliefs about the nature of mathematics. He argues that beliefs about the nature of mathematics provide a basis for beliefs about mathematics learning and mathematics teaching. This means a teacher holding constructivist beliefs about the nature of mathematics is likely to have similar views about mathematics learning and teaching.

Teachers have a range of mathematical beliefs, and researchers have categorised them in multiple dimensions (Askew, Brown, Rhodes, Wiliam, & Johnson, 1997; Ernest, 1989; Kuhs & Ball, 1986; Perry et al., 1999; Raymond, 1997). For example, Askew, et al., (1997) classify teachers' mathematical beliefs into *connectionist*, *transmission*, and *discovery*. "Connectionist" teachers believe that teaching strategies and methods that focus on establishing connections within mathematics is important. "Transmission" describes beliefs about mathematics as collections of separate rules and procedures. "Discovery" refers to beliefs about the ability of learners to discover mathematics.

As reform in mathematics education has been influenced by constructivist learning theories, much of the recent research on teacher beliefs distinguishes between teachers' traditional beliefs and constructivist beliefs (Sang, Valcke, Braak, & Tondeur, 2009). Such studies typically "measure whether teachers believe that students can actively construct their own knowledge [constructivist belief] or whether they are passive recipients of knowledge [traditional belief]" (Muis & Foy, 2010, p. 436).

Beswick (2005) and Perry et al.'s (1999) belief survey questionnaires about teachers' mathematical beliefs, and Raymond's (1997) criteria for categorisation of teachers beliefs and practice have identified a number of elements of traditional and constructivist beliefs regarding the nature of mathematics, mathematics teaching, and mathematics learning. Tables 2.1, 2.2, and 2.3 provide a summary of descriptions of traditional and constructivist perspectives drawn from these studies.

Table 2.1
Elements of traditional and constructivist perspectives about the nature of mathematics

Constructivist	**Traditional**
1. Mathematics is a way of thinking	1. Mathematics is a collection of unrelated but applicable facts, rules, and procedures
2. Mathematics is dynamic and expanding	2. Mathematics is a fixed body of knowledge
3. Mathematics involves problem solving, figuring out relationships, and patterns	3. Mathematics is all about computations

Table 2.2
Elements of traditional and constructivist beliefs about learning mathematics

Constructivist	**Traditional**
1. Mathematics learning is enhanced when students work in groups collaboratively, and demonstrate their solutions to others	1. Working alone in silence is an important part of mathematics learning
2. Students create their own version of knowledge by active participation in learning activities	2. Students learn mainly from teachers' explanations
3. Students can learn mathematics without following textbooks and worksheets	3. Using textbooks and worksheets for practice is important in mathematics learning
4. In order for students to learn mathematics they need to be presented with problems, questions, or situations that force them to think differently	4. Engaging in repeated practice for mastery of skills is a critical part of mathematics learning
5. Students are more responsible for their own learning than teachers	5. Teachers are more responsible for students' learning than the students
6. Relating mathematical concepts to students' prior knowledge and experience is important	6. Memorising rules, facts, and procedures is the way to learn mathematics
7. Learning is evident when students can demonstrate their ability to figure out mathematical relationships	7. Students learn mathematics if they can follow procedures
8. Problem solving is important in learning mathematics	8. Getting the right answer quickly is a significant evidence of learning

Table 2.3

Elements of traditional and constructivist beliefs about the nature of mathematics teaching

Constructivist	Traditional
1. Teachers provide students with problem solving situations to investigate in small groups	1. Teachers explain thoroughly the mathematical rules and procedures before giving students mathematical problems
2. Teachers provide manipulative materials for students to explore mathematical ideas and concepts themselves	2. Students are mainly given drill exercises (e.g. worksheets) to master the skills
3. Teachers listen to students and seek elaboration of learners' responses	3. Students are not encouraged to express their ideas
4. Lessons are not planned solely based on students' textbooks	4. Teachers plan instruction based on students' textbooks, and verify that students have mastered the knowledge in these books
5. Teachers' role is to guide students rather than telling students what they should do	5. Teachers' role is to explain and demonstrate the rules and procedures
6. Teachers engage learners in situations that might bring about contradictions and then encourage discussions.	6. Learning activities provided are focused on memorisation of skills and procedures by doing repetitive practice
7. Students are assessed by their ability to think, express, and figure out mathematical relationships	7. Teachers assess students' understanding by checking the number of right answers and the speed of getting them
8. Teachers focus more on conceptual understanding	8. Teachers focus more on procedural understanding

Research on teachers' mathematical beliefs (e.g., Alamu, 2010; Cross, 2009; Thompson, 1984; Whitehouse, 2003) reveals that most teachers do not hold beliefs that fit exactly within one dimension or framework. They often hold beliefs that have a mixture of elements of constructivism and traditional views (Askew et al., 1997). A study by Whitehouse (2003) found that among 59 secondary teachers who filled in a questionnaire designed to measure traditional and constructivist beliefs, none described beliefs that were consistently traditional or constructivist. A study (Alamu, 2010) conducted in the Solomon Islands which explored beliefs, knowledge, and practice of sixteen primary mathematics teachers reveals similar results.

Some studies report that teachers' beliefs about the nature of mathematics, mathematics learning, and mathematics teaching are not always consistent across these categories (e.g., Barkatsas & Malone, 2005; Raymond, 1997). In her case study of an elementary mathematics teacher's beliefs and practice, Raymond (1997) found that the teacher had traditional beliefs about the nature of mathematics while her beliefs about mathematics learning and mathematics teaching were non-traditional.

As teachers may hold a range of beliefs between "fully traditional" and "fully constructivist", various descriptive labels have been used to indicate different combinations or position in this range. For example, Raymond (1997) describes a number of sub-categories as: *traditional*, *primarily traditional*, *even mix of traditional and non-traditional, primarily non-traditional,* and *non-traditional*. Sang et al. (2009) identify four categories: *constructivist profile*, *mixed constructivist/traditional profile*, *mixed low constructivist/traditional profile*, and *traditional profile*. According to Handal (2003), the differences in teachers' beliefs are interpreted by some of the researchers as either "stages of a developmental process, individual cognitive differences, or simply due to differences in socio-economic status, educational systems, or cultural environments" (p. 50).

Studies that focused on identifying teachers' mathematical beliefs have obtained mixed results. According to Handal (2003), a large number of teachers believe that mathematics teaching and learning is more effective when teachers employ the traditional approach. However, recent studies suggest more and more teachers are starting to recognise the effectiveness of constructivist strategies in teaching and learning mathematics (Boz, 2008).

2.6 Relationship between mathematical beliefs and practice

Previous research identifies that teachers' mathematical beliefs influence their approach to teaching (e.g., Barkatsas & Malone, 2005; Cooney, 1985; Nespor, 1987; Pajares, 1992; Philipp, 2007; Raymond, 1997; Roesken, Pepin, & Toerner, 2011; Speer, 2005). However, these studies do not show consistent results. Some of the studies have indicated a high degree of consistency, while others identify a significant level of discrepancy between beliefs and practice. There is no linear or simple relationship between teachers' beliefs and practice (Cross, 2009; Liljedahl, 2008; Wood & Cobb, 1991).

Thompson (1984), for example, investigated the relationship between three secondary mathematics teachers' beliefs and practice using a qualitative multiple case study approach. The study shows teachers' beliefs about mathematics, and teaching and learning mathematics play a significant role in shaping their instructional practice. However, the teachers in the study showed different degrees of consistencies between beliefs and practice.

Stipek, Givvin, Salmon, and MacGyvers (2001) assessed beliefs about mathematics, mathematics learning, and mathematics teaching of 21 primary mathematics teachers and their practice. The findings indicate a high level of consistency between beliefs and practice. Cross (2009) interviewed and observed five secondary mathematics teachers. The findings show that teachers' beliefs about the nature of mathematics, mathematics learning, and mathematics teaching were consistent with their practice. These studies suggest teachers' beliefs about the nature of mathematics serves as a primary source of their beliefs about mathematics teaching and mathematics learning.

Conversely, other studies have shown that there can be significant discrepancies between teachers' mathematical beliefs and their instructional practices. The discrepancy reported in studies indicates that there are number of other factors affecting teachers' instructional practice (A. G. Thompson, 1992). Ernest (1989) notes the "constraints and opportunities provided by the social context of teaching" as the main cause for discrepancy between beliefs and practice (p. 253). According to Ernest, these constraints include expectations of students, parents, and colleagues and "It also results from the institutionalised curriculum: the adopted text or curricular scheme, the system of assessment, and the overall national system of schooling" (p. 253).

Reinforcing this, Handal (2003) writes:

> Parents and professional colleagues ... expect teachers to teach in a traditional way. Teachers are also expected to focus on external examinations, to adhere to a textbook, and to keep a low level of noise and movement in the classroom. (p. 49)

Similar factors were reported in a number of other studies. For example, Raymond (1997) investigated inconsistencies between mathematical beliefs and practice of a primary teacher. The study showed the beliefs were not fully consistent with the teacher's practice. The study also showed that the teacher's belief about the nature of mathematics was more closely related to her practice than her beliefs about mathematics learning and mathematics teaching. Raymond identified time constraints, lack of resources, assessment methods, and students' behaviour as factors influencing the teacher's practice.

Jorgensen, Grootenboer, Niesche, and Lerman's (2010) study on the beliefs and instructional practice of beginning teachers working in an indigenous region of Australia showed a significant degree of discrepancy between beliefs and practice. Jorgensen and colleagues found that isolation, the remoteness of the context of teachers, and teachers' lack of confidence in teaching might have played a role in making it difficult for them to translate their beliefs into practice.

Barkatsas and Malone (2005) investigated mathematical beliefs and instructional practices of a veteran teacher. The study revealed that the teacher's practice was more traditional than her mathematical beliefs. The social and cultural contexts of teaching were found to be influencing instructional practice. The factors identified in the study included standardised tests, time constraints, curriculum materials, textbooks, other teachers, and students' attitudes toward teaching and learning. Similarly, Cross (2009) identified teacher identity, teacher efficacy, and also external factors such as school culture, curriculum mandates, resources, and class sizes as significant factors affecting teachers' practice.

Cooney (1985) also reported conflicts between a mathematics teacher's beliefs and his actual teaching practice. Cooney (1985) described the struggle and tension that existed between the teacher's conceptions of effective mathematics teaching and the influence of the classroom environment. The teacher's instructional practice was strongly influenced by the pressure to cover the content and maintain discipline.

Bolden and Newton (2008) studied three primary teachers' epistemological beliefs about teaching and learning mathematics, and barriers to investigative teaching. They report that despite the teachers' desire use an investigative approach, they did not practise it. The teachers' reported factors affecting their teaching as the volume of the curriculum to be covered, time available to cover the curriculum, teachers' accountability for student learning, and ways of assessment.

The inconsistencies between beliefs and practice may also be due to teachers lacking the necessary pedagogical skills and knowledge to translate beliefs into practice (A. G. Thompson, 1992). Research has shown that teachers find it quite difficult to implement constructivist teaching (Muijs & Reynolds, 2005).

The search for literature shows no study conducted in the Maldives regarding teachers' mathematical beliefs and practice. However a study (Mohamed, 2006) about Secondary English teachers' beliefs and practice revealed that their practice was not wholly consistent with their beliefs. According to Mohamed, teachers projected themselves as "modern teachers who believed in teaching through student-centred methods of instruction and in communicative approaches to teaching" (p. 270). Describing the observed practice, Mohamed writes:

> The teaching … was very teacher-centred, with a remarkably high amount of teacher talking time. In many classes, all that was required of the students was to sit passively and listen to the teacher, copying down whatever was written on the black board. (p. 197)

Mohamed (2006) identified the conflicts between teachers' beliefs and social or cultural norms, the large number of students in classrooms, and difficult working conditions as barriers to changing teachers' instructional practices. As these barriers are similar to factors that were identified limiting instructional practices of mathematics teachers elsewhere in the world, it is possible that such factors may be affecting practice of primary mathematics teachers in Maldives.

2.6.1 Discussion

Key factors identified in the literature that are reported to be influential on teachers' instructional practice are summarised in Figure 2.1. The arrows indicate the direction of influence. Factors that affect instructional practice are also reported to be influential on teachers' beliefs through their practice (e.g., Beswick, 2005; Kagen, 1992; Pajares, 1992; Wood & Cobb, 1991). This indicates the importance of removing factors that have negative influence on instructional practice, if teachers are to change their beliefs and practice.

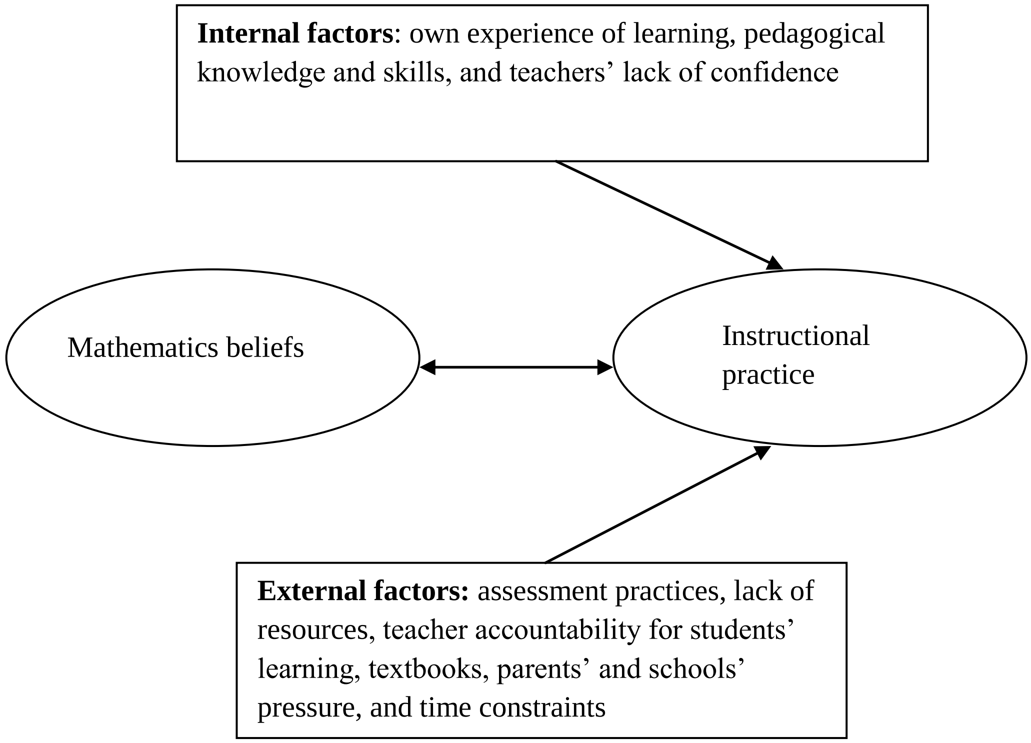


Figure 2.1 Relationship between mathematics beliefs, teaching practice, and factors affecting them

2.7 Professional development, teacher beliefs, and practice

Teachers' beliefs are generally resistant to change, and usually teacher education and professional development programmes have little effect on them (Kagan, 1992; Nespor, 1987).The information gained through teacher education and professional development programmes are filtered through teachers' beliefs and experiences forming their own unique pedagogies (Higgins & Parsons, 2009; Kagan, 1992) which may be contrastingly different from intended ones.

Powerful approaches to professional development take into consideration teachers' beliefs and encourage teachers to challenge these beliefs (Higgins & Parsons, 2009). Researchers suggest that in order to change teachers' beliefs and practice, teachers have to reflect on their current beliefs and practice (Darling-Hammond & McLaughlin, 1995). Professional development programmes that enable teachers to reflect and re-examine their beliefs and practice are shown to be successful in changing those beliefs and practice (Duran, Ballone-Duran, Haney, & Beltyukova, 2009; Rosenfeld & Rosenfeld, 2008; Swan, 2007; Swan & Swain, 2010). Swan and Swain (2010) report on a four-step procedure they used in a successful professional development programme: facilitating teachers to recognise their current beliefs and practice; facilitating teachers to confront teaching practice that contrasted to their current practice; encouraging teachers to try new practices; and facilitating teachers to reflect on their new practice.

2.8 Role of assessment in teaching

Assessment is an important part of the instructional process. A number of research studies on teachers' beliefs and their practice have identified assessment practice as an influential factor affecting teachers' instructional practice (e.g., Bolden & Newton, 2008; Ernest, 1989; Handal, 2005; Raymond, 1997).

There are two main purposes of assessment - formative and summative. Formative assessment provides teachers with information about whether students are learning what has been taught to them, informs the effectiveness of teaching, and helps to shape instructional practice (Muijs & Reynolds, 2005). Formative assessment plays a significant role in effective teaching (Miller, Linn, & Gronlund, 2009).

Summative assessment measures the extent of students' learning over a period of time, and is conducted at the end of a unit, term, year, or course (Wiliam & Black, 1996). Traditionally, the summative form of assessment is used as the only means to assess students' learning (Morgan, 2000) and is in the form of pencil and paper tests. Even today, pencil and paper tests are widely used for assessing students' mathematical understanding (Clements & Ellerton, 1996). These kinds of tests are only weakly connected to the learning experience of the students (Black & Wiliam, 2008).

In the traditional view, "learning functions like a switchboard, occurring when one person transmits the universal characteristics of reality to another" (Scheurman, 1998, p. 6). When knowledge is viewed this way, the task of assessment is to find out how much of this knowledge the students reproduce (Delandshere, 2002), the purpose of which is to rank the students rather than support their learning and enhance teaching. The assessment results are not only used to rank students and decide their future, but also to rank teachers and schools (Morgan, 2000).

When test results are used to evaluate teachers or schools, assessment is not considered as a tool to enhance teaching and learning (Heritage, 2007). Harlen (2007,) explains:

> When passing tests is high stakes (that is, the results are used for making decisions that affect the status or future of students, teachers or schools), teachers adopt a teaching style that emphasises transmission teaching of knowledge, thereby favouring those students who prefer to learn by mastering information presented sequentially. (p. 2)

A number of studies on assessment have shown that when teachers and schools are held accountable for students' test results this puts pressure on teachers to improve the results (Harlen, 2008; Padilla, 2005). Consequently, teachers focus more on tests and spend most of their instructional time on practising for tests and answering test questions rather than teaching for understanding (Harlen & Crick, 2008). Studies have shown that when teachers have pressure to improve test results they emphasise drill-based learning exercises (Smith, 1991). By focusing on tests and doing drill practice, students can pass tests even if they do not understand the concept and do not have the thinking skills the tests are intend to measure (Harlen, 2007). Boaler (2002) noted that students who learnt mathematics through textbook exercises performed well in pencil and paper tests but found it difficult to apply the knowledge in different situations or real-life contexts. Therefore "assessment leads the curriculum and the style of classroom interactions" when school and teachers have pressure on assessment results (Harlen, 2008, p. xli).

The influence of tests on teachers' practice is not always negative. Some scholars argue that measurement-driven reform is one way to promote teaching and learning. A study by Vogler (2002) shows that when tests assess high-level thinking skills, teachers change their practice accordingly. Popham (1987) and Airasian (1988) also agree that teachers teach what is measured. According to them, changing assessment practice will change teaching and learning in the classroom.

With reforms in education there is an increasing number of researchers calling for assessment to be used as a part of the teaching and learning process (Black & Wiliam, 2008), and to reduce, if not eliminate, the number of high stake tests (Harlen, 2007). According to Harlen (2007) summative assessment can be practised in ways that encourage understanding, thinking, and students' active engagement in learning. In addition to pencil and paper tests, project work, students' regular work, computer programmes, interviews, journals, portfolios, investigation, and practical work are all examples of assessment tasks that can be used to assess students' learning (Black & Wiliam, 2008; Clements & Ellerton, 1996; Harlen, 2007). Likewise, teacher observations during regular work is a major assessment tool (Brown, Campione, Webber, & McGilly, 2008; Padilla, 2005) as observations enable teachers to obtain information about the process rather than about products of learning (Black & Wiliam, 2008).

2.9 Summary

The main areas discussed in the literature review have included epistemology and mathematics education, constructivist teaching and learning, the traditional model of teaching, teacher beliefs and practices, the role of assessment in teaching, and professional development. The chapter has examined the significance of beliefs about knowledge and knowing in mathematics education. It has described constructivist approaches to teaching and learning, and identified principles, elements, and teaching strategies that lead to constructivist teaching and learning. The role of constructivist teachers and students has been highlighted in the chapter. The chapter has also described and identified the elements and characteristics of traditional models of teaching. Relevant studies regarding teachers' beliefs about mathematics, mathematics teaching, and learning have been examined to explore mathematical beliefs and practice, and the factors affecting teachers' instructional practice. Finally, the role of assessment in teaching, and the impact of teacher beliefs on professional development have been presented. The following chapter describes and justifies the research methodology used in the study.

CHAPTER THREE

Methodology

The chapter provides details of the methodology used in this study. It describes and justifies the philosophical worldview that guided the study (Section 3.1), the research design (Section 3.2), the selection of participants (Section 3.3), the data collection methods and tools (Section 3.4), and the procedures employed in analysing the data (Section 3.5). It also discusses the trustworthiness of the research procedures (Section 3.6) and ethical issues relevant to the study (Section 3.7). A summary is provided at the end of the chapter (Section 3.8).

3.1 Nature of the research

The philosophical worldview that guided this study was constructivism (Creswell, 2009). In the past decades, constructivism "has had a profound impact on research on the psychology of mathematics education" and "underpins many recent developments in teaching" (Ernest, 1998, p. 28). Constructivism holds the assumption that social reality is subjective (Creswell, 2009). It regards the world as a creation of the human mind through the experience of the world, and assumes that the social world is comprised of multiple realities (Denscombe, 2010). Individuals construct meanings of the social world as they engage in the world, and these meanings are based on historical and social perspectives (Corbin & Strauss, 2008). Constructivism acknowledges that social realities are based on culture, society, and the individual's experiences. Social realities are, therefore, "specific in nature (although elements are often shared among many individuals and even across cultures)" (Guba & Lincoln, 1994, p. 110).

This study assumed that teachers' beliefs and practice are contextually and experientially based and depend on individual teachers or groups of teachers. The study assumed that it is through interpreting that researchers understand teachers' practice and beliefs. Guba and Lincoln (1994) assert that understanding a social phenomenon mainly consists of interpreting activities of individuals and the social context of the phenomena.

The epistemological position taken in this research sees the interdependency between knower and known as subjective, and acknowledges the interaction that shapes both the researcher and participant (Krauss, 2005). The study acknowledges the position of the researcher as the primary instrument for data collection and analysis (Merriam, 1998) and, consequently, the researcher's own bias in conducting and interpreting the data (Maxwell, 2005). It also acknowledges the possibility that the participants may become aware of the research purpose and act differently from normal (Denscombe, 2010). The researcher recognised the impossibility of eliminating researcher influence while conducting the research (Maxwell, 2005; Newby, 2010). Rather than trying to eliminate this influence and participants' reactivity to the research, attempts were made to explore and understand it, and use it productively (Maxwell, 2005; Merriam, 1998).

The *strategy of inquiry* (Creswell, 2009) or *the research approach* (Newby, 2010) that suits the ontological and epistemological assumption of this study is a qualitative approach. Qualitative research is based on constructivist ontology and on the assumption that the relationship between knower and known is subjective (Glesne, 2006).

Qualitative approaches are useful when the researcher seeks to understand and explain the meaning of social phenomena within their natural settings (Maxwell, 2005; Merriam, 1998). It is the most suitable paradigm for studies that aim to "understand and interpret how the various participants in a social setting construct the world around them" (Glesne, 2006, p. 4). According to Glesne, a qualitative approach is used when a study seeks to understand social phenomena from the perspectives of participants. There are two main reasons that qualitative methodology was considered appropriate for this study. Firstly, it may not be possible to understand teachers' practice and beliefs without understanding the context in which their teaching and beliefs have been practised and shaped. This is because teachers' practice is contextual, and so are their beliefs (Green, 1971). Munby (1984) recognised the importance of understanding the social and cultural context of the classroom and the school in order to understand the teachers' beliefs and practice. Munby also believes that understanding context is important for implementation of research findings about beliefs and practice. Secondly, to understand practice and beliefs also requires the researcher to understand the teachers' personal meaning or perspectives which lie behind their practice.

3.2 Research design

There are many types of qualitative research, "an umbrella concept covering several forms of inquiry" (Merriam, 1998, p. 5). Yin (2009) states that "a case study is 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" (p. 18). Merriam writes that a case is "a thing, a single entity, a unit around which there are boundaries" (p. 27). As for other types of qualitative research, case studies are employed to gain an in-depth understanding of the phenomena under study. Case studies focus on one or a few instances of a phenomenon and provide an in-depth description of process occurring in that instance (Denscombe, 2010). What makes a case study different from other types of qualitative research is its intensive analysis of a single unit and its in-depth description of "situation and meaning for those involved" (Merriam, 1998, p. 19).

Teachers' instructional beliefs and practice are contextually bounded, and are influenced by many internal and external factors (Pajares, 1992) which cannot be easily manipulated. Case study is preferred when phenomena of interest are contemporary and the factors influencing relevant behaviours cannot be manipulated (Yin, 2009). Yin argues that case studies cover a large number of potentially relevant variables; both phenomena of interest and the situation around them.

Furthermore, beliefs may be consciously or unconsciously held (Pajares, 1992; A. G. Thompson, 1992), and are not always consistent with a person's behaviour (e.g., Jorgensen et al., 2010). This makes it important to verify the relevance of teachers' expressed beliefs, and to explore teachers' perceptions of their specific instructional practice (Bolden & Newton, 2008). Thus, the study requires "in-depth exploration" (Creswell, 2008, p. 476) of practice and beliefs of individual teachers, as well as thick description of the situation (Merriam, 1998), making a case study approach relevant and effective for this study.

Case studies can employ different designs (Merriam, 1998). "One's selection of a research design is determined by how well it allows full investigation of a particular research question" (Hancock & Algozzine, 2006, p. 31). Multiple case studies allow the reader to study the differences and similarities between cases, so providing a deeper understanding of the phenomena of interest. Yin (2009) states that "evidence from multiple cases is often considered more compelling, and the overall study is therefore regarded as being more robust" (p. 48). This study used a multiple case study approach as it suited the research purpose. The inclusion of multiple cases in the study enhances generalisability, and stability of the findings (Merriam, 1998; Miles & Huberman, 1994). In this study an individual teacher is regarded as case or a *unit of analysis* (Patton, 2002; Yin, 2009).

3.3 The participants

The researcher needs to identify sampling strategies, and explain why a particular sampling strategy is important for the study (Creswell, 2008). Therefore, this section explains the strategies used in this study to select participants, and their rationale.

Eight teachers were selected from four schools in two different islands in the Maldives (Figure 3.1). A *purposive* (Denscombe, 2010) or *purposeful* (Patton, 2002) sampling procedure was used to select participants. In purposeful sampling the researcher intentionally selects participants who can provide relevant information for the study based on the researcher's knowledge of the population (McMillan, 2008).

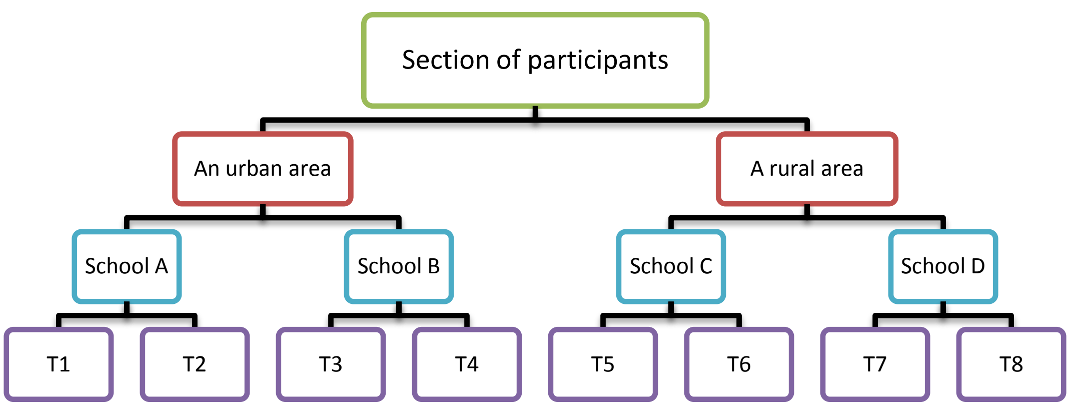


Figure 3.1 Selection of schools and participant teachers (T1, T2 …T8)

The schools were selected from two different locations in the Maldives; two schools from the capital, and two schools from a rural island. The reasons for selecting these two locations are the differences in their contexts, and that they are typical of schools in the Maldives. They are, therefore, likely to produce meaningful data helpful for answering the research questions. The capital and rural islands have economic differences and differences in their way of living. Of the country's 44,530 primary school students, 11,545 attend schools in Male' (Department of National Planning, 2010). The city schools have better facilities than island schools and, on average, the performance of their students in national exams is better than that of island schools. The schools across different rural islands are in many ways similar to each other, and there is not much difference in terms of economic conditions and the way of life among people living on the different rural islands.

The schools were selected because they were "not in any major way atypical, extreme, deviant, or intensely unusual" (Patton, 2002, p. 173). As for the selection of islands, attention was given to selecting schools that represented typical school situations in the Maldives. Apart from a few international schools in Male', which were not the focus of this study, there are no major differences among other schools in Male'. Thus, in selecting schools in Male' attention was given only to selecting schools from different locations. The other island chosen for the study had only two primary schools and both were selected for the study. Table 3.1 provides some background information of the schools selected for the study.

Table 3.1

Selected schools

Schools	Grade levels	No. of teaching sessions	No. of teachers	No. of students
School A (Urban)	Grade 1 to 8	2	170-180	1600-1900
School B (Urban)	Grade 1 to 8	2	180-190	1700-2000
School C (Rural)	Grade 1 to 7	1	70-80	700-1000
School D (Rural)	Grade 1 to 12	2	30-40	300-400

The participant teachers were locally trained Maldivian teachers teaching mathematics in upper primary classes. The selection criterion for participants was that teachers had a minimum of one year experience of teaching mathematics in the study school. Teachers with a minimum of one years experience were assumed to be more familiar with school culture and society in which they were teaching than those with less experience. Consequently, the teachers would be more aware of the factors influencing instructional practice, hence were assumed to be informative for the study.

Permission for conducting this study was sought from the Ministry of Education before approaching schools and potential participants. The researcher visited two potential study schools in Male', had meetings with the principals, provided information about the study and invited them to participate in the study. The principals in rural schools were contacted by the phone regarding the research. All the four invited schools were willing to participate.

The schools provided the names and contact details of teachers who met the criteria mentioned above. Among potential participants, the two teachers with the most experience in teaching mathematics were chosen from each school as they would understand the school culture more than less experienced teachers. In each school, a meeting was arranged with the potential participants, and the researcher provided information about the study. Teachers from the rural schools were contacted by phone and information about the research was given before visiting the island. The purpose was to check if the schools and participants were willing to participate before visiting the island, and therefore, to reduce time and cost of data collection. All of the eight invited participants (Table 3.2) showed interest in participating, and took part in the study.

Table 3.2

Background information of participant teachers

Pseudonyms	Gender	Age	Mathematics qualification	Teaching Qualification	No. of years teaching	Grade level observed
Aisha (School A)	female	20-30 years	Secondary school mathematics	Diploma of teaching (primary)	5-10 years	Grade 5
Aini (School A)	female	20-30 years	Secondary school mathematics	Diploma of teaching (middle school)	5-10 years	Grade 6
Beena (School B)	female	30-40 years	Secondary school mathematics	Diploma of teaching (primary)	15-20 years	Grade 5

Binesh (School B)	female	20-30 years	Secondary school mathematics	Diploma of teaching (middle school)	5-10 years	Grade 6
Cala (School C)	female	20-30 years	Secondary school mathematics	Diploma of teaching (primary)	1-5 years	Grade5
Chanda (School C)	female	20-30 years	Secondary school mathematics	Advanced certificate in teaching (primary)	1-5 years	Grade 4
Dean (School D)	male	30-40 years	Secondary school mathematics	Advanced certificate in teaching (primary)	5-10 years	Grade 6
Dhakir (School D)	male	30-40 years	Secondary school mathematics	Advanced certificate in teaching (primary)	10-15 years	Grade 6

Note: The Diploma of Teaching (a two year course) is a higher qualification than the Advanced Certificate in teaching (a one year course).

Care has been taken not to reveal participants' identities. For identification purposes within the thesis alphabetical letters were assigned to each school, and the two teachers from each school given pseudonyms that started with the letter assigned to their school.

3.4 Data collection

There is no fixed method for data collection in case studies (Cohen, Manion, & Morrison, 2000). "Understanding the case in its totality" requires multiple qualitative methods of data collection (Merriam, 1998). In this study, data were collected using a questionnaire, semi-structured interviews, observations, and analysis of teachers' lesson plans and test papers. Questionnaires, interviews, observation, and document analysis are four tools often used in social research to collect data, and one of the strengths of the case study is that it allows the researcher to use a variety of these methods (Denscombe, 2010).

For each individual case, the questionnaire was collected and observations were completed before conducting the interview. Documents were collected after individuals completed the interview (see Figure 3.2). The following sections describe the development of data gathering tools and process of data collection.

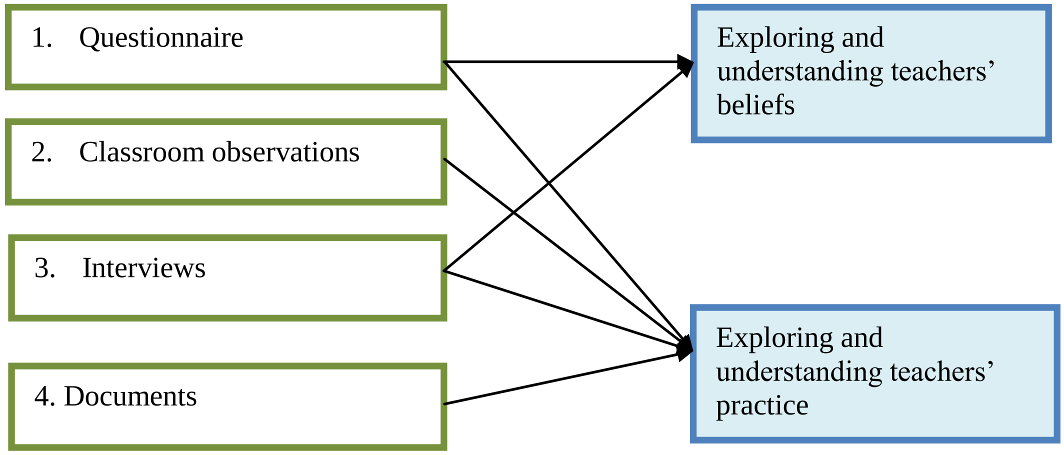


Figure 3.2 Data collection methods, their purpose, and the order in which they are used for each participant.

3.4.1 Questionnaire

Many scholars do not include a questionnaire as a common method for data collection in qualitative case study (e.g., Hancock & Algozzine, 2006; Merriam, 1998). However, according to Denscombe (2010) and McMillan (2008) self-report questionnaires can be used to explore people's attitudes, beliefs, and views. A person may not be conscious about a particular belief (Pajares, 1992), thus answering questions regarding beliefs may need time for thought and reflection. Questionnaires give respondents time without the presence of the researcher for such reflection.

The questionnaire in this study used both "open" and "closed" questions (see Appendix A). Open-ended questions give the respondent flexibility of choosing wording and length of the answer; in contrast, closed questions only allow respondents to choose from categories pre-established by the researcher (Denscombe, 2010). They both have strengths and weaknesses, and the strengths of one may compensate for the weakness of the other. Denscombe writes that open-ended questions allow respondents "to reflect the full richness and complexity of the views" whereas closed questions can easily be quantified and compared (p. 166). Closed questions were included in the questionnaire so that teachers' beliefs and practice could be easily categorised and compared. In contrast, open-ended questions could provide a richer picture of individual teachers' beliefs and practice.

Several steps were taken in order to produce a good questionnaire that would provide meaningful data to answer the research questions. The clarity and suitability of the questions were discussed with the supervisors, two fellow master students, a PhD student, and a colleague – a lecturer at the Maldives National University. Questions were modified based on these discussions. For example, questions were categorised and written under headings; *nature of mathematics, mathematics learning, mathematics teaching, and mathematics assessment and evaluation*. The questionnaire was also trialled with three teachers in the Maldives. Based on these teachers' feedback, the wordings of some of the questions were modified.

A copy of the questionnaire was given to teachers after the first individual meetings with participants. The questionnaire would take thirty to forty minutes to answer. However, teachers were given a minimum of a week to complete the questionnaire. This provided teachers with sufficient time and space to think and reflect on their experience.

3.4.2 Observation, field notes, and audio recordings

Observation is a major source of information in case study research (Hancock, Algozzine, 2006). Patton (2002) writes "there are limitations to how much can be learned from what people say" (p. 21). He argues that to understand the complexity of most phenomena, observation may be the best approach. In doing observations, researchers do not base their evidence only on what people say they do, but also on what people actually do (Denscombe, 2010). Observation allows the researcher to investigate the phenomenon of interest in its natural setting (Merriam, 1998). It gives the researcher knowledge of the context or the situation in which the behaviour occurs.

A *Running Record* (Good & Brophy, 2003) was used as a method of recording what was being observed. Patton (2002) contends that the purpose of observational analysis is "to take the reader into the setting that was observed", thus data must be "sufficiently descriptive" (p. 23). A running record describes a situation in detail, so that anyone who reads the description can visualise the phenomenon as it occurred (Good & Brophy, 2003).

Lessons were audio-recorded to capture the dialogue between teacher and students as hand written notes alone may result in loss of some important information. Audio-recording was preferred over video because its less intrusive nature is less likely to affect teacher and student behaviour during the lessons.

Efforts were made to observe teachers in their normal practice of teaching. The selection of the period for data collection, and choice of lessons for observations were carefully considered "to avoid any bias and to incorporate a representative sample of the things in question" (Denscombe, 2010, p. 211). The second half of the first semester was chosen for data collection so that teachers' established practice could be observed. The school year started in January, and the data collection period was from April 2 to May 7th.

The researcher consulted with individual teachers about observation lessons selection, and participant teachers chose the lessons in which they wanted to be observed. Initially the lessons to be observed were to be decided by the researcher, and if the teachers were willing they would not be given prior notice of the observation: this was intended to reduce the likelihood of any "special" preparation for lessons that were to be observed, therefore increasing the chance of observing their normal practice. However, this plan was changed after trial observations and informal talks with some teachers (not involved in the study). It was decided that the researcher appearing for an observation without informing the teacher would be more intrusive. Also, during the period of data collection, the study schools had student-teachers on practicum who were taking some of the lessons of participant teachers, making observations without notice more difficult. Finally, teacher observation is not commonly used for research in the Maldives. Teachers are normally observed by school leaders for evaluation purposes, and the results of these observations normally have consequences for the teacher. Thus, it was very important for the researcher to build a positive relationship with participant teachers and convince them that the observation was not to judge the effectiveness of their teaching. Teachers' own selection of the lessons for the observations was used to increase teacher confidence and positively affect teacher-researcher relationships, therefore minimising the possibility of teachers practising differently from their normal teaching.

In order to practise using the observation schedule (see Appendix B) and to check its usefulness, two trial observations of mathematics lessons were conducted in Maldives classrooms. Although no significant changes were made to the observation schedule, the trialling process helped to identify issues such as how to describe teacher and student actions and what aspect of the classroom environment needed to be focused on when making field notes.

Each teacher was observed three times on different days when they were teaching mathematics in their classroom (same class each time). Field notes were taken in all three lessons, and lessons were audio-recorded. During observations, the researcher was positioned at the rear of the classroom. During the observations, specific attention was paid to aspects of teaching that indicated a constructivist or transmission style of teaching (see Appendix B). For example, does the teacher acknowledge students' responses sufficiently and make use of their prior knowledge? Immediately after each observation, as suggested by Merriam (1998), the researcher listened to the recordings of the observation, and added additional notes including the researcher's own reflection of the observations.

3.4. 3 Semi-structured interviews

The meaning people have about the world is not observable; it is interviewing that allows us to understand other peoples' perspective (Patton, 2002). Patton states the purpose of interviewing is "to find out what is in and on someone else's mind" (p. 341). The purpose of interviewing in this study was to explore teachers' perspectives about mathematics, mathematics teaching, and learning.

There are variations within qualitative interviewing. In semi-structured interviews, a structured interview guide is used to get the information needed to answer the research questions, and has a predetermined list of issues and questions to be covered (Newby, 2010). Hancock and Algozzine (2006) argue that this type of interview is "well-suited" to case study research.

In semi-structured interviews, the researcher has flexibility to change the wording and the order of questions (Denscombe, 2010). Researchers have the freedom to ask follow-up questions and use probes to explore the viewpoints of the participants (Newby, 2010). Semi-structured interviews allow participants to "express themselves openly and freely and to define the world from their own perspectives, not solely from the perspective of the researcher" (Hancock and Algozzine, 2006, p. 40). It is for these reasons that semi-structured, face-to-face interviews were used as a data collection tool in this study (see Appendix C).

In this study, teachers were interviewed after their questionnaire and lesson observations were completed, allowing the researcher to clarify what was unclear from the teachers' written accounts, and observed practice. A guide using analysis of the written responses of participants to the questionnaire was prepared before conducting each interview. The written responses of each participant were read and the areas that needed clarification or elaboration were highlighted. Similarly, to identify key issues that needed to be discussed about the observed lessons, the researcher listened to the audio-recording and read the written notes made during the classroom observations. Additional notes were made about specific actions observed and the decisions teachers made during the lessons. In the interviews, teachers were asked about these activities and pedagogical decisions.

Each teacher was interviewed within a day or two of his/her last observation. Teachers decided the location and time for the interviews. The venues for the interviews were the schools where participant teachers were employed. Before starting the interviews the researcher reminded the participants about the research purpose, the confidentiality of their comments made during the interview, and reconfirmed the participants' permission to record the interviews.

The interview structure had two main sections. The first part of each interview was to explore and clarify more about teachers' written accounts from the beliefs questionnaire. The combination of written accounts and semi-structured interviews maximises the depth of the examination of the particular phenomenon under study (King & Horrocks, 2010). The second part of the interview explored teachers' thoughts, view points of the instructional strategies, pedagogical decisions made, and specific actions observed during lesson observations. Seidman (1998) argues that it is never possible to understand another person's behaviour without knowing what meaning the person himself makes out of that behaviour. The purpose of the second section of the interview was to understand teachers' interpretation of their action and decisions made during observed lessons.

The quality of data obtained from an interview mainly depends on the interviewer (Patton, 2002). It is well written questions that provide good data (Merriam, 1998). The interview schedule was trialled with some teachers to improve questions and to get practice in interviewing. Two sections of the interview were trialled separately as two different interviews. The first part of the interview was trialled with two teachers in the Maldives after their completion of a trial questionnaire. The second part was also trialled with two teachers in the Maldives after a trial observation of each teacher. The trialling helped further refine and order the interview questions, and provided a sense of direction for the interview.

3.4.4 Documents

Documents and written materials provide rich information and evidence in qualitative studies (Patton, 2002), but should not be a substitute for other types of data (Silverman, 2010). In this study, teachers' lesson plans for observed lessons, samples of students' work during these lessons, and selected test papers were collected to help understand the teachers' instructional practices.

3.5 Data analysis

Data analysis is the process of interpreting data (Creswell, 2009) and is guided by the purpose of the study (Patton, 2002). Understanding mathematical beliefs and practice of participant teachers is the main purpose of data analysis in this study. This involves understanding the beliefs and practice of individual teachers, and understanding similarities and differences among these teachers. Thus, as Merriam (1998) suggests, this multiple case study has two stages of analysis; the within-case analysis and the cross-case analysis.

First, each individual teacher's beliefs and practice were analysed as a separate case. Patton (2002) writes "first and foremost responsibility [of a researcher conducting a multiple case study] consists of doing justice to each individual case" (p.448). Patton argues the credibility of overall findings depends on the quality of individual cases. In this study, cross-case analysis started after individual teacher's beliefs and practice were analysed. Both of these stages of analysis involved identifying themes, constructing categories, and interpreting them.

The first step in data analysis is to explore the data to get a general sense of it (Creswell, 2008). Many qualitative researchers agree that analysis needs to begin during data collection and become more intensive after (e.g. Hancock & Algozzine, 2006; Merriam, 1998; Patton, 2002). Qualitative analysis is a recursive process (Creswell, 2008; Merriam, 1998), and needs an ongoing examination of data throughout the collection period (Hancock & Algozzine, 2006). Such initial analysis guides the researcher to information which is potentially meaningful to the study (Hancock & Algozzine, 2006; Newby, 2010).

Once data collection was completed, data were prepared for analysis (Denscombe, 2010; Newby, 2010). Electronic files of audio-recorded interviews, field notes of observations, copies of lesson plans, and copies of test papers were duplicated. Each duplicated set of data was then labelled with indices for reference purposes and arranged systematically. Each piece of data was given a reference code or an index which indicated basic information needed to identify the piece. Denscombe argues that coding data pieces with indices makes it easier for the researcher to locate and navigate between pieces; furthermore, it helps to retain the confidentiality of data.

Next, the researcher transcribed selected parts of the interviews and audio-recordings of the observed lessons. It is often not necessary to analyse all the data collected (Newby, 2010). Although early elimination of potential data may undermine the researcher's ability to gain a complete understanding of the case, "focusing on irrelevant information is equally counterproductive" (Hancock & Algozzine, 2006, p. 57). It is important to select out data as researchers have limited resources and time (Newby, 2010). However, Newby emphasises the importance of engaging and familiarising oneself with the data before selecting sections to analyse.

In order to gain a good understanding of data before selecting them for transcription, all the audio-recordings were listened to multiple times. Field notes of observations and interviews were also read and re-read. Having become thoroughly familiar with the data the researcher was able to select and transcribe sections of the interviews and teacher and student talks from the observed lessons which were meaningful to the research questions. Familiarity with data is also important for coding. According to Denscombe

(2010), the researcher will be in a position to identify appropriate codes only if he has a sound grasp of the data.

Transcripts, questionnaires, documents, and field notes from the observations were then coded to identify themes using the following steps informed by Denscombe (2010) and King and Horrocks (2010):

1) Coding the data: reading through transcripts to find relevant materials, attaching comments, defining descriptive codes, and refining them.
2) Categorising the codes: identifying ways in which codes can be grouped.
3) Identifying themes and categories: identifying key themes for data set.
4) Developing general statements or conclusions.

The guideline used in the coding process of this study was informed by Creswell (2008). All the texts related to each case were read several times and text was divided into segments. These segments were then labelled with codes which described the segments. Once the whole text related to a case was coded, a list of codes were written, and examined for similarities among codes. Similar codes were then grouped and interpreted into themes. The process was iterative, moving back and forth, and was repeated several times in order to refine and check for the accuracy of the codes and themes.

The emerging themes for individual teachers were compared with elements of traditional and constructivist views drawn from literature (see Chapter 2, Tables 2.1, 2.2, and 2.3) for categorisation of individual teachers' beliefs about the nature of mathematics, mathematics learning, and mathematics teaching respectively.

The next step was to conduct analysis across cases to investigate the differences and commonalities between the cases. The code lists constructed during within-case analysis were compared for their similarities and differences. Categories of codes and their themes, along with evidence, were then put in matrices to facilitate cross-case analysis. Main themes were identified as suggested by Creswell (2008) by examining codes that occurred most frequently across cases, were unique, and had most evidence to support them.

3.6 Trustworthiness of findings

Qualitative methodologists (e.g., Lincoln & Guba, 1985; Merriam, 1998; Silverman, 2010) argue that conceptualisation of validity and reliability and sets of criteria judging them should be different from quantitative research as qualitative research aims at understanding people's perceptions of reality, whatever they may be, and the world as it appears to them (Merriam, 1998). It is not to confirm if these perceptions are a true reflection of a situation (Corbin & Strauss, 2008). Lincoln and Guba (1985) proposed criteria of "trustworthiness" to measure the issue of validity and reliability in qualitative inquiry. Criteria of trustworthiness in a qualitative study is a way of evaluating the study's findings that are "worth paying attention to", and addresses issues regarding credibility, transferability, dependability, and confirmability of the study (Lincoln & Guba, 1985). The subsequent sections explain how these issues were addressed in this study.

3.6.1 Credibility

Credibility refers to the extent to which the researcher can demonstrate the study's findings are *reasonably likely* to be true (Denscombe, 2010). It is not possible for a qualitative researcher to prove to the readers that the study's findings are true (Lincoln & Guba, 1985). Thus, the aim of qualitative researchers is to show that the "data have been produced and checked in accord with good practice" (Denscombe, 2010, p. 297).

According to Hancock and Algozzine (2006), the most powerful strategy to address the credibility of the research is to share the data and findings with the participants. What was observed during lesson observations was shared with the teachers during the interview. Teachers' perspectives and reasons behind their actions and pedagogical decisions made during the observed lessons were explored in the interviews. During interviews the researcher's understanding of participants' response to the belief questionnaire was confirmed through communicating his understanding of their accounts, and seeking further clarification and elaboration of important points. At the end of the interview, the researcher summarised the important points to check for accuracy of the researcher's understanding of the points made during the interview.

The use of triangulation is another strategy used to gain credible qualitative data (Maxwell, 2005; McMillan, 2008). Maxwell writes that triangulation is a process of "collecting information from a diverse range of individuals and settings, using a variety of methods" (p. 93). In this study, data were collected from different sources using multiple methods to help view the context from a range of perspectives (see Figure 3.2). Written responses to open-ended questionnaires and semi-structured interviews were used to explore teachers' beliefs. In addition to these two methods, observation of lessons, copies of teachers' lesson plans, and test papers were used to gain a deeper understanding of the practice, and to ensure participants' perceptions were interpreted accurately. "Interviews, questionnaires, and documents are all vulnerable to self-report bias" (Maxwell, 2005, p. 174), and to prevent self-report bias, observations were included. According to Hancock and Algozzine (2006), findings based on data from interviews, questionnaires, observations and documents are more likely to be true than findings based on data from one or two of these methods. Furthermore, data was collected from eight teachers in four schools in two different regions of the country. Findings based on information from different settings and sources are more credible than those based one or two sources (Denscombe, 2010; Hancock & Algozzine, 2006).

In qualitative research, researcher bias is a threat to the credibility of the research (Hancock & Algozzine, 2006; Patton, 2002). It is impossible to eliminate researcher bias, as it is impossible to fully eliminate a researcher's own theories, perceptions, and values (Maxwell, 2005). However, acknowledging researcher bias and explaining how to deal with those biases enhances the credibility of a study (Hancock & Algozzine, 2006; Maxwell, 2005). This includes a report of assumptions the researcher made during the research process (Newton, 2009). Newton observes that reflecting on researchers' assumptions during the research enables the researcher to understand the implications of those assumptions in relation to the research findings, thus, enhancing the credibility of the findings. Patton (2002) insists the researcher "report any personal and professional information" that may have influenced the findings of the study. In this study, researcher bias was recognised, and a brief account of the researcher's position and background information (Chapter One), and assumptions the researcher made (Chapter Three) were provided.

In qualitative research, it is also important for the research procedures and the report to be reviewed by a third party who is familiar with the goals and aims of the study

(Hancock & Algozzine, (2006). The procedures and findings have been discussed with supervisors, who thoroughly critiqued the procedures and findings. As Hancock and Algozzine (2006) point out, this review enables the researcher to "identify discrepancies that may threaten the credibility of the research" (p. 66).

3.6.2 Transferability

External validity is "used in a limited way in qualitative research" (Creswell, 2009). In recent years qualitative researchers have tried to redefine the concept in a different way that is useful to qualitative research (Schofield, 2002). According to Merriam (1998), external validity in qualitative research refers to the degree to which the study is generalisable or transferable to other settings. Lincoln and Guba (1985) proposed the term transferability as an analogue to external validity. Transferability is the same as Maxwell's term *internal generalizability* and refers to the generalisability of findings within the setting or group studied. According to Schofield, this "generalizablity [transferability] is best thought of as a matter of the 'fit' between the situation studied and others" in which the finding is to be applied (p. 198). A qualitative researcher can enhance transferability by providing enough information so those who wish to transfer the findings will be able to make a judgement about the extent the findings could be transferrable. In this study, measures were taken to enhance transferability. A detailed description of the research context, procedures, analysis, and assumptions central to the research will be provided so that those who are interested in applying the findings will have adequate information to do so (Merriam, 1998).

3.6.3 Dependability

In qualitative research dependability (Lincoln & Guba, 1986) is commonly used as an analogue to reliability, because, in qualitative research, reliability refers to the extent to which researchers' findings are dependable (Merriam, 1998). According to Denscombe (2010), this is done by providing a clear explanation of procedures and the decisions made during the research process. By providing the readers with a detailed description of the process of inquiry, the research process is open for audit (Creswell & Miller, 2000). As suggested by Creswell and Miller, in this study, an audit trail was established by providing detailed documentation of the researcher's position and the research procedures and activities. Thus, readers or other researchers can confirm the findings by evaluating the research process and decisions, and can make judgements (Creswell & Miller, 2000; Denscombe, 2010).

3.6.4 Confirmability

Confirmability refers to the extent to which qualitative research can produce findings that are free from the influence of the person who conducted the research (Denscombe, 2010). A number of the strategies suggested by Denscombe were utilised in this research project. Firstly, the researcher's background information was provided to enable readers to identify his personal experience and values that could influence the findings of the study. Secondly, once preliminary themes were established, the data was analysed for evidence that confirms and challenges these themes. As Patton (2002) explains, our understanding of patterns found in data analysis is "increased by considering the instances and cases that do not fit within the pattern" (p. 554). Finally, categories and themes were examined and re-examined for rival explanations in order to avoid the "temptation to jump to easy conclusions just because there is some evidence that seems to lead in an interesting direction" (Silverman & Marvasti, 2008, p. 261).

3.7 Ethical considerations

The study conformed to the Victoria University of Wellington Human Research Ethics Regulations and New Zealand Association for Research in Education ethical guidelines (NZARE, 2010). Ethical approval was obtained from Victoria University's Faculty of Education Ethics Committee.

In the Maldives, there are no specific ethical guidelines to follow. However, the research was conducted with care and respect for research participants and their community as outlined in NZARE ethical guidelines, "this is particularly important in research that seeks to question participants' educational beliefs and practice" (NZARE, 2010, p. 5).

In all research involving people it is important to obtain informed consent by providing all interested parties with clear information about what the research involves and to gain approval for participation in the research from those people. At the outset of this study, the Ministry of Education of the Maldives was informed about the research process, and written permission to conduct the research was obtained. Permission and consent were obtained from principals of the study schools. The participant teachers, students, and their parents were fully informed about the research including the voluntary nature of it, and written consent was obtained before data collection began (see samples in Appendix D).

The research purpose and process was explained to students in writing and by participant teachers, and all the students gave their consent. Consent forms and information sheets for parents were sent home and returned by students. All the parents, except five (in two classes) whose forms were not returned, gave their consent. Information about the five students for whom consent was not received was not taken during the observations. These students were seated far from the recording device so that their voices could not be clearly recorded. Furthermore, the timing of their responses was noted and their voices were not included in the transcription of classroom observations.

Consideration was given to protect research participants from any harmful effect due to their participation in the research. The identity of participants was protected at all the stages, and any information about the participants acquired during the research process was kept confidential to ensure that their professional integrity was not compromised by anything they contributed to the study. Only the researcher and the supervisors had access to the research data. In the researcher report, the names of the students were not used, and pseudonyms were used for the schools and participant teachers. Any biographical information that may lead to identification of the participants was not provided in the study report.

3.8 Summary

Chapter Three has outlined philosophical and methodological underpinnings of the study. The research design, the study participants, the data collection methods, and the procedures employed in analysing the data are discussed in detail in the chapter. The chapter also discusses issues related to trustworthiness of findings and ethical issues relevant to the study. Chapter Four presents findings and descriptions of individual cases.

CHAPTER FOUR

Findings and descriptions of individual cases

This chapter describes the findings from the within-case analysis. As Stake (2006) states, the description of individual cases gives an in-depth understanding of the phenomena being studied, and at the same time provides contextual and “situational uniqueness” of each case (p. 6). The descriptions of cases in this study were developed by combining the information from questionnaires, interviews, classroom observations, lesson notes, test papers, and samples of student work during observed sessions. The information for each case was analysed independently to identify key themes regarding beliefs and practice of individual teachers in their contexts.

Each case is described under the headings: (i) beliefs about the nature of mathematics, (ii) mathematics learning, (iii) mathematics teaching, and (iv) factors affecting instructional practices (Figure 5.1).

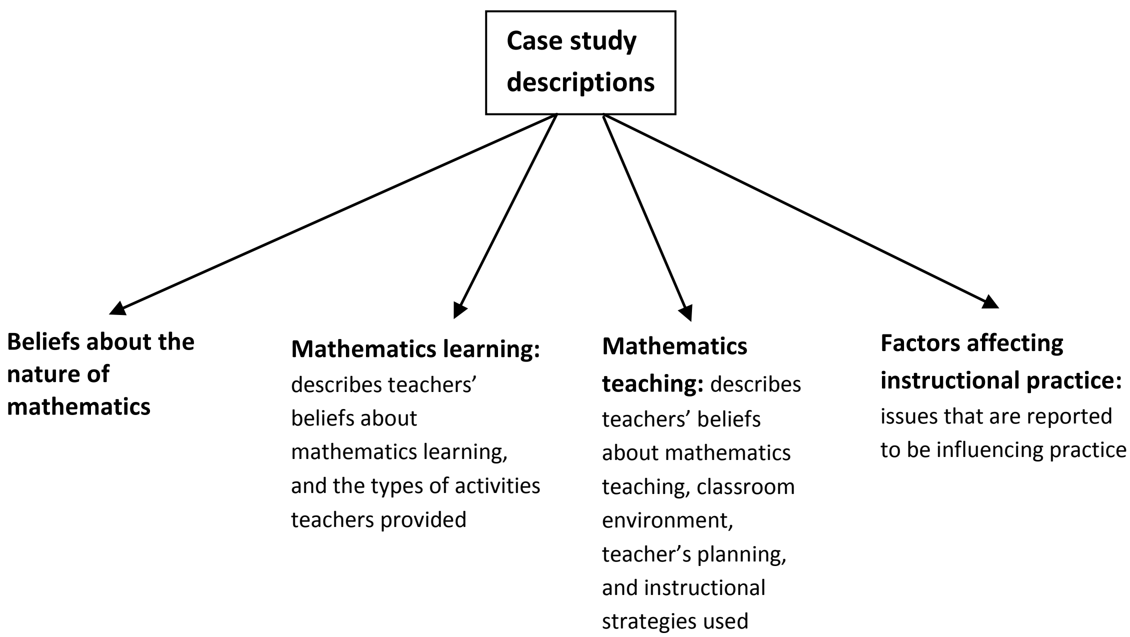


Figure 4.1 The structure of case study descriptions

Note: In all four participant schools, teachers had weekly “coordination meetings” and were expected to cover the topics, contents, etc. as decided in these meetings (see Section 1.2.2). Therefore, in this chapter, discussions and of teachers’ planning refers only to how teachers developed their personal plans.

4.1 Aisha

4.1.1 Beliefs about the nature of mathematics

Aisha's beliefs about mathematics were a blend of traditional and constructivist. She believed mathematics was more than the use of theories, symbols, and rules; it was also about finding relationships and simplifying complicated problems:

> Mathematics is not only about calculations, it is more than that. Those who are good at mathematics study the situation [problem] and then relate that to less complex and similar situations they are familiar with.

Aisha believed mathematics was useful, and described it as a "practical subject" that was related to everything people do in their life. According to her, those who were good at mathematics were also good at logical thinking.

4.1.2 Mathematics learning

Aisha's beliefs about mathematics learning were mainly constructivist. Aisha considered that working in small groups to do mathematical activities was an effective way of learning mathematics:

> I don't think that students can understand everything just by listening to a teacher's explanation and doing workbook sums . . . I include lots of group work in my lessons.

She further explained:

> There are weak students and bright students. When they work in small groups the students can help each other. Those who understand can explain to others . . . by explaining in their own language and listening to each other they understand better.

According to Aisha, students "learn quickly and easily if they actively participate". She also believed that using manipulative materials in learning activities facilitates students' understanding:

> When I plan lessons I think about possible materials I can use, I always use available materials. When students use relevant materials, it makes understanding easier.

Aisha also had beliefs that indicated traditional elements. She thought repeated practice and the use of textbook and workbook activities were essential in mathematics learning, but, in her opinion, the extent to which the textbook and workbook were followed in teaching mathematics in her school was counterproductive. According to her there is no "benefit of doing forty or thirty sums of the same type".

The learning opportunities Aisha provided for her students were mostly consistent with her beliefs, but were less constructivist compared to her beliefs about learning mathematics. In each of the three observed lessons students were given an activity to complete in small groups which took about 6-8 minutes to complete. Students also used manipulative materials during group work. In one lesson, students worked in small groups to form different types of angles (e.g. acute, obtuse) by gluing toothpicks onto a sheet of paper. In another lesson, students worked together forming an outline of shapes given by using rubber bands and a geoboard. A clear explanation of the step-by-step procedures of how to do the tasks was given prior to each task.

During the group work students engaged in some discussion. However, none of the tasks given seemed challenging or required much thinking and reasoning. After group work, in all the observed lessons, students spent a roughly equal amount of time doing individual exercises from the workbook (see Figure 4.1), and any unfinished work was assigned as homework.

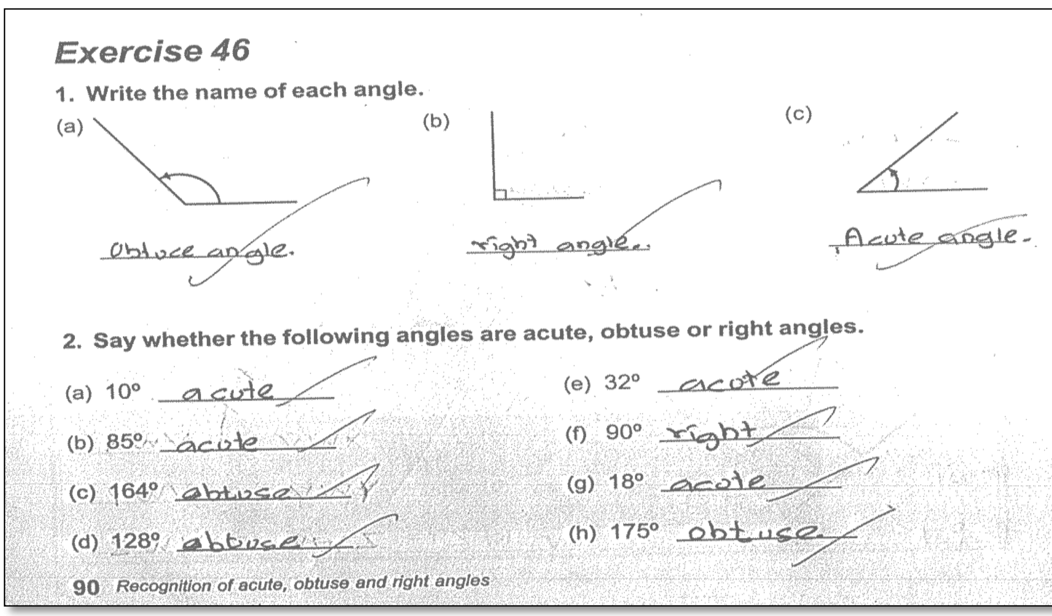


Figure 4.2 A part of an activity Aisha assigned for students from the workbook (Naseer, Adam, 2007, p. 90)

4.1.3 Mathematics teaching

Aisha's beliefs about mathematics teaching showed a mix of traditional and constructivist elements. Her responses indicated that she believed the teacher was a guide as well as the one who transmits knowledge. In her opinion teaching is more effective when teachers include small group activities, provide students with problem solving situations, and give students manipulative materials to use themselves. She strongly believed in the importance of making connections between the content students learned and their real-life experiences:

> Before my explanation I always ask students' opinions on the topic and what they know about it. I include real-life situations so that they can link what they learnt to real life.

Aisha also thought it was essential for teachers to give a thorough explanation of mathematical rules and procedures before assigning a mathematical problem. She believed that it was necessary to involve students in such explanations. She said, "If I explain everything to them without involving them . . . they will not understand much". She also held a belief that students should be given individual work to practise. According to Aisha, she "includes lots of group works and individual works".

Although, Aisha's beliefs were reflected in her instructional practice, the practice was less constructivist than her beliefs about teaching mathematics.

Classroom environment: There were 30 students in Aisha's class, seated in groups of about six facing a whiteboard. The students worked mostly at their desks. Aisha maintained a disciplined atmosphere throughout her lessons. Students raised their hands before they spoke or asked questions.

Planning: Aisha planned her lessons based on the textbook and students' workbook. In her lesson plans she marked the workbook and textbook pages she would cover during the lessons. For example, in one of three successive daily lesson plans, she wrote under the heading *materials* [to be covered]: workbook pages 86, and 87; second lesson plan – workbook pages 88, 89 and 90; fourth lesson plan - workbook page 91, 92, and 93. Teacher explanations and student activities were all based on the exercises in these pages.

Instructional Strategies: In the observed lessons, Aisha gave brief introductions to her lessons before explaining the content. Sometimes, she asked questions to find out what students already knew about the topic. Other times she started the lessons by revisiting the previous day's lessons; for example:

Aisha: What did we learn in the previous period?
Eman: Shapes.
Aisha: What were the shapes we learned?
Students: (students named different shapes they learned).
Aisha: Now tell me the properties of an equilateral triangle?
Ali: Three sides are equal and angles are equal.

After asking about the properties of a few shapes, she explained to the students that they were going to learn different “types of angles”.

Aisha took more than half of her class time explaining concepts involving whole class discussions. For instance, in the episode discussed above, she moved on to explain the types of angles. She demonstrated different types of angles by bending her arms through the elbow, and students imitated her. The angles were then drawn on the board, and properties explained. In another lesson which was about solving “word problems” using basic arithmetic operations, she explained the meaning of a group of words (share, equally, quotient, and average) that appear in word problems and told students what arithmetic operation to use to solve problems that have these words. Aisha asked her students questions to check their understanding of her explanation. For example, during her explanation of solving word problems:

Aisha: (reads a word problem from students’ workbook).
Ahmed: Divide.
Aisha: Tell me why do we divide in this case?
Ahmed: Because of the word equally.
Aisha: Yes, when we want to know how much each person gets, we divide.

Following the explanation, in all observed lessons, she set students a group activity, and then individual exercises to complete. Aisha concluded the lessons by giving a brief summary of important points and asking questions of students. Sometimes students were invited to demonstrate their work.

4.1.4 Factors affecting Aisha’s instructional practice

Aisha’s instructional practice showed some degree of consistency with her beliefs. Although her instructional practice indicated some characteristics of constructivist teaching, the observed practice was more traditional than her beliefs about teaching and learning.

Aisha thought there were some factors that limited her from practising the way she wanted; for example, large workbook exercises, workbook- and textbook-based exams, and time constraints. She said that she assigned the exercises from the workbook, not because she thought all of them were important, but because she was supposed to use them and received complaints from parents if all the exercises were not completed. Aisha thought this was because the tests were exclusively based on the textbook and workbook:

> The assessment is very much based on the textbook and workbook. So how can a teacher give different types of work? If, for example, a teacher gave different types of activities and gave only a few book exercises then what would happen to students? They will not be able to score good marks. The teacher will be blamed for it at the end.

4.2 Aini

4.2.1 Beliefs about the nature of mathematics

Aini had constructivist beliefs about nature of mathematics. According to her, "mathematics is a study about problem solving". She believed that mathematics was all about finding solutions which involve thinking, reasoning, and simplifying real-life situations. She viewed logical thinking, and reasoning as fundamental aspects of mathematics. Aini also thought that mathematicians apply "real-life logic" to come up with theories that can be applied to solve mathematical problems.

4.2.2 Mathematics learning

Aini's responses during the interview and her remarks on the questionnaire indicated that she believed learning was effective when students think critically and engage in activities on their own. She thought that students needed to "discuss and interact with each other". She believed that "they learn well from each other's explanations rather than from teachers' explanations".

Aini believed that students should take responsibility for their own learning. She also believed that students learned well when they actively engage in learning activities and relate mathematical knowledge to their experience:

> Students learn through practical works, through interactive discussions. They learn well from each others' explanations than from teachers' explanations . . . sometimes they need to debate about how to solve difficult problems.

She also believed that it was necessary for students to engage in repetitive practice for mastery of skills, though she did not agree that it was necessary for students to use textbooks and worksheets to practise mathematical skills. Neither did she believe that it is vital for students to work alone in silence most of their class time.

Aini's primarily constructivist learning beliefs were not reflected in the learning activities she set her students. All the tasks she provided for her students were individual, and from the textbook and workbook. Although, she gave opportunities for a few students to come to the front of the class and demonstrate some of their answers on the board, other students remained at their desks observing and working on their own.

4.2.3 Mathematics teaching

Aini stated "group work, collaborative learning, practical sessions, discussions, and presentations" were effective methods of teaching. She regarded effective teachers as facilitators, and thought teachers were responsible for providing learning opportunities for students to construct understanding. She believed that in teaching mathematics it was important to make use of a variety of learning aides such as PowerPoint and manipulative materials. In her view, students would understand clearly and retain concepts better when they used such materials and were active in learning. However, she believed more time would be needed if students were given materials to manipulate, explore, and investigate mathematical ideas themselves than using a teacher explanation of the content, procedure, and algorithmic rules in a traditional way followed by drill exercises.

Unlike her primarily constructivist belief about mathematics teaching, Aini's observed practice was mainly traditional. Even though she believed that collaborative learning, group work, and students' active engagement in exploring mathematical ideas were effective teaching strategies, she didn't use any of these approaches in her teaching. This inconsistency may be explained by her belief that such methods were more time consuming. According to her, if she included more student-centred activities she would not be able to cover the materials for the term.

Classroom environment: There were 31 students in Aini's class, seated in rows of single desks facing a large white-board attached to the classroom wall. The room seemed small for a class of this size with not enough room for the teacher and students to walk between rows. Throughout the lessons, students worked alone at their desks.

Planning: Aini planned her mathematics lessons one week at a time. For each lesson she wrote objectives for the lesson, the procedure for how she would conduct the lesson, as well as the workbook exercises the students would do in the class. The workbook and textbook pages that would be covered were highlighted in her lesson plans.

Instructional Strategies: Aini's instructional practice followed the same pattern in all her observed lessons - teacher explanation, students' individual exercises, and teacher-centred whole class discussions. During her explanation and discussions, Aini often asked questions to check students' understanding of procedures and facts. However, the questions did not appear to stimulate students' thinking. In the following episode, Aini explained to the class how to simplify algebraic expressions:

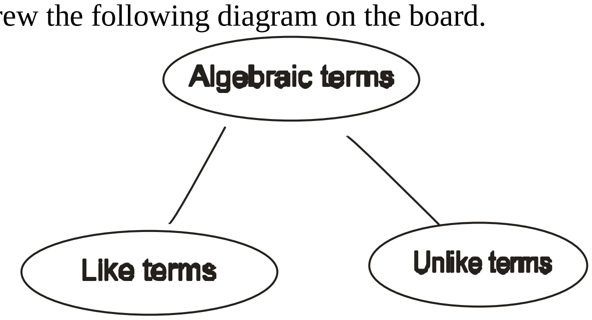
Aini: In the previous lesson I explained to you what algebraic terms are; what like terms and unlike terms are. Ali, can you tell me what an algebraic term is?

Ali: An algebraic term is a number with variables.

Aini: Yes, a number with some variables. For the number part we called coefficient, and the letters are called variables. I explained in the previous class what like terms, and unlike terms are. Who can explain that to me? Ahmed!

Aini: Like terms have the same variables …. Unlike terms have different variables

The teacher drew the following diagram on the board.



Aini: Unlike means different letters, like means the same letters. Now what will happen when they have the same letter? Like terms we can add or subtract; if they are unlike terms we can't add or subtract.

At the end of instructional periods she discussed some of the answers to practise exercises. Again, the discussions were teacher-centred, and in a question and answer fashion where she asked all the questions. Aini also chose a few students to demonstrate their answers to the class.

4.2.4 Factors affecting Aini's instructional practice

In the interview, Aini gave her reasons for the instructional strategies she used:

> The term test is near and I have to cover all the topics. So these days I don't include activities in my lesson. We have to finish all the topics before May 15th. We have a textbook to cover. We have a curriculum. For activities like group work you need time. Students need lots of time even to form a group.

She added:

> In the Maldives things are very much based on exams. Students are evaluated by tests. Even teachers are evaluated by test results. Teachers want the students to be able to work out the type of problem that comes in the test.

Aini's remarks in the interview show that the instructional approach she used in teaching was not the way she wanted to teach. When probed, she stated:

> Obviously, I don't want to teach in a teacher-oriented way. Especially topics like algebra which is new to students. I want to do activities, use different types of materials, and show them things to make them understand the concept. But there is not enough time for that. However, I have to finish the topics. You have to prepare for the tests. Somehow I have to manage.

According to Aini, she did not have much choice but to teach the way parents and the school expected her to teach. She said, "We give exercises [drill] from the textbook and workbook that were decided in the teacher coordination meeting".

Aini's comments indicated that a large curriculum, including expected use of the textbook, limited time, and unit and term tests were constraints to teaching in the way she wanted.

4.3 Beena

4.3.1 Beliefs about the nature of mathematics

Beena's responses to the questionnaire and her description of mathematics during the interview indicated that she had predominantly traditional beliefs about mathematics. Beena viewed mathematics as a fixed body of knowledge, facts, and rules. She believed numbers and symbols were a significant part of mathematics: "When I think of mathematics the first thing that comes to my mind is numbers". Beena also believed that mathematics involved problem solving, and was useful and applicable to real-life situations. However, her responses during the interview indicated that she regarded problem solving as the application of mathematical facts in calculations to find solutions to problems that were presented as text or word problems. Discussing what she meant by problem solving, she described "word problems . . . for example, let's say to find the area of a place, or perimeter". In her view, "doing calculations mentally and in written form" using numbers was a significant part of mathematics.

4.3.2 Mathematics learning

Beena's beliefs about mathematics learning contained a mix of traditional and constructivist elements. She believed students should be active learners. Beena's comments in the questionnaire and her responses during the interview suggested that her conceptualisation of effective ways of learning mathematics included group work, student-to-student discussions, students' demonstration of their own solutions, and students' active engagement in learning activities; through these strategies students could relate the knowledge they learnt to real-life activities, thus, they would be able to apply the knowledge to solve problems.

Conversely, she indicated that once a mathematical concept was understood it was very important to do drill exercises for memorisation and mastery of skills. She thought use of the textbook and workbook for practice was important in mathematics learning. She believed that some students scored poor marks in tests not because of their lack of understanding of the concepts, but because they forgot the methods and procedures:

> It is repetitive work that makes students good, isn't it? For example, in Grades one, two, and three students learn four operations [addition, subtraction, multiplication and division].

Relating the discussion to her class who had learned short divisions the previous week she added:

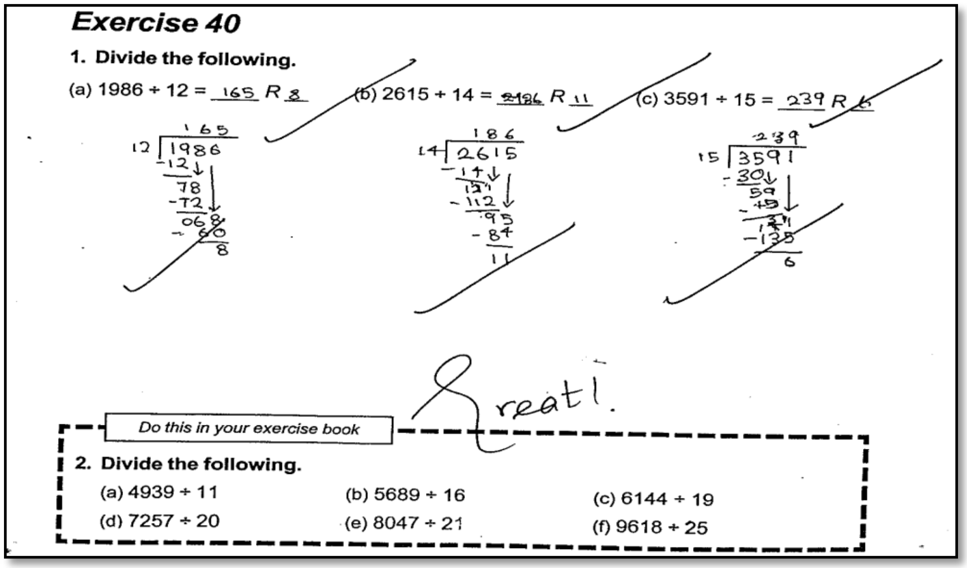
> Let's say we gave only workbook exercise in short division and stopped [giving more exercises, then afterwards] students will not remember. Today they have a test on short division, even now some don't remember.

The learning activities Beena provided to her students appeared consistent with her beliefs about learning mathematics. Apart from drill exercises, during the observed sessions, she engaged her students with whole class and group discussions reflecting her constructivist as well as traditional beliefs. She gave students opportunities to demonstrate and explain their solutions.

However, the group work, discussions, and demonstrations were focused on obtaining “correct” answers rather than eliciting ideas as a way to develop mathematical thinking. Often, Beena rejected the answers she thought were incorrect. For example, when she asked the class to describe a parallelogram, a student commented: “A parallelogram can be formed if you step on a rectangle [made up of wire]”. For this Beena replied, “What… how can a shape change when you step on it”?

The individual and group activities presented during the observed periods were focused on providing practice of procedures, memorising facts, and checking understanding of what was explained. For example, during a geometry period, after explaining the types of triangles and quadrilaterals, Beena gave each group different kinds of triangles to sort into categories. In another lesson, she gave her students what she called a “field activity” which she believed to be a good example of students actively participating in learning. In this activity, she took students to the school yard, and asked them to look for problems displayed in different locations in the field. The type of sums displayed is shown in Figure 4.3. Figure 4.4 shows another individual exercise provided to her students from their workbook (Naseer & Adam, 2007, p. 75) in one of the observed lessons.

Figure 4.3 Sums displayed in the schoolyard



Exercise 40

1. Divide the following.

(a) 1986 ÷ 12 = 165 R 8

(b) 2615 ÷ 14 = 186 R 11

(c) 3591 ÷ 15 = 239 R 6

Great!

Do this in your exercise book

2. Divide the following.

(a) 4939 ÷ 11

(b) 5689 ÷ 16

(c) 6144 ÷ 19

(d) 7257 ÷ 20

(e) 8047 ÷ 21

(f) 9618 ÷ 25

Figure 4.4 An activity from student workbook with marked student work

4.3.3 Mathematics teaching

Beena's answers to the questionnaire and her comments during the interview indicated that her beliefs had characteristics of both traditional and constructivist teaching. She believed that students' active participation in learning, and activities that help students to relate what they learn to their experience, enhance understanding:

> When we teach we try to relate mathematics to students' real-life activities. For example, we sometimes give them shopping games. In teaching weights we give them opportunities to measure the weights. Then only they will understand.

During the interview, she also emphasised the importance of conducting a lesson in a "practical way"; for example:

> In geometry, students can be given cut out shapes. So they can touch and feel, so they can understand better. Also, in teaching perimeter, giving shapes to students will help them understand.

She also believed giving a teacher explanation, and drill exercises were vital parts of mathematics teaching. This view of mathematics teaching reflected more on her observed practice than her constructivist beliefs.

Classroom environment: There were 30 students in Beena's class. Students' desks were arranged in clusters with enough space between groups for the teacher to move around and work with groups. During her instruction, Beena tried to maintain a quiet atmosphere. From time to time Beena reminded the students to be quiet, listen, and raise their hands before answering.

Planning: Beena's lesson plans indicated the topics, objectives of the lessons, pages of the workbook, and the types of activities to be covered in class. Beena acknowledged closely following the textbook and workbook in planning her lessons: "We do all the exercises in the workbook. There is no activity that can be left, all are important".

Instructional Strategies: Beena used a variety of activities during the observed lessons. She started one of the lessons by giving students a puzzle. A game to revise the multiplication tables was given in another lesson as a starter. However, Beena's explanation of the content and demonstration of examples was the main activity on which she spent a substantial amount of her mathematics period. In the observed lessons she gave students group work for which she allocated about five minutes. After the group work, students worked individually on exercises from the students' workbook. Generally, Beena discussed the answers when most of the students had completed the work.

4.3.4 Factors affecting Beena's instructional practice

Beena's responses during the interview and to the questionnaire revealed that time, resources, and the way students were assessed limited her instructional practice. She thought time allocated to mathematics was not sufficient for students to spend time on activities such as group work. She believed that the school had limited resources and materials for teachers to use. Her remarks during the interview also suggested that teachers were expected to closely follow the textbook and the workbook. She acknowledged that teachers could skip some activities, exercises, or sums, but, according to her, teachers often had to explain to parents the reason a certain activity or exercise was not given to students. Beena also indicated that her teaching and the type of activities she chose to give students were influenced by the way students were assessed:

> It will not be good for students if we teach something and assess something else…for example, if there were questions in a test that weren't taught in the class, students would not be able to answer.

4.4 Binesh

4.4.1 Beliefs about the nature of mathematics

Binesh had mainly traditional beliefs about the nature of mathematics. Her description of mathematics in the belief questionnaire suggested that she regarded mathematics as a study of structures, numbers, measures, and changes. She thought mathematics involved recognising and describing patterns, and making accurate statements about mathematical objects. She also viewed the use of numbers and calculations as a significant part of mathematics.

Binesh thought there were differences in the way mathematicians and others practice mathematics. For her, mathematics is invented by mathematicians and other people use the procedures and rules they invented for measuring, counting, and calculation. Her responses indicated that mathematics was a dynamic and constructive subject for mathematicians, but less dynamic for others:

> I think they [mathematicians] do maths by studying patterns. They investigate and find the rules that explain relationships between mathematical objects. We use numbers, units, and formula they created to calculate. They invented them by exploring.

This indicated that she viewed school mathematics as rules, procedures, and algorithms already established and fixed.

4.4.2 Mathematics learning

Binesh had a mix of constructivist and traditional beliefs about mathematics learning. She believed that children learn best by actively engaging in activities and relating what they learn to their own experiences:

> I think students learn well when they explore, think, solve problems on their own and explain how they get the answers. I think children learn easily when they engage in activities that help them to connect mathematics concepts to real-life experiences.

Contrary to her constructivist learning beliefs, she also believed that it was essential to use repeated practice for mastery of skills, and thought it was vital for students to make use of textbooks and workbooks to practise mathematics concepts.

Although Binesh had a mix of constructivist and traditional beliefs, the learning activities Binesh provided for her students were only consistent with her traditional beliefs. All the work given for students during her observed instructional practice was to practise algorithms and the skills to calculate mathematical sums related to the topic under study.

She gave her students both individual and group tasks to do in class. However, the types of questions given were similar in both cases. The responsibilities of the students in these tasks seemed to follow the step-by-step procedures explained to them. No activity during the observed lessons encouraged student discussion or exploration of mathematical ideas. In group tasks students were only required to follow the procedures or worked examples. Table 4.1 shows a worked example explained on the board, an example of a sum given to do in small groups, and a sum she gave for students to do individually.

Table 4.1

A teacher demonstrated sum, and an activity given to students

An example teacher demonstrated in the class	A sum students did in small groups	A sum given for students to do individually
If $a = 3,\ b = 2,\ c = 1$, find the value of: $-abc$ $= -a \times b \times c$ $= -3 \times 2 \times 1$ $= -6$	If $a = 2, b = 1, c = 3$ find the value of: $-2ab$	If $x = 2, y = 1, z = 3$ find the value of: $-10xy$

4.4.3 Mathematics teaching

Binesh's beliefs about effective ways of teaching mathematics contained both traditional and constructivist elements. According to her, "inductive and deductive methods of teaching, problem solving, lecturing, and actively engaging students" are all effective methods of teaching. She believed that a teacher presenting problematic situations for students to investigate and find solutions was an effective way of teaching. In talking about inductive methods during the interview, she explained:

> Sometimes teachers can give problems to students without explaining them. Students can be asked to create mathematical problems and give them to others to solve.

She also thought that engaging students in small group discussions was an effective strategy, as was the teacher explaining content and then giving students textbook exercises: “Students are supposed to understand the content in textbooks and they need to do those exercises in order for them to understand the content”.

Despite holding some constructivist beliefs Binesh’s observed teaching reflected more a transmission of knowledge approach than a constructivist approach.

Classroom environment: In Binesh’s class, students were seated in five groups with an average of six students in each group making a total of 31 students. Binesh maintained a controlled environment where student sat quietly at their desks. Most of the time only Binesh talked and students listened.

Planning: Binesh prepared a separate lesson plan for each instructional period observed. She wrote in brief the content and type of example sums she would demonstrate to her students. She closely followed the textbook and workbook in planning her instruction. Her lesson objectives always included that students were able to do book activities. For example, an objective of one of her lessons was: “[Students should be] able to do all the questions given in the workbook exercise”.

Instructional Strategies: Binesh spent more than half of the lesson time explaining the content, and the students spent nearly one third of the lesson doing exercises from the textbook or workbook. She read the answers at the end of the lesson. However, before assigning students individual work, she set small group work which was similar to students’ individual work. She described this as her usual way of teaching.

4.4.4 Factors affecting Binesh’s instructional practice

Clearly, there were discrepancies between Binesh’s beliefs and practice. The observed practice reflected her traditional beliefs, but not her constructivist beliefs. Binesh admitted that her practice was more teacher-centred than her beliefs. Yet because they did group work and demonstrated some of their work to the class, she thought the students actively engaged in learning during her instructional practice, so indicating that she believed her teaching was constructivist.

When asked about factors that limited her instructional practice, she stated that she did not face any difficulty in teaching the way she wanted. Binesh believed that her students’ good performance in school tests was a strong indicator of her effective teaching strategies. However, she admitted that some of her students did not perform well resulting in complaints from some "individual parents". She believed students who do not perform well in tests were those who don't attend the class regularly or the ones who don't do homework.

4.5 Cala

4.5.1 Beliefs about the nature of mathematics

Cala's beliefs about the nature of mathematics had both traditional and constructivist elements. She viewed mathematics as a fixed set of rules or laws as well as logical thinking and ideas. According to her, "Mathematics is not only about facts and rules that we learn in textbooks; it involves logical thinking and makes use of the brain". She also believed understanding facts and rules was essential in solving mathematical problems:

> It is vital to know the facts in order to perform. If you don't know the mathematical facts I don't think you will be able to solve mathematical problems.

She also believed that mathematics was related to life science and real-life activities.

4.5.2 Mathematics learning

Cala's beliefs about learning mathematics were primarily constructivist in nature. According to her, providing students with problematic situations that can be related to their life experience and encourages them to explore mathematical ideas themselves helps students to learn mathematical concepts. During the interview she said, "Being a passive listener in the class will not help them learn the concept; when we actually do, we understand". She also believed that collaborative group work and use of manipulative materials facilitates students' understanding. Conversely, Cala believed that a sufficient amount of practice was important for students to remember. According to her repetitive practice can make students remember the concept for a longer time.

The learning opportunities Cala provided to her students were mostly consistent with her beliefs about learning mathematics. She presented her students with activities to work on both individually and in groups. The episode below illustrates small group work she assigned in one of the observed classes after she had demonstrated to students how to read times by showing a real clock.

Teacher: I want the group leaders to come to the front.

(Group leaders stepped forward. The teacher handed each a clock, and they went back to their groups.)

Teacher: I want you to show me the time I tell. Are you ready?
Students: Yes
Teacher: First, you are going to show me 50 minutes past eight.

A student moved the hands on the clock to show fifty minutes past eight. The teacher checked the groups' display of the time, and helped the students if the time displayed was wrong. The activity was continued until all the students got a chance to display the time.

Cala believed that the group task she assigned to students facilitated their understanding. Regarding the group work described above, she said:

> The students used real clocks to show times. I was not only showing them; the students used the clocks themselves. When students see clock at home or somewhere they will remember what they did in class. In that lesson, when they worked in groups discussing and demonstrating the time using clocks, they understood the concept better.

Apart from the group work, Cala also gave students the opportunity to work individually. The individual activities given seemed aimed at practising skills students learned in the class, and were mostly from the students' workbook.

4.5.3 Mathematics teaching

Cala had a mix of traditional and constructivist beliefs about mathematics teaching. For her, effective ways of teaching mathematics included teachers providing students with problems and activities that encouraged them to think and discuss with each other; to "allow them to use their brain" and "present their solutions". In her opinion, active engagement and collaborative group work were effective ways of teaching mathematics. According to Cala, activities such as "field trips, project work, and experimenting" were useful strategies for teaching mathematics as "mathematics is completely related to real-life". Furthermore, she thought it was necessary for teachers to provide students with "concrete materials" in order for them to have "concrete experience".

Cala also held some traditional beliefs about teaching. Although she did not believe that it was essential for teachers to closely follow the textbook, she believed that it was vital for teachers to give clear and thorough explanations of content and provide students with enough drill exercise to cement their knowledge.

Cala's observed instructional practice was largely consistent with her beliefs about mathematics, mathematics teaching, and learning. However, the practices observed were less constructivist than the beliefs.

Classroom environment: There were 17 students in her class, seated in four groups with an average of four students in a group. She encouraged students to ask questions and discuss their ideas. Students also engaged in discussion, and worked collaboratively. However, much of the dialogue was between teacher and students.

Planning: Cala made daily lesson plans. In planning her lessons, Cala closely followed the textbook and workbook. According to her, this is because students are assessed entirely through written tests based on types of questions from the text and workbook (see Figure 4.5).

a) b)

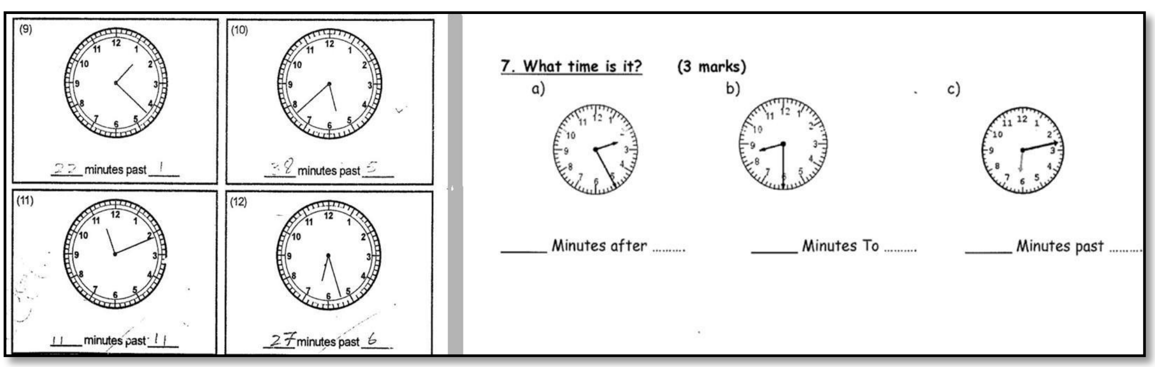


Figure 4.5 a) An extract from student workbook (Naseer, Adam, 2007, p. 93), and b) a question that appeared in the first term test

Instructional Strategies: In her teaching, Cala used different materials to demonstrate mathematical ideas giving students the opportunity to use some of the materials themselves. She encouraged students to work collaboratively. Activities were provided for students to work in groups. However, the classroom discussions and demonstrations reflected a teacher-centred approach which took about half the instructional time. The following was typical of a whole class discussion:

Cala: We are going to find out how many millilitres there are in one litre. I brought this hundred millilitre cylinder, an empty bottle, and a bottle of water. The empty bottle is a one litre bottle. Can you tell me how we can find out, using these, how many millimetres there are in one litre.

Shahid: Pour water from the bottle using the cylinder.

Cala: Ok. I am going to show how we can find this.

She demonstrated how they could find a solution by adding ten cylinders of water to the bottle. At the end of the demonstration she found that the bottle was not fully filled as would be expected. Instead of creating dialogue among students to discuss what the problem was, she explained, “It is because when we filled the cylinders we didn’t measure accurately”. Another discrepancy noted was, although Cala believed in problem solving and investigative work, during the observed sessions students were not provided with any. The lessons followed similar patterns. Cala began mathematics classes by asking questions and reminding students about what they learned in the previous class. She then explained the content and demonstrated examples before assigning students group or individual work.

At the end of group and individual work, Cala discussed the answers with the students emphasising getting the correct answers rather than process. Groups were given scores based on their speed and the number of correct answers they got. If a group got all correct, they would get a star displayed on a chart at the top corner of the whiteboard. She believed that when students’ work was graded they would work hard to improve and finish the work on time.

4.5.4 Factors affecting Cala’s instructional practice

Cala acknowledged that her instructional practice was less constructivist than her beliefs about teaching and learning. According to her, the reasons included, firstly, limited time and an inflexible time schedule for mathematics lessons. Secondly, students were expected to complete all the workbook and textbook exercises as they were assessed from the content in these books:

> We don’t actually assess whether they can use the knowledge in real-life. If we don’t complete all the workbook exercises we may get complaints from parents, and pressure from the school. Even students would not be happy if they don’t do them. It was the way they have been practising.

Thirdly, she believed the school had “very limited resources for both teachers and students”.

4.6 Chanda

4.6.1 Beliefs about the nature of mathematics

Chanda had mainly traditional beliefs about the nature of mathematics. She described mathematics in terms of numbers and calculations. According to her, numbers and arithmetic operations were a significant part of mathematics. She regarded addition, subtraction, multiplication, and division as “the basics of all mathematical operations.” Her responses suggested that mathematics was a subject of specific rules, facts, and computations. She believed that mathematics was very useful and related to real-life because its rules and procedures can be applied in real-life activities and computations. According to her, “All the topics we learn in mathematics have some use . . . geometry is used in building construction, and equations are used in calculating amounts”. However, she believed that knowing rules and facts would not be enough to apply them in computations. She also believed doing mathematics required thinking.

4.6.2 Mathematics learning

Chanda’s beliefs about learning mathematics represented characteristics of both traditional and constructivist elements. She believed that textbooks and worksheets played an important role in mathematics learning. According to her, students learn from the teachers’ explanation and by doing repetitive practice for mastery of skills. She also believed that it was necessary for students to work in groups, and to explore and learn themselves. She thought “using real-life objects . . . getting concrete experiences”, and relating to “real-life examples” helped students to understand the concepts.

However, the types of activities she provided for her students were more traditional. In none of the observed periods were students given the time to explore, investigate, or work in groups to encourage discussion. Both the group and individual learning situations she provided were to practise skills and content she had explained earlier. Similar work was set as group tasks and individually. For example, after explaining different types of triangles (acute, right, and obtuse), she set an activity where students identified the type of triangle from a set of triangles in a group. Chanda encouraged her students to finish quickly, and announced the rank order in which the students finished the work. This was competitive, it did not encourage discussion, and students who needed time to think did not contribute. Figure 4.6 shows this group got all the answers correct, but was in the third place. A similar activity from the workbook was set for students to do individually.

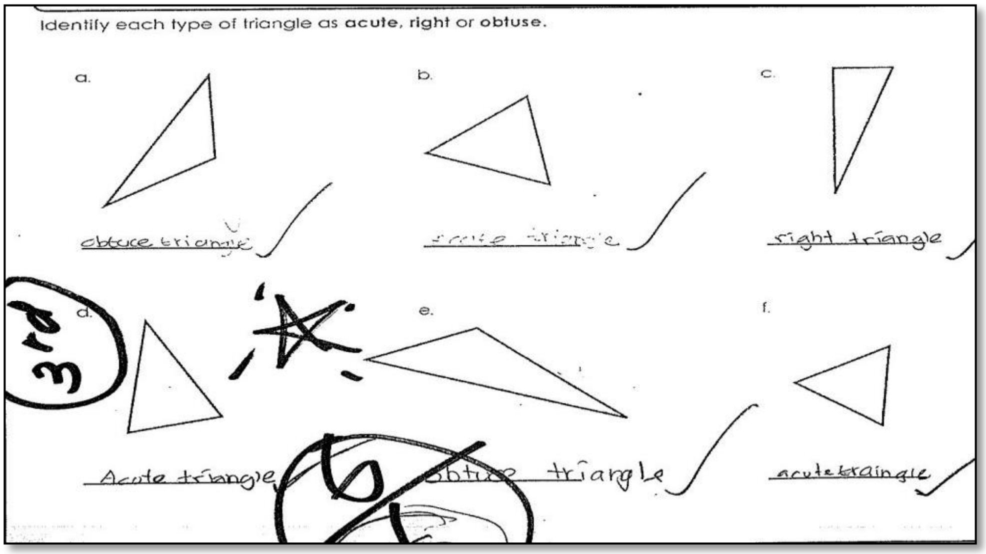


Figure 4.6 Group work given to Chanda's class

4.6.3 Mathematics teaching

Chanda had a mix of the traditional and constructivist beliefs about mathematics teaching. When asked her opinion about effective ways of teaching mathematics she responded:

> Provide students with opportunities to work on real-life situations . . . encourage them to think critically . . . solve problems, small group activities . . . explain the concept using a variety of teaching aids . . . give them enough practice.

She also believed that mathematical instruction should be based on students' textbooks and teachers should verify that students received the knowledge from the book.

Instructional practice observed during Chanda's mathematics class indicated that her teaching was more traditional than her beliefs about mathematics teaching. Although she believed that it was necessary for students to be provided with real-life situations to explore and investigate mathematical ideas, no such work was observed in any of her observed lessons.

Classroom environment: There were nineteen students in Chanda's class, seated in four groups with an average of five students in each group. She maintained a quiet classroom environment. Often students raised their hands before they spoke or answered her questions.

Planning: Chanda wrote a detailed lesson plan for each of the lessons observed. For each session she wrote a set of objectives, teacher activities, and students' activities. The lesson plans indicated that her instructions were planned based on the textbook and workbook: doing workbook activities was a stated objective of all her observed lessons. For example, an objective of one lesson read "students to complete page 90 themselves and get all 12 questions correct".

Instructional Strategies: In all Chanda's lessons, more than half of the instructional time was spent on explaining the content and showing students how to do similar types of sums which they would do later as a group or individual work. When students finished the group work, she would check and discuss the answers with them. In all the observed lessons, group work was graded and ranked as described earlier. Chanda concluded her lessons by recapping important points of her lesson.

4.6.4 Factors affecting Chanda's instructional practice

Chanda's responses suggest that limited time, availability of resources, and a large curriculum have on effect on her instructional practice. According to her, if teachers gave activities for students to explore and investigate mathematical ideas, there would not be enough time to complete the syllabus. She said, "We can't give many time-consuming activities. Time is not enough for practical types of activities". Her responses also suggested that teachers would get pressure if their students test results were notably low compared to other parallel classes: "If a class scored low marks compared to other classes of the same grade, parents would complain . . . in such cases we have to teach the topic again and assess".

4.7 Dean

4.7.1 Beliefs about the nature of mathematics

Dean's beliefs about the nature of mathematics were closely aligned with the traditional belief category. His responses to the questionnaire indicated that he viewed mathematics as a computational subject that consists of a fixed body of knowledge, rules, methods, and procedures. During the interview, he said, "Mathematics is more or less about calculation using numbers to measure or estimate something". However, he believed that mathematics was more than a set of unvarying methods and procedures learnt in school:

> I think mathematics is one of the most useful subjects. People use mathematics all the time, knowingly or unknowingly. They use mathematics whether they are educated or not.

This suggests that although he believed mathematics was useful and applicable, he viewed school mathematics as more procedural.

4.7.2 Mathematics learning

Dean had traditional beliefs about mathematics learning. Dean's descriptions of mathematics learning suggested that he believed that students learn best through an effective teacher demonstration of how to complete mathematical sums followed by practising similar types of sums. When asked his opinion about effective ways of learning mathematics, he explained:

> I think children learn mathematics best through group work and then sit individually to solve the same kind of problems they did in the group. I give group work after the explanation. Students will discuss among them about what they learnt during the explanation. If there are students who didn't understand a part from the explanation, these discussions will help them to learn.

Dean regarded group work as a means for weaker students to understand teachers' explanations by observing and listening to other students who understood the teacher's explanations, rather than providing students a social context for mathematical discussions or to develop students' mathematical thinking.

The learning situations Dean provided his students were mainly parallel with his beliefs. For example, the group task he provided to students was similar to the type of question he explained on the board. Similar sums were then given for students to complete individually. The following were two tasks (Figures 4.7 and 4.8) he assigned to students as group and individual activities in one of the observed teaching lessons.

1. Find the possible factors of: a) 6 b) 30 2. Find the prime factorisation of a) 150 b) 310 a) 420

Figure 4.7 Group work given to Dean's class

2. Find the possible factors of: c) 24 d) 27 e) 48 3. Find the prime factorisation of c) 315 d) 200

Figure 4.8 Individual work given to Dean's class

Dean's belief that working alone in silence "for practice" as an important part of mathematics learning was evident from the number of tasks given to students. In all the observed lessons, students spent a considerable amount of time working alone on mathematical sums from the workbook. In addition, at the end of instructional periods he assigned students homework from the workbook, reflecting his belief that doing repetitive practice was an important part of mathematics learning.

4.7.3 Mathematics teaching

Dean's responses during the interview and to the questionnaire showed that he considered direct instruction as very effective. In the questionnaire he indicated that the teacher was more responsible for student learning than students themselves. In his description of the teacher's role during the interview, he suggested that his role as a teacher was to give students clear explanations of content and algorithms by giving examples and ensuring students understood what was explained.

Dean believed that without a clear explanation and demonstration of worked examples, students would not be able to do mathematical sums and would lead students to confusion and, many questions which he thought would not result if teaching was effective. He questioned:

> Can students solve a problem if they don't know how to solve it? If it is not something they learnt earlier they will not be able to . . . Even if they can they will take more time to complete.

Dean's traditional views of mathematics teaching were clearly evident in his instructional practices.

Classroom environment: Dean taught in a large classroom where students' desks were arranged side-by-side in long rows. There were 29 students, seated facing a white board, most of the time copying notes from the board, listening, and observing Dean's explanations and demonstration of examples. From time to time Dean reminded the students to "look at the board and listen". However some students were seen chatting and engaging in other work.

Planning: Dean wrote a detailed lesson plan for each of the observed lessons describing the teacher's activities in one column and students' activities in another. The sums he would explain on the board and the sums to be given to students to practise were clearly outlined in lesson notes. The extract below (Figure 4.9) is a section from Dean's lesson plan to revise addition and subtraction of fractions with the same and different denominators.

	15 mins	Write a question like $\frac{3}{7}+\frac{2}{7}$ and ask them to simplify it. Check their answers. Explain them how to add fractions with same denominator. Show examples on the board. Give same kind of questions on the board and ask them to simplify it individually.	Students will give the answer. Students attentively listening to the explanation and answer the question asked by the teacher while explaining.
	20 mins	Explain them how to add fractions with different denominators by showing examples on the board which should include mixed fractions. Give similar questions on the board and ask them to simplify the sums. Explain them how to subtract fractions with same denominators by showing example on the board.	
	10 mins	Give similar questions on the board, and ask them to subtract the given questions. Explain the students how to subtract fractions with different denominators which includes mixed fractions. Show examples on the board.	

Figure 4.9 A section from Dean's lesson plan

Instructional Strategies: Dean's observed instructional practices were consistent with his beliefs about mathematics, and teaching and learning mathematics. The only discrepancy between his beliefs and practice was, though he believed mathematics was useful and applicable, this was not reflected on his observed practice. He did not make connections of what students learned to their real-life encounters.

When asked, "If I was to visit your class, what would I normally see happening during the lesson?" he remarked:

> I would first explain the topic, and give students a task in groups or in pairs. After that, students would do an individual task. I would check their work while they are on task. Students' doubts would be explained on the board by highlighting common mistakes I observed them making. Finally I would revise the important points of the day's topic.

Dean's practice was similar to what he described would be seen if visiting his class. The focus of his instructional strategies was on procedural understanding rather than conceptual understanding. He did not make clear the reasons underlying these step-by-step procedures or explain any practical significance of the topic. The following episode showed a section of Dean's explanation about solving a simple linear equation.

At the beginning of the instructional period Dean gave an overview of what the students would be learning. He then wrote on the board

$$2 + x = 8$$

Dean:	In equations we find the value of the unknown. To find the value of x what do we do?
Students (many at once):	Take 2 to the other side and subtract.
Dean:	Yes, when you take 2 to the other side the sign changes. What is the sign of 2?
Students (many at once):	Plus, and it changes to minus when taken to other side

Dean wrote on the board: $x = 8 - 2$

$$x = 6$$

Dean then moved to another worked example.

4.7.4 Factors affecting Dean's instructional practice

Dean's practice reflected his beliefs about teaching and learning mathematics. He thought there were not any constraints that limited the way he would like to practise. However, his responses indicated that the school assessment was a significant factor shaping his instructional practice.

The observed sessions indicated that the main focus of his teaching was to prepare the students for unit tests and term tests. Apart from doing regular repetitive practice from the workbook and worksheets, Dean took revision lessons before unit and term tests.

For example, according to Dean, there would normally be a minimum of a week's revision for term tests. When his class was observed there were three more weeks until the term test, yet two of the lessons observed were revision lessons indicating the influence assessments had on his instructional practice. The effect was also evident from his responses during the interview. He thought his teaching was effective, because the students' performance in tests was good.

Dean's responses also indicated the pressure teachers had to improve students' performance in school tests:

> If they get comparatively less marks than the previous tests, parents would complain to school management ... it has happened to me in the past.

4.8 Dhakir

4.8.1 Beliefs about the nature of mathematics

Dhakir had traditional beliefs about nature of mathematics. He described mathematics mainly as calculations and numbers. His responses during the interview and comments in the questionnaire indicated that he thought mathematics was a fixed body of knowledge, facts, and skills which were useful in everyday life. He said, "We use mathematics every day; for example, we use numbers all the time . . . we use addition and subtraction when we do shopping". His responses also indicated these rules, methods, and procedures have to be learnt from others in order to use them in computations:

> One problem can be solved using different methods. We need to learn easier methods from people who are good at mathematics so we can explain them to children.

4.8.2 Mathematics learning

Dhakir's beliefs about mathematics learning were primarily traditional and aligned well with his conceptualisation of the nature of mathematics. According to him, teachers were more responsible for student learning as the students' role was to follow what was being demonstrated to them. In his view, students learn mathematics by listening to teachers' explanations and then engaging in repetitive practice for mastery of skills. He believed it was essential but not sufficient for students to complete all textbook and workbook exercises for practice:

> I think it is important for students to do exercises until they learn the concept thoroughly. We can provide students with different sources such as worksheets for students to do more practice of the types of sums they learn in the class.

His responses during the interview indicated that the problems given to students should be easily solvable using simple methods and believed that teachers had to give explanations to students that are easy to follow, step-by-step procedures for them to understand:

> When there are different methods I explain to the students the easier methods. Some students are slow learners. They need lots of teacher support. I think teachers have to explain those easy methods of doing mathematics.

Furthermore, in the questionnaire Dhakir stated that he was not sure if students' learning would be enhanced if students actively participated in learning activities that enabled them to create their own version of knowledge. However, he thought learning was enhanced when students worked in groups. He also believed students learn mathematics by playing mathematical games.

The learning activities Dhakir provided for his students in class were largely consistent with his beliefs about learning mathematics. In his observed lessons, students spent nearly two thirds of the period listening to and observing his demonstrations of worked examples followed by group and individual practice of similar types of mathematical sums. Following individual or group work he read the answers to the students for them to check their work. Often one or two students were asked to demonstrate their work on the board. According to Dhakir this was to check if the students could follow the methods correctly.

4.8.3 Mathematics teaching

Similar to his beliefs about the nature of mathematics and mathematics learning, Dhakir had traditional beliefs about mathematics teaching. He believed effective teachers were those who gave good explanations of mathematical procedures and methods in clear ways, so that students could understand, "I think it is easier for students to understand mathematics when the teacher simplifies the methods and explains step-by-step". He believed that giving familiar daily life examples was important for students to understand concepts, "I give lots of examples from daily life that students can understand, for example, teaching fractions I gave examples of things they know".

Dhakir also believed that revising previous work at the beginning of an instructional period was an important part of effective teaching, “I start all my lessons by revising what they already learnt. They forget otherwise . . . I ask them questions and check if they can recall”.

Parallel to his beliefs about learning mathematics, Dhakir thought both group and individual “problem solving activities” should be a significant part of mathematics teaching. However, he believed students needed to be given clear explanations of methods by demonstrating worked examples prior to assigning group exercises indicating the group tasks also as a means to practise the algorithms explained.

Dhakir’s instructional practice was congruent with his traditional beliefs about mathematics teaching and learning.

Classroom environment: There were 29 students in Dhakir’s class. The desks were arranged as shown in Figure 4.10. Dhakir maintained a controlled environment where students worked consistently at their desks, listening to the teacher’s explanations and watching his demonstrations, then mostly working individually on workbook exercises.

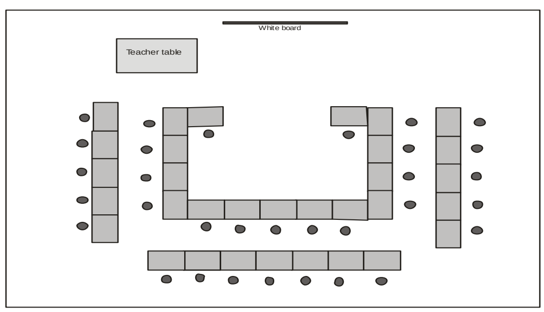


Figure 4.10 Dhakir’s classroom arrangement

Planning: Dhakir made daily lesson plans for the lessons observed. His lesson plans indicated that the instructions were based on the textbook. The mathematical sums to be explained and given to students to do in class and as homework were clearly outlined, and were taken from the workbook. The content and exercises were followed in the same order given in the textbook.

Instructional Strategies: Dhakir began each mathematics lesson by reviewing the previous day’s lesson, and giving an overview of what students were going to learn. He spent a considerable amount of time on explaining and demonstrating examples.

In the following episode Dhakir demonstrated how to add fractions with the same denominators. The lesson was a revision lesson about the addition and subtraction of fractions.

Dhakir	Wrote on the board $\frac{5}{6} + \frac{4}{6}$
Dhakir:	These fractions have same denominators. How do you add when fractions have the same denominators?
Nasheed:	We write the denominator, and add the numerators.
Dhakir:	Yes, six, five plus four is nine. (Simultaneously he writes $\frac{9}{6}$ on the board)
	What do we do next?
Fathimath:	Change to an improper fraction.
Dhakir:	Before changing to an improper fraction you have to see if you can reduce it. You can divide both the numerator and denominator by 3. (He then writes: $\frac{3}{2}$). What is the final answer?
Fathimath:	One, one by two.

Dhakir then writes $1\frac{1}{2}$ on the board.

After providing a few examples, he gave one or two similar examples for students to complete, and walked around the class to check students' work. He gave general feedback about the mistakes he observed before demonstrating other examples of slightly different types. Following the explanation and demonstration of different types of examples, students were again given individual exercises from the workbook.

In one of the observed lessons, students were also given small group work before individual work, and were given similar types of sums to those explained on the board. Students did not engage much in discussion as they completed this work. One or two students in each group did the work while others observed. Before concluding the lessons Dhakir discussed the answers with the students and assigned homework.

4.8.4 Factors affecting Dhakir's instructional practice

The way students were assessed seemed a significant factor affecting Dhakir's instructional strategies. As a teacher he was concerned about students' performance in tests. He gave similar worked examples and explained easy-to-follow methods for students to recall. He gave enough practice for students to remember, and revised the lessons one or two days before each unit test, as well as a week or two before term tests. According to Dhakir, he used teaching strategies which he experienced as the most effective. He believed students scored good marks in school tests with the teaching strategies he used.

4.9 Summary

This chapter has presented descriptions of individual cases. Each one of them provided a unique story of a teacher. In presenting each case, the focus was on describing the teacher's beliefs about nature of mathematics, mathematics learning, mathematics teaching, and factors affecting instructional practice of the teacher. In the next chapter, the focus will be on building an overall understanding of teachers' mathematical beliefs, and practice.

CHAPTER FIVE

Findings across the case studies

This chapter reports the findings of the cross-case analysis. The cross-case analysis was conducted in stages. First, teachers' beliefs about the nature of mathematics, mathematics teaching, and learning identified from the within-case analysis were compared with the criteria for categorisation of teachers' beliefs (Tables 2.1, 2.2, and 2.3). Next, findings from individual cases were analysed for emerging themes that describe teachers' beliefs and practice, and factors affecting their practice. Finally, teachers' beliefs about mathematics, mathematics learning, mathematics teaching, and practice were compared for their consistencies.

The findings are discussed under the headings: nature of mathematics (Section 5.1), mathematics learning (Section 5.2), mathematics teaching (Section 5.3), and beliefs and practice (Section 5.4).

5.1 Nature of mathematics

This section describes findings of cross-case analysis regarding teachers' beliefs about the nature of mathematics. The section first presents a brief description of teachers' beliefs about the nature of mathematics and their categorisation. Next, it describes the themes that emerged from the cross case analysis concerning teachers' beliefs about the nature of mathematics.

5.1.1 Teachers' beliefs about the nature of mathematics and their categorisation

Teachers' beliefs about the nature of mathematics had elements of traditional and constructivist perspectives to varying degrees. Table 5.1 provides a summary of teachers' beliefs about the nature of mathematics and their categorisation. The belief statements are not teachers' exact wordings; they describe themes that emerged from the within-case analysis regarding teachers' beliefs about the nature of mathematics.

Table 5.1

Teachers' beliefs about mathematics and their categorisation

Participants	Beliefs about the nature of mathematics	Categorisation
Aisha	▪ Mathematics consists of a fixed body of knowledge and set of procedures, but is not limited to these ▪ Mathematics is logical, and useful in everyday life ▪ Mathematics is related to the physical world, and involves thinking	Mix of traditional and constructivist
Aini	▪ Mathematics is applicable ▪ Mathematics is all about problem solving and logical thinking	Constructivist
Beena	▪ Mathematics is mainly a fixed body of knowledge, facts, and procedures ▪ Mathematics is useful in everyday life ▪ Mathematics involves problem solving (Beena regards problem solving as applying mathematical procedures in computation – word problems)	Primarily traditional
Binesh	▪ "School mathematics" contains mainly rules, procedures, and algorithms already invented ▪ Mathematics is a study of structures, numbers, and measures ▪ Mathematics is dynamic for mathematicians	Traditional
Cala	▪ Mathematics is partially a fixed body of knowledge, rules, and procedures ▪ Mathematics involves logical thinking and ideas	Mix of traditional and constructivist
Chanda	▪ Mathematics is mainly a fixed set of rules and procedures ▪ Mathematics is useful in everyday life ▪ Mathematics is mainly computation ▪ Mathematics involves thinking	Primarily traditional
Dean	▪ Mathematics is a fixed body of knowledge, rules, and procedures ▪ Mathematics is mainly computations ▪ Mathematics is useful in everyday life	Traditional
Dhakir	▪ Mathematics is a fixed body of knowledge, rules, and procedures ▪ Mathematics is mainly computation ▪ Mathematics is useful in everyday life	Traditional

As shown in the table, five of the eight teachers had traditional or primarily traditional beliefs. Two of the teachers indicated a mix of traditional and constructivist elements in their beliefs about mathematics. Only one teacher showed beliefs that had only constructivist features.

Figure 5.1 shows the relative position of the teachers' beliefs in relation to the two categories as shown in Table 5.1. The coloured rectangles represent belief types. The line between the blue and green rectangles indicates that beliefs are mainly traditional.

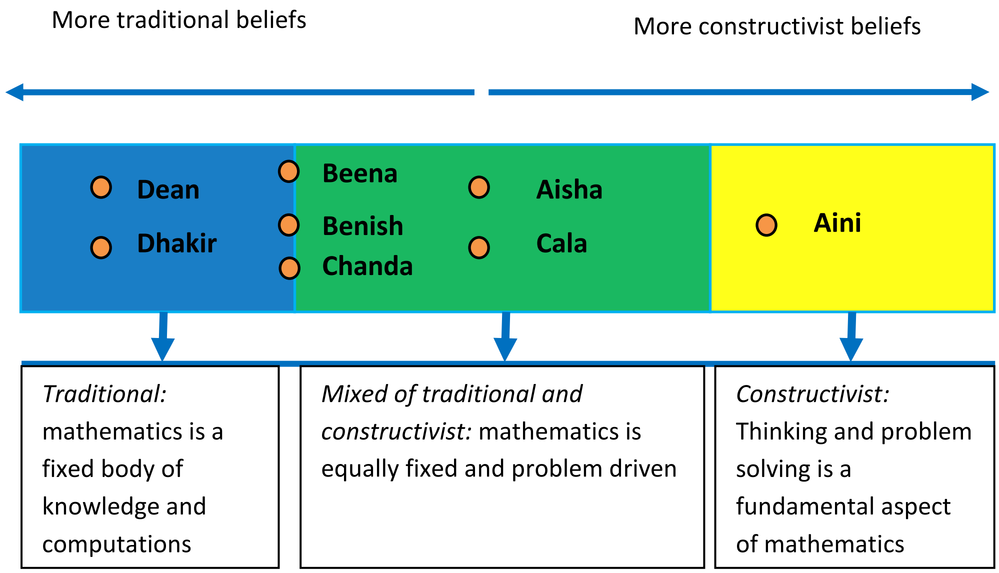


Figure 5.1 Relative positions of teachers' beliefs about the nature of mathematics

The teachers' description of mathematics revealed two distinctive perspectives about the nature of mathematics. The first is of mathematics as a subject consisting of a fixed body of knowledge and computations. The second view is mathematics is a way of thinking and involves problem solving. Although the two perspectives are contrastingly different, two of the eight teachers hold a combination of these two views. The other teachers had beliefs that indicated mainly elements of one of these two views.

5.1.2 Fixed body of knowledge versus a way of thinking and problem solving

Five of the eight teachers indicated strong traditional beliefs, regarding mathematics as a fixed entity. For example, Dean and Dharkir described mathematics in terms of numbers, symbols, and calculations, and believed in mathematics as rules and procedures that must be transmitted from teachers to students in order for students to use them in calculation (Sections 4.7 and 4.8). The traditional view of mathematics was also evident in their remarks regarding the use of mathematics. For example, during the interviews, Dhakir emphasised the use of computation in calculating costs in shopping. Dean mentioned use of formulas in calculating areas and perimeters as good examples of everyday use of mathematics. Dean also believed that people use mathematics regardless of whether they have learned mathematical formulas, facts, and procedures in schools or not. This indicated that he regarded school mathematics as more or less different from the mathematics people use every day.

Beena, Binesh, and Chanda all shared similar conceptualisation of mathematics. For example, Beena stated "numbers" as the first thing that came to her mind when thinking about mathematics. She added "symbols" and "calculations" as important parts of mathematics. She also believed that problem solving was a part of mathematics. However, her responses indicated that she viewed problem solving as applying mathematical facts, rules, and algorithms to answer mathematical problems presented as text (see Section 4.3). Binesh had a similar view for school mathematics. She believed mathematics was dynamic for mathematicians, but not for others (Section 4.4). Apart from viewing mathematics as figures, rules, and procedures, Chanda too believed mathematics involved thinking in order to apply mathematical rules and procedures in computations (Section 4.6).

Aisha and Cala held beliefs that indicated characteristics of both traditional and constructivist beliefs about the nature of mathematics. Aisha, and Cala also believed that mathematics involve rules, facts, and procedures. However their responses to the questionnaire and comments during the interviews suggested that they believed that mathematics was not limited to fixed rules and procedures, but was also dynamic, expanding, and problem driven. They believed problem solving and thinking were important aspects of mathematics.

For example, in describing mathematics, Aisha talked about finding relationships and simplifying complicated problems. Her responses suggested that mathematics was not always absolute or certain, but also a process of thinking and simplifying more complicated problems to less complicated, familiar ones. Cala's conceptualisation of mathematics was quite similar. She believed memorising facts was essential in learning mathematics. At the same time she believed "logical thinking, and make use of brain", and "problem solving" were significant elements in mathematics. She also described mathematics as "ideas" indicating it was creative.

By comparison, Aini's responses indicated only constructivist elements. For her, mathematics involved thinking, reasoning, and problem solving. When asked to describe mathematics she responded: "mathematics involves applying real-life logic to solve problems". She believed that mathematics helps students to learn to think.

Most of the teachers, therefore, had very traditional beliefs about mathematics, viewing it as fixed, procedural, involving applying facts and procedures in computations. Only three of the eight teachers regarded mathematics as a way of thinking and involving problem solving. Of these three teachers, two thought mathematics was partially fixed and involved thinking and problem solving, while the other regarded problem solving as a fundamental aspect of mathematics.

5.1.3 Discussion

Research shows that teachers' beliefs about the nature of mathematics has a strong influence on how they teach it (Raymond, 1997), because, teachers' beliefs about the nature of mathematics are associated with beliefs about teaching and learning mathematics (Ernest, 1989). This suggests that teachers holding traditional beliefs about the nature of mathematics are more likely to employ traditional approaches to teaching and learning mathematics. According to Sapkova (2011), teachers who believe mathematics is a fixed body of knowledge focus on transmitting this knowledge by telling and giving rote learning exercises to students rather than focusing on understanding. This indicates the necessity of changing Maldives teachers' perceptions in order to implement constructivist practice as encouraged in the Maldives curriculum (EDC, 2000a; EDC, 2000b; EDC, 2011a).

5.2 Mathematics learning

This section first presents a summary of teachers' beliefs about mathematics learning that were revealed by the within case analysis. Next, it discusses the themes identified regarding teachers' beliefs about mathematics learning and related practice (learning activities).

5.2.1 Teachers' beliefs about mathematics learning and their categorisation

As with the nature of mathematics, the teachers had a range of beliefs about mathematics learning. However, compared to their views about the nature of mathematics, the teachers had more constructivist beliefs about learning mathematics (Table 5.2).

Table 5.2

Teachers' beliefs about mathematics learning and their categorisation

Participants	Beliefs about mathematics learning	Categorisation
Aisha	▪ Repeated practice is necessary in learning mathematics ▪ Students' textbooks and workbooks are important, but not necessary always ▪ Students learn by working with others, and listening to each other's explanations ▪ Students' prior experience and their active engagement are important in understanding mathematical ideas	Mainly constructivist
Aini	▪ Doing repetitive practice for mastery of skills is important ▪ Students learn through active engagement in learning activities that have meaning to them ▪ Students learn when they relate mathematical knowledge to their experiences ▪ Students learn by working with others	Mainly constructivist
Beena	▪ Drill exercises are crucial for mastery of skills ▪ Following a textbook is important in learning mathematics ▪ Students are active learners ▪ Students learn when they work collaboratively in groups	Mix of traditional and constructivist
Binesh	▪ Repeated practice is essential in learning mathematics ▪ Following a textbook is necessary in learning mathematics ▪ Students learn best by actively engaging in activities ▪ Students learn well when they work in groups ▪ Students' prior experience plays an important role in learning	Mix of traditional and constructivist
Cala	▪ Repeated practice is necessary for students to remember ▪ Students' learn by actively engaging in learning activities, and doing real-life related activities ▪ Exploring and investigating in small groups is essential in learning mathematics ▪ Students learn well by using manipulative materials	Mainly constructivist
Chanda	▪ Textbooks are necessary in learning mathematics ▪ Listening to teachers' explanations and doing repeated practice is essential in learning mathematics ▪ Students learn when they work in small groups and explore mathematical ideas themselves ▪ Students learn when they use manipulative materials	Mix of traditional and constructivist
Dean	▪ Students learn mainly through teacher demonstration and explanation ▪ Students learn well working in groups doing similar types of problems to those the teacher demonstrated or explained	Traditional
Dhakir	▪ Students learn from teachers' explanation and demonstration ▪ Doing all the textbook exercises is necessary in learning mathematics. ▪ Students learn working with others doing similar types of problems to those the teacher demonstrated or explained ▪ Students also learn when they play mathematical games	Mainly traditional

As shown in Table 5.2, two of the eight teachers held a traditional conceptualisation of mathematics learning, three teachers demonstrated beliefs that showed a mix of traditional and constructivist perspectives, and three indicated mostly constructive beliefs about learning mathematics. Figure 5.2 shows the relative position of the teachers' beliefs in relation to these two categories.

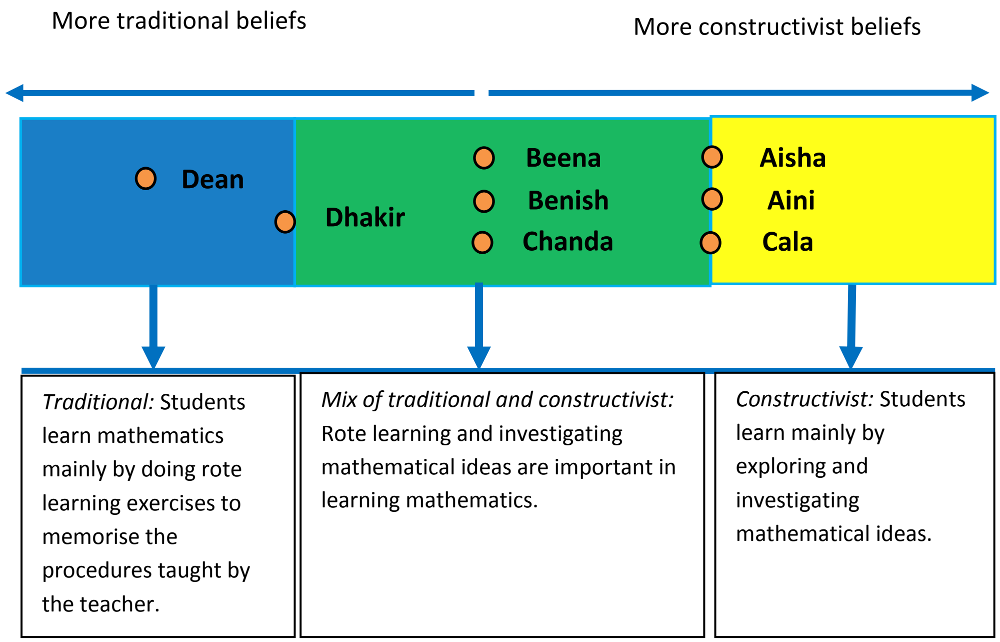


Figure 5.2 Relative positions of teachers' beliefs about mathematics learning

Analysis of the teachers' descriptions of mathematics learning revealed two contrasting views. In one perspective, students learn mathematics best by doing repetitive practice. According to the second perspective, students learn through active engagement in learning activities. However, most of the teachers held beliefs that indicated a mix of these two perspectives to varying degrees.

5.2.2 Rote learning versus exploration and active engagement

Dean and Dhakir[6] had the most traditional beliefs about mathematics learning. They believed students learn mathematics through listening to teachers' explanation, by observing teachers' demonstrations of worked examples, and then doing repetitive practice of similar types of problems. This view was reflected in their instructional practice. In Dean and Dhakir's classes, students spent between 50 and 65 percent of

[6] Dean and Dhakir are from same school and teach at 6th grade

class time listening and observing teacher demonstrations. In all the lessons observed, Dean and Dhakir gave students drill exercises after demonstrating worked examples on the board. Students then spent 20 to 35 percent of class time on individual work.

Dean and Dhakir's beliefs in repetitive practice and memorisation of algorithms were also evident from the group work they assigned to their classes. In this task, students in both the class were given a set of sums after similar types of examples were demonstrated on the board (See Figures 4.7, and 4.8). During the group work, virtually no discussion among the students was noticed. One of the group members worked on the task, while others observed. In some of the groups, students took turns – when one student finished a sum, another student would do the next sum, while the rest would observe.

During the interviews both Dean and Dhakir were asked why they organised the group work in this manner. Both explained that they believed group work helped students to learn mathematics; the purpose of group work was for students who did not understand the teacher's explanation to learn by observing other students doing similar work. Their responses indicated that they did not believe activities requiring students' own exploration and investigation of mathematical ideas in groups enhanced students' learning (Sections 4.7 and 4.8).

During the interview, Dhakir emphasised that it was vital for students to do all of the textbook and workbook exercises. In the questionnaire Dean also indicated that using the textbook and workbook is important in mathematics learning. While both follow the textbook and workbook when giving practice exercises to students, Dhakir believed that practice worksheets and extra sums were also necessary if students were to learn a concept thoroughly.

Likewise, Beena, Binesh, and Chanda believed that students listening to and observing the teacher's explanation, doing drill exercises, and following textbooks were crucial;, but they also believed that students' active participation and working in groups exploring, problem solving, and investigating mathematical ideas was important in understanding mathematics. However, the degree of consistency between these beliefs and the learning activities provided for their students varied from teacher to teacher.

For example, although Binesh held some constructivist beliefs about learning, the learning activities she provided were mostly repetitive drill exercises. Her students spent between 20 and 35 percent of class time working individually on drill exercises. Binesh also gave her students a group activity in two of the three observed lessons. However, similar to Dean and Dhakir, these tasks were not different to the individual work she assigned. Furthermore, little discussion was observed amongst students (Sections 4.7 and 4.8). Chanda's classroom practice was much the same. Although she gave her students group work in all the observed lessons, none of these tasks encouraged discussion, exploration, or investigation of mathematical ideas. In contrast, apart from giving students drill exercises to practise, Beena gave her students some opportunities to work collaboratively in groups and to demonstrate and explain their solution to the class. Yet, these activities seemed focused on getting right answers rather the facilitating students' communication of their thoughts and ideas (Section 4.3).

Aisha, Aini, and Cala had mainly constructivist perspectives about learning mathematics. They believed students' active engagement in learning activities was a fundamental aspect of learning mathematics. For example, Aisha believed that students exploring and investigating mathematical ideas using manipulative materials would facilitate their understanding. According to her, working in small groups, and listening to each others' explanations enhanced students' learning. Aini believed that students understand better when teachers provide them with a situation to discuss and interact with each other. According to her, students need to discuss about how to solve problems. She believed students learned when they "dealt with situations personally". Aisha, Aini, and Cala also believed rote learning was necessary, but they did not think it was important to closely follow the textbook.

The observed practices of Aisha, Aini, and Cala were not consistent with to their beliefs about mathematics learning. While Aisha and Cala demonstrated a mix of traditional and constructivist practice, Aini's observed practice was traditional. Aisha and Cala provided their students with activities to do in small groups. Students also used manipulative materials, and engaged in discussions while doing their work. Although students used manipulative materials, no significant activities were observed that encouraged students' investigation and exploration. Students followed the teachers' step-by-step guide doing the activities, the activities were focused on obtaining "right" answers, and students were not given any problem solving activities.

The only learning activities Aini provided for her students were drill exercises. Furthermore, desks were arranged in single rows and she didn't set any group activities during the observed lessons.

In general, teachers' observed practice was more traditional than their beliefs. The learning activities provided did not encourage students to explore or investigate mathematical ideas and create their own version of knowledge. Furthermore, students spent roughly half of their class time listening and observing teachers' demonstrations of worked examples. The rest of the instructional time students spent mostly doing rote learning exercises. Figure 5.3 shows the percentage of class time students spent doing individual tasks, mostly from students' workbooks

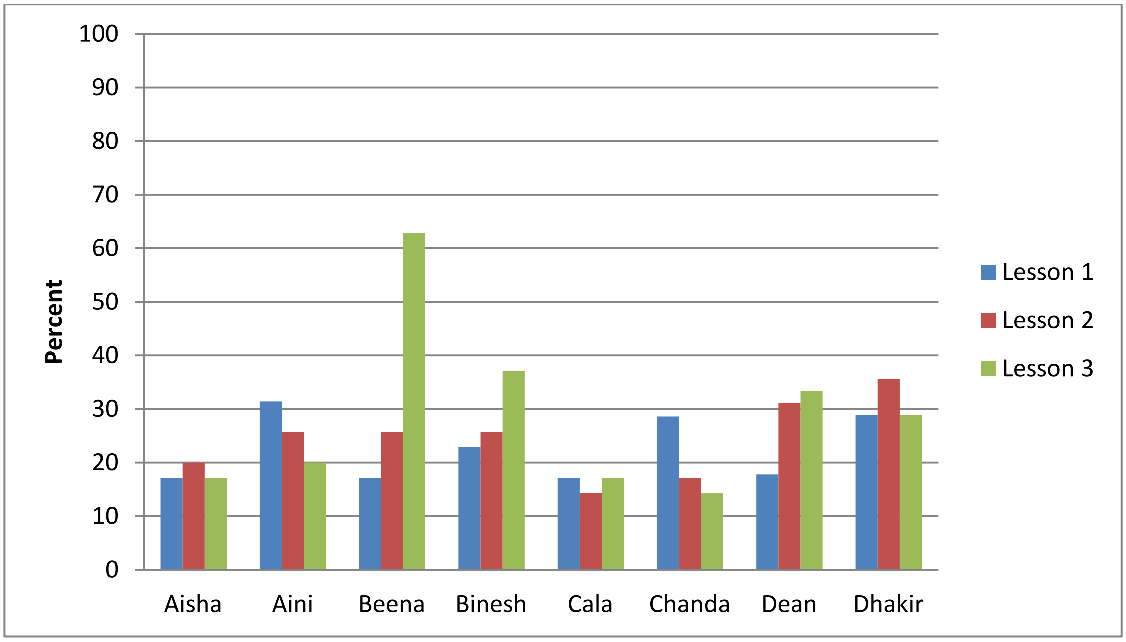


Figure 5.3 Percentage of class time students worked on individual tasks

Often, the teachers gave their students work to complete in groups. Figure 5.4 shows the percentage of class time students spent on group work. However, group work provided by some teachers - Dean, and Dhakir who had predominantly traditional beliefs, and Binesh and Chanda who indicated a mix of traditional and constructivist perspectives - was much the same as the individual exercises. It is important to note that although

Binesh and Chanda had mixed beliefs about learning mathematics, their beliefs about the nature of mathematics were primarily traditional. The overall trend noted in these four teachers' practice was: the teacher explained content, demonstrated worked examples, and then set as group work a few sums of the type explained. In general, group work was followed by individual work from the workbook. No significant discussions were observed in most of the classes.

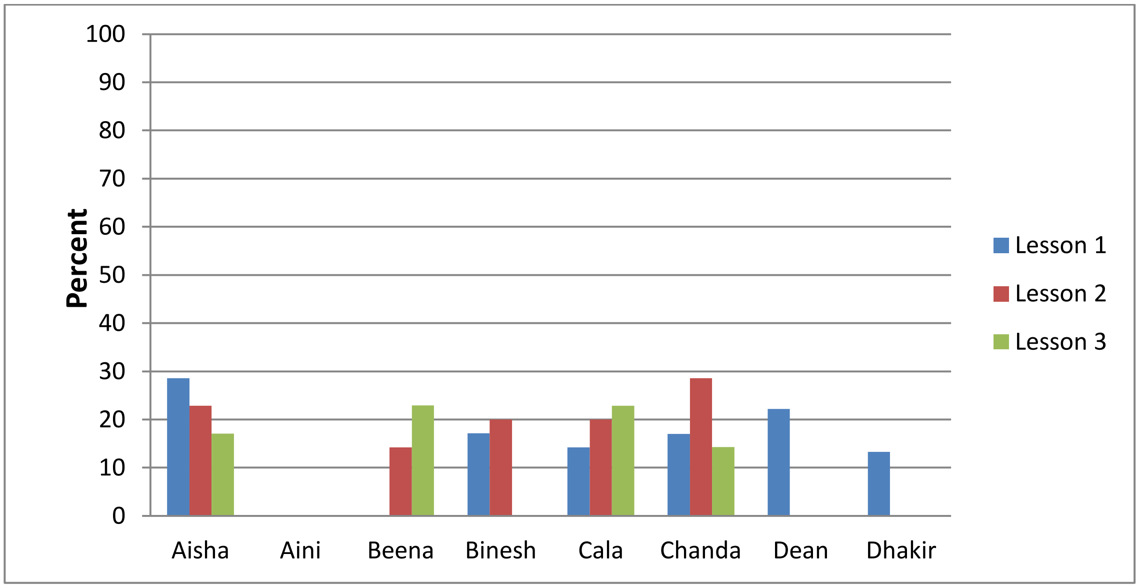


Figure 5.4 Percentage of class time students spent on small group work

In contrast, Aisha, Beena and Cala provided group work that encouraged some discussion. Some of the tasks they provided were not pencil and paper tasks. However, their emphasis was more on correct answers than encouraging students' discussion and seeking to elaborate students' ideas.

All the teachers, regardless of their beliefs about learning mathematics, followed the students' workbook. In all the 24 lessons observed, the teachers gave a book exercise either to do in class or as homework.

5.2.3 Discussion

Only two teachers believed that students learn mainly from teacher explanation and practising the types of sums demonstrated by the teacher. The majority had a mix of traditional and constructivist beliefs about mathematics learning. They recognised the importance of active engagement, problem solving, use of manipulative materials, investigating and exploring mathematical ideas, and collaborative group work in enhancing students' learning. At the same time, they believed in the importance of rote learning exercises to understanding mathematics. Some teachers appear to believe that using particular strategies such as group work and manipulative materials are indicators that their students are actively engaging in learning process regardless of the way they are used. Similarly, for some, problem solving seems to be the same as applying mathematical procedures in computation or solving word problems.

Although, some of the beliefs of the teachers about how students learn mathematics are compatible with the constructivist curriculum of the Maldives (EDC, 2000a; EDC, 2000b; EDC, 2011a), these beliefs are not reflected in the learning activities provided to their students. The learning activities observed were similar to traditional ways of learning described by Pritchard and Woollard (2010) and Gregg (1995). Activities the students undertook were predominantly drill learning to promote memorisation of rules and algorithms. Students spent most of their time on learning by rote, working in silence, and doing practice sums from workbooks. Problem solving, the sharing of ideas, and use of manipulative materials were not commonly observed. Although group work was a frequently used teaching strategy, it was not different to drill exercises provided for students to do individually.

5.3 Mathematics teaching

This section first provides a summary of teachers' beliefs about mathematics teaching as revealed by the within-case analysis and their categorisation with respect to traditional and constructivist perspectives. Next, it describes the themes that emerged from the cross-case analysis regarding teachers' beliefs about mathematics teaching and instructional strategies.

5.3.1 Teachers' beliefs about mathematics teaching and their categorisation

As with their perspectives about the nature of mathematics and mathematics learning, teachers held a range of beliefs about mathematics teaching (Table 5.3).

Table 5.3

A summary of individual of teachers' beliefs about mathematics teaching

Participants	Beliefs about mathematics	Categorisation
Aisha	▪ The teacher must provide students with small group activities and encourage them to express their ideas and opinions ▪ The teacher must provide students with problem solving situations and manipulative materials for them to explore mathematical ideas themselves ▪ The teacher must help students to link new knowledge they learn to their real-life experience ▪ Teachers should give thorough explanation of mathematical rules and procedures before assigning a problem	Primarily constructivist
Aini	▪ The teacher's responsibility is to provide a learning situation for students ▪ The teacher must use a variety of teaching aides to facilitate students' understanding, and provide students with manipulative materials for them to use and explore mathematical ideas ▪ The teacher should encourage and provide activities for students to work with each other, and encourage discussions	Constructivist
Beena	▪ The teacher must provide activities that encourage students to engage actively ▪ The teacher must facilitate students to link the new knowledge to students' daily life experience ▪ The teacher should provide students with drill exercises	Mix of traditional and constructivist
Binesh	▪ The teacher should provide students with problematic situations for them to investigate and find solutions themselves ▪ The teacher should follow the textbook ▪ The teacher's explanation of content is vital in mathematics teaching	Mix of traditional and constructivist
Cala	▪ The teacher should provide students with problems, and activities that encourage them to think and discuss with each other ▪ The teacher must encourage students' active engagement ▪ The teacher should provide students with activities that encourage experimenting and exploration of mathematical ideas ▪ The teacher should provide students with clear explanation of content, and provide drill exercise for them to practise	Mix of traditional and constructivist
Chanda	▪ The teacher must facilitate the link with what students learn to real-life situations, and encourage them to think critically ▪ The teacher should provide students with problem solving activities, and small group work ▪ The teacher should follow students' textbook in giving instructions, and make sure students receive this knowledge	Mix of traditional and constructivist
Dean	▪ The teacher's role is to give clear explanations, and make sure students receive the content explained ▪ The tasks and practice exercises given to students must not confuse them, and the teacher should give step by step procedures to follow before assigning them tasks	Traditional
Dhakir	▪ The effective teacher gives a clear explanation of content and step by step procedures for students to follow ▪ The teacher should provide drill exercises for students to practise both individually and in groups	Traditional

Two of the eight teachers indicated primarily traditional beliefs; five showed a mix of traditional and constructivist beliefs, with one holding a quite constructivist conceptualisation. Figure 5.5 shows the relative position of teachers' beliefs about mathematics teaching.

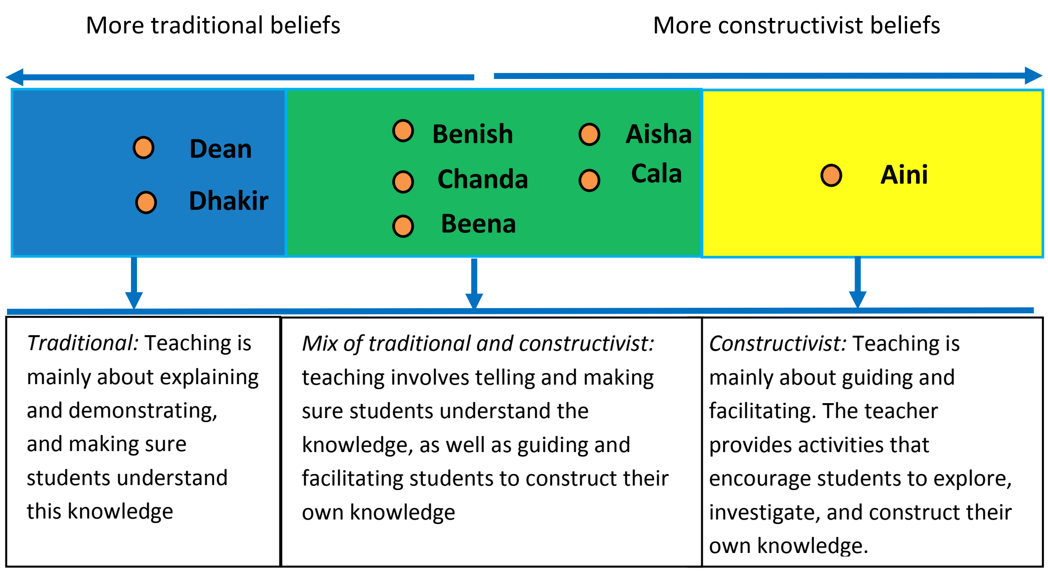


Figure 5.5 Relative positions of teachers' beliefs about teaching of mathematics

The analysis of teachers' responses regarding mathematics teaching revealed two contrasting themes. The first is the belief that teaching is all about telling and demonstrating procedures to students, and assigning exercises to practise the intended skill or memorise the procedures. The second theme is associated with the belief that teaching is about guiding and facilitating students' learning. In this view, effective teaching involves providing students with a chance to actively engage in the learning process. The teachers' demonstrated beliefs related to these two contrasting views to different degrees.

5.3.2 Telling and demonstrating versus guiding students

Dean and Dhakir had traditional beliefs. Their responses indicated that they believed the teachers' role was to explain and deliver knowledge from the textbook. For example, in the questionnaire, Dean and Dhakir pointed out that teachers should plan instruction based on students' textbook and workbook, and should verify that students received the knowledge in these books. Also, they strongly agreed that teachers should explain thoroughly mathematical rules and procedures before giving students mathematical problems.

This view was also reinforced in Dhakir and Dean's comments during the interviews and their responses to open questions in the questionnaire suggesting that they believed a good and clear explanation was an important aspect of effective teaching. For Dean and Dhakir, step-by-step algorithms need to be explained before assigning students tasks. They viewed the students' role as following what was being demonstrated to them. For example, Dean believed that it would lead to confusion if work was given to students without a clear explanation of a step-by-step procedure of how to get the answers. Both in the questionnaire and in the interview Dhakir mentioned explaining to the students the "easy methods of doing mathematics". In the questionnaire he also mentioned that he was not sure if students could learn by actively participating in the learning process. His responses suggest that he regards a good teacher as one who simplifies step-by-step procedures to students.

Dean and Dhakir's classroom practice reflected their beliefs. They spent between 50 and 70 percent of the class time on explanation and demonstration of content from the textbook. The focus of teaching was on how to get the right answers rather than making meaning. For example, both were observed teaching linear equations and addition and subtraction of fractions. They explained to the students step-by step-algorithms and provided students with exercises to help them memorise the algorithms. Students' understanding was checked by their ability to get the right answers.

Aisha, Beena, Benish, Chanda, and Cala all had a mix of traditional and constructivist beliefs about teaching mathematics. They believed teaching involves explanation and demonstration of specific content knowledge and making sure students understand this knowledge. They also believed that effective teaching includes guiding students with activities that encourage investigating and exploring mathematical ideas indicating the role of the teacher is not always transmitting the knowledge.

However, the constructivist beliefs of these teachers were not reflected much in their instructional practice. Like Dean and Dhakir, they spent a large amount of time on explanation and delivering the content, or on drill exercises, rather than focusing on meaning making activities[7] - see Figure 5.6.

[7] Learning activities teachers provided for their students are discussed in Section 5.3.

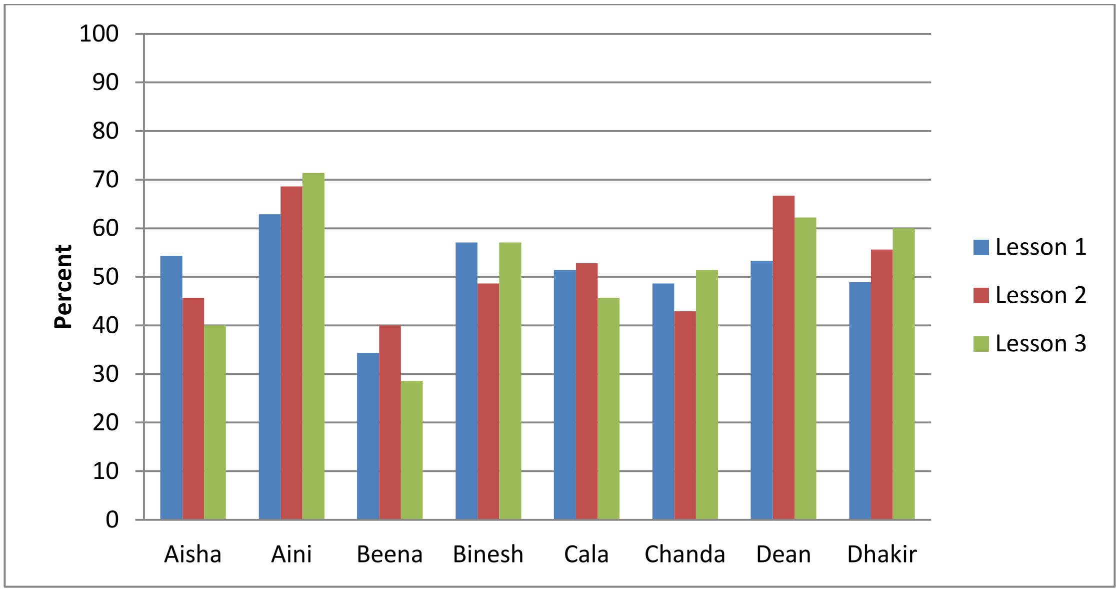


Figure 5.6 Percentage of instructional time spent on explanation and demonstration of content materials and procedures

Although the teachers spent a large amount of time explaining the content, some of them provided students with small group activities and materials to use themselves. Aisha, Beena, and Cala's students were comparatively more active. Student-to-student discussions were observed during small group activities. However, the tasks provided were straightforward and did not appear to challenge the students or encourage exploration and investigation of mathematical concepts. Students were not observed to be puzzled or trying to figure out how to arrive at a solution.

Aini's responses during the interview and her comments in the questionnaire suggested that she had quite constructivist beliefs. She was the only teacher who thought it was not necessary for teachers to explain mathematical rules and procedures thoroughly before assigning students a task. She described the teacher's role as that of a facilitator, and believed that the teacher's responsibility was to provide a learning environment for students. She believed students using manipulative materials and working collaboratively in small groups to be effective teaching strategies.

However, Aini's instructional practice was also similar to Dean and Dhakir who believed the students' role was to follow what was being told and demonstrated. She was not observed facilitating learning situations where the students took an active role in learning. Students in her class were not observed engaging in any group activity during three observed lessons. They listened and observed the teacher's demonstration, and worked alone at their desks. Discussions were only between Aini and the students in the form of questions and answers where she asked almost all the questions. The questions were focused on checking if students knew the right answers and the procedures to perform to get the right answers.

Aini, Dean, Dhakir, and Binesh (6^{th} grade teachers) were observed teaching simple linear equations. None provided students with problematic situations, rather they demonstrated step-by-step procedures to get the answers, and then gave students exercises to practise paper and pencil computational skills. For example, after demonstrating six examples of the type $\mp x \mp c_1 = c_2$, where c_1 and c_2 are constants, and x is the unknown, Binesh gave similar types of sums for students to practise. In this lesson she introduced the equation for the first time. However, no activity was given that focused on meaning making.

5.3.3 Discussion

Overall, teachers held a mix of traditional and constructivist beliefs about mathematics teaching. The majority of them thought teachers should provide students with activities that encourage them to explore and investigate mathematical ideas. They also believed that thorough explanation of procedures and rules was necessary before assigning any mathematical task. However, only three teachers included constructivist elements in their practice. The observed practices of these teachers were also less constructivist than their beliefs.

In general, the practices were traditional. As Gregg (1995) describes, teachers spent most of their instructional time explaining to the whole class and then assigning drill exercise to practise what was explained. The role of most of the teachers seemed to be transmitting the knowledge from students' textbooks and workbooks, and making sure they reviewed this knowledge. Class discussions were aimed at checking whether students understood the content teachers explained to them rather than promoting students' thinking and helping them construct understanding. Therefore, despite some constructivist beliefs of the teachers, the observed instructional practice of the majority of the teachers was not consistent with constructivist learning theories (see Section 2.2) or the goals of the Maldives' curriculum of such development of students problem solving, and critical thinking (see Section 1.2.1).

5.4 Beliefs and practice

Individual teachers expressed more or less similar beliefs about teaching and learning mathematics (Figure 5.7). However, inconsistencies were observed between individual teachers' beliefs about the nature of mathematics and the other two belief categories (mathematics teaching and mathematics learning). Apart from Aini and Dean, all the teachers' beliefs about the nature of mathematics were more traditional than their beliefs about teaching and learning mathematics. Dean's beliefs about mathematics, and mathematics teaching and learning were consistently traditional. Only Aini had beliefs about the nature of mathematics which were more constructivist than her beliefs about mathematics learning.

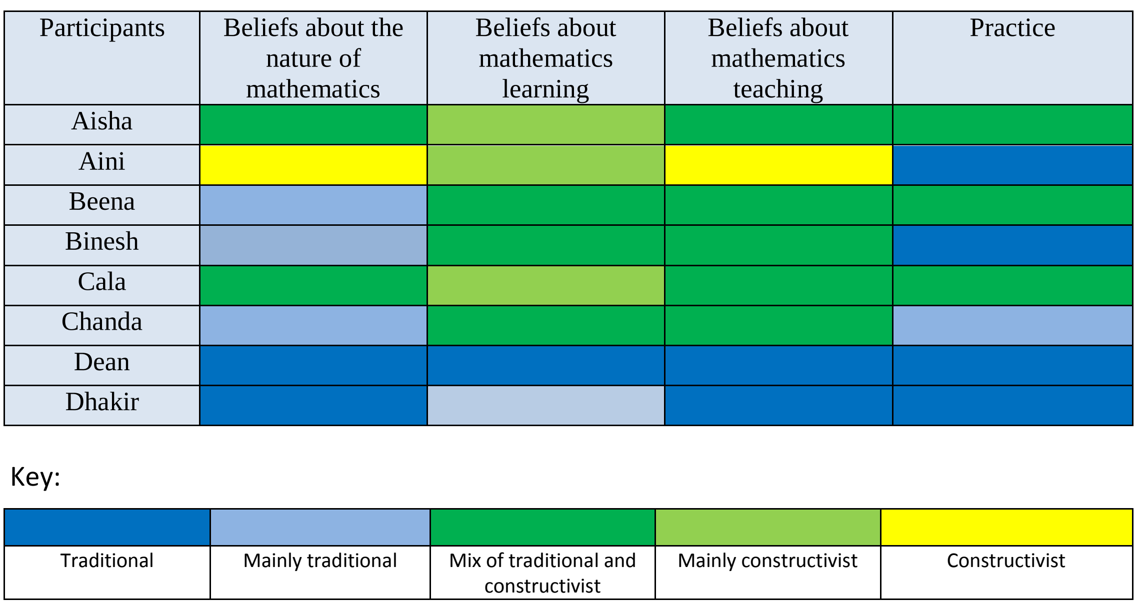


Figure 5.7 Categorisation of teachers' beliefs about the nature of mathematics, mathematics teaching, and mathematics learning

Teachers' beliefs about the nature of mathematics, mathematics teaching, mathematics learning were not fully consistent with their practice. The degree of consistency varied.

Aisha, Beena, Cala, Dean, and Dhakir showed the highest degree of coherence between beliefs and practice. Dean and Dhakir held quite traditional conceptualisations about mathematics, and its learning and teaching. These beliefs were clearly evident in their instruction practice and the learning activities they provided to the students. The only inconsistency observed was that their belief that mathematics was applicable and related to everyday life activities was not reflected in their instructional practice. On the other hand, Aisha and Cala both had mainly mixed beliefs about mathematics, and teaching and learning mathematics, and these beliefs were reflected in their practice. Similarly, as with her beliefs about mathematics learning and mathematics teaching, Beena's instructional practice had a mix of elements. However, in general, the observed practices of all the three were less constructivist than their beliefs. Although they used strategies that are regarded as constructivist, often these strategies were not used in a constructivist manner (see Section 2.2.3).

Binesh and Chanda's instructional practice was more consistent with their beliefs about the nature of mathematics. Their beliefs about mathematics and observed instructional practice were predominantly traditional while their beliefs about teaching and learning were mixed.

Aini had the highest degree of incongruity between beliefs and practice. She held quite constructivist beliefs about mathematics, mathematics learning, and teaching whereas her observed practice was very traditional.

Figures 5.8, 5.9 and 5.10 (visual displays, not graphs) illustrate the relationship between practice and each of three belief categories. These Figures might be interpreted with a great deal of caution and are worthy of further investigation.

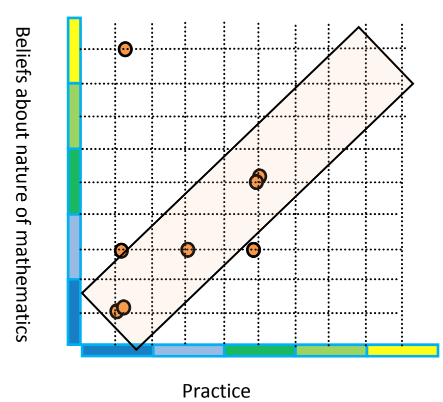


Figure 5.8 Beliefs about the nature of mathematics and instructional practice

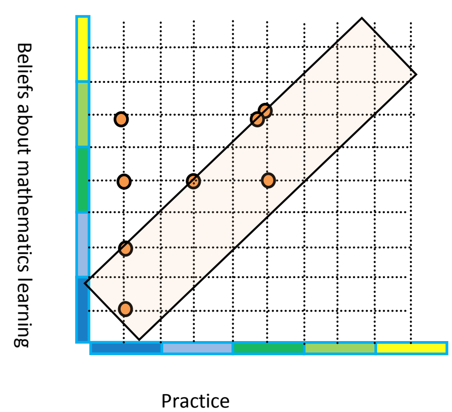


Figure 5.9 Beliefs about mathematics learning and instructional practice

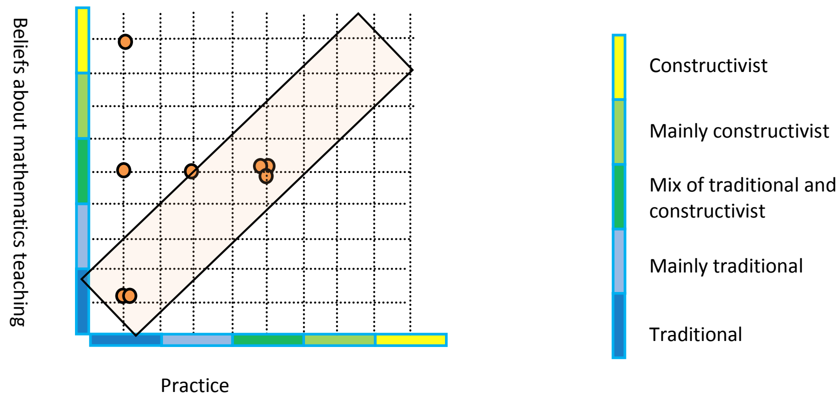


Figure 5.10 Beliefs about mathematics teaching and instructional practice

Note: Each circular mark represents the type of belief and practice of a teacher. The rectangular box highlights those with some consistency between beliefs and practice.

As shown in Figures 5.8, 5.9 and 5.10 the teachers had more constructivist beliefs about teaching and learning mathematics than about the nature of mathematics. Their practice, however, seemed more consistent with their (more traditional) beliefs about the nature of mathematics. Although three sets of beliefs and practice were not consistent, it suggests that beliefs have influence on teachers' instructional practice. As shown in Figures 5.8, 5.9 and 5.10, only two teachers had practice that was notably different from their beliefs.

5.4.1 Factors affecting teachers' instructional practice

In the questionnaire and interviews teachers were asked about factors that inhibited or promoted translating their beliefs into practice. The analysis of teachers' responses revealed that the way students were assessed and evaluated had a strong influence on teachers' instructional practice. Other key mediating factors included the availability of time, school culture, curriculum material to be covered, and expectations of parents.

All of the teachers indicated that the way students were assessed - by paper and pencil tests only - played a significant role in shaping their instructional practice, and that teachers did not have the flexibility to assess students in a different way. For example, during the interview, Aini identified paper and pencil tests and exams as a major limit on her instructional practice; besides assessing students' progress, tests results were the main indicator of effectiveness of teaching. Aini's responses suggested that teachers who produced "good results" were regarded as effective teachers and, therefore, wanted to teach the same types of problems that appeared in the tests and exams as that would improve test results.

Although Aisha thought it was not necessary for students to do all of the workbook exercises or for the teacher to instruct solely from the textbook, her instructional practice was based on the textbook, and her students were regularly assigned exercises from the workbook in class as well as for homework. Aisha said she followed the textbook because students were assessed by workbook and textbook-based tests and exams. Beena, Chanda, and Cala also indicated their instructional practice was influenced by the way students were assessed. Beena believed that teachers could not teach one thing if the assessments were on something else. Similarly, during the interview, discussing the reasons for doing workbook or textbook exercises, Cala said that they assessed students from the textbook. According to her, the students were not assessed to find out if they could apply the knowledge in real-life.

While the way students were assessed limited some of the teachers' instructional practice, others regarded this as a supporting factor. Binesh indicated that the way students were assessed justified teaching in a teacher-centred way. She thought her instructional practice was effective because her students got good results (Section 4.4). Dean and Dhakir's responses and practice suggested that their teaching was mainly focused on exams. Dean believed rote learning and revision lessons were important because that improved test results. When teaching his students how to solve mathematical sums, Dhakir explained "simple and easy-to-follow" methods which he believed would help students to recall what to do in exams. Furthermore, Dean and Dhakir also believed that students' results were an indicator of how effective their teaching was.

The teachers' responses indicated time as another factor that influenced their instructional behaviour. Several thought they did not have enough time to include activities that encouraged students to explore and investigate mathematical ideas. For example, Aini said she used direct instruction in order to cover the content in the limited time she had. She believed student-centred activities took more time. Similarly, Beena, Cala, and Chanda thought that they needed more time if they were to include activities for students to actively engage in the learning process. Furthermore, Cala thought inflexible time schedules also limited her instructional practice. While teachers were sometimes required to lengthen the class period based on the topic and the type of activities they wanted to include, maths periods were fixed (Section 4.5) and, therefore, she could not include any activity that would require more time.

Parents and schools' pressure to improve test results, and follow the textbook seemed to also affect teachers' practice. Teachers indicated that they were supposed to follow the students' textbook and workbook. For example, during her interview Cala said that parents expect the teachers to follow the textbook and do all the workbook exercises. Aisha, Beena, and Aini also expressed their concern about parents' complaints if they didn't closely follow the workbook, but acknowledged that they could decide not to give students some textbook exercises provided the reasons were explained to parents.

In addition to pressure to follow the textbooks, parents and school management demanded teachers work to improve test results. For example, in discussing limitations in translating beliefs into practice, Cala, Chanda, Binesh, Dean, and Dhakir all expressed concern about pressure to get good results from school tests and exams. According to Cala and Chanda they had to re-test students if the students had lower marks than expected.

All the teachers mentioned that the topics and practice exercises from the workbook or textbook that would be given to students were decided in weekly subject coordination meetings[8], also limiting teachers' freedom to vary instructional practice. However, teachers acknowledged that individual teachers decided how they conducted the lessons and the types of learning activities given to students.

5.4.2 Discussion

The teachers' expressed beliefs about the nature of mathematics, mathematics learning, and teaching were not fully consistent with their instructional practice. Teachers'

[8] Subject teachers teaching the same grade level met at the end of each week to decide the materials to be covered in the next week. These meetings were often coordinated by the leading teacher/s supervising the grade level (see Chapter Four).

traditional beliefs were more closely related with their practice than were their constructivist beliefs. Based on literature, there are two possible explanations for this.

Firstly, according to Green (1971), some beliefs are held more strongly than others. Teachers' beliefs about subject content and its teaching and learning originate from their own experience of former schooling (Thompson, 1984). Furthermore, teacher education and professional development programmes often focus on transmitting pedagogical content knowledge, thereby strengthening instead of modifying teachers' traditional beliefs (Handal, 2003). Thus, the traditional nature of the teachers' practice may be due to the psychological strength of their traditional beliefs which may be held more strongly than their constructivist beliefs because of their own experiences of education.

Secondly, teachers' instructional practice is not only based on beliefs, but also on constraints and opportunities provided by the social context of teaching (Ernest, 1989). Jorgensen et al. (2010) note that the beliefs reflected through teachers' instructional practice are more "real-life" and affected by other concerns of the classroom. Teachers may find constructivist beliefs more difficult to implement due to the constrained nature of the school environment and factors limiting their practice (see Section 2.6).

The study teachers reported a number of factors affecting their instructional practice: assessment practice, teacher accountability for students' results, school' and parents' pressure, nature of textbooks, time constraints, and lack of teaching and learning resources. The assessment practice was associated with all the factors except teaching and learning resources (see Figure 5.11).

Teachers' instructional practice was guided to a great extent by students' performance in the tests. Teachers adopted the methods which they believed helped students to pass the exams. They did not put much effort into making mathematics meaningful to the students; rather the emphasis was on memorising the mathematical procedures, rules, and symbols they were assessed on. Students were believed to be good at mathematics if they could apply the procedures even without knowing the reasons for using them. The literature suggests that this is the case when students are assessed only by pencil and paper test and teachers are accountable for students' results (e.g., Airasian, 1988; Harlen & Crick, 2008; Popham, 1987; Smith, 1991). According to Harlen (2008) assessment guides the classroom instruction when schools and teachers experience pressure about students' results.

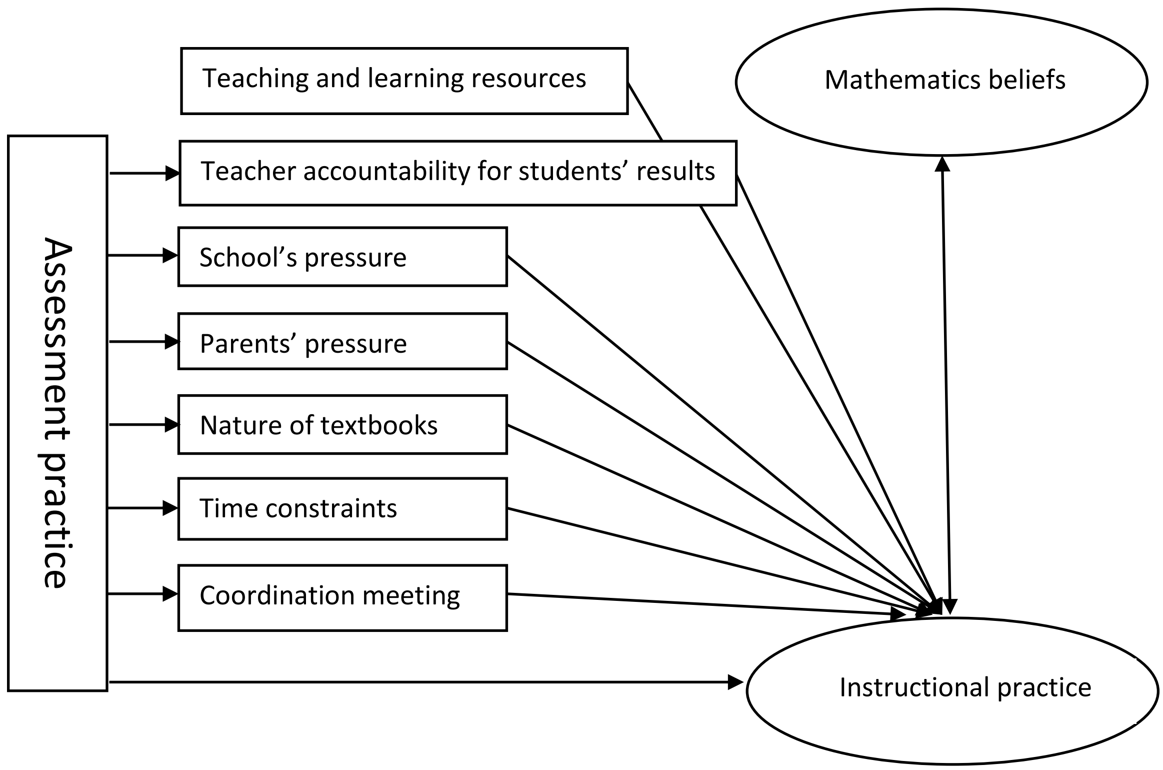


Figure 5.11 Relationship between teachers' beliefs, practices, and factors affecting them
Note: The arrows indicate the direction of the influence.

Parental pressure to use textbooks was apparently due to "pencil and paper tests" which are the only method of assessment in upper primary classes. These tests focused on measuring students' procedural understanding rather than higher level thinking and conceptual understandings. Exercises in textbooks are similar to questions that would come in these tests. From teachers' descriptions of parents' pressure it seems that parents regard teachers' failure to complete textbook exercises as evidence of teachers not properly covering areas of the curriculum that are to be assessed. For teachers, completing all the exercises in textbooks and giving extra worksheets for practice seems less risky in relation to, as well as an effective method of, helping students pass.

Teachers thought the time available was insufficient to cover all textbook materials and include activities that encourage students to explore and investigate mathematical ideas.

The textbook materials support and encourage the traditional approach as they consist of a number of worked examples and exercises to practise these procedures.

Another influential factor that is related to assessment methods was teachers' coordination meetings (see Chapter Four). In these meetings teachers mainly discussed the content and workbook pages to be covered. The purpose seems to be to teach exactly the same content at the same rate to all the parallel classes. This is because students in parallel classes are assessed by uniform test papers at the same point in time. A number of teachers mentioned that they had to do all the textbook exercises because it was decided in coordination meetings, and would be assessed by pencil and paper tests. Other reported factors included classroom size, and lack of resources.

5.5 Summary

The teachers beliefs about mathematics, mathematics teaching, mathematics learning, and their practice can be placed on a continuum between traditional and constructivist beliefs. Although inconsistencies were observed, in general, the beliefs of the teachers were reflected to varying degrees in their practice. The teachers' identified reasons for inconsistencies included assessment practice, limited time, pressure from parents' and schools, teachers' accountability for students' results, and coordination meetings. The next chapter provides an overall discussion of findings and a conclusion.

CHAPTER SIX

Discussion and conclusions

The purpose of this study was to explore and examine primary teachers' mathematical beliefs and practice in the Maldives and identify the factors affecting their practice. For this purpose, the study considered the following four questions: What beliefs do upper primary teachers hold about teaching and learning mathematics? How are the Maldivian upper primary teachers' beliefs and practices regarding teaching and learning mathematics different from or similar to the constructivist approach? Are there inconsistencies between upper primary teachers' beliefs and their instructional practice? What are the factors that inhibit or promote upper primary teachers' translation of beliefs into practice?

The study used a qualitative multiple case study approach. The participants for the study consisted of eight teachers and their classes from four schools in two different regions in the Maldives. Data were collected using a questionnaire, observations, interviews, and an analysis of documents which consisted of lesson notes for observed lessons, samples of students' work, and test papers. Data were analysed within and across cases using a thematic approach.

This chapter summarises the main findings (Section 6.1); implications of the study (Section 6.2); its limitations (Section 6.3); and areas for further research (Section 6.4). The chapter closes with a brief summary (Section 6.5).

6.1 Main findings

The main findings are summarised as follows: section 6.1.1 summarises the findings associated with the research questions one and two, while sections 6.1.2 and 6.1.3 outline the findings related to questions three and four respectively.

6.1.1 Teachers’ beliefs about the nature of mathematics, mathematics learning, and mathematics teaching.

As in the findings of earlier studies (e.g., Alamu, 2010; Cross, 2009; Thompson, 1984; Whitehouse, 2003), teachers in this study were found to hold beliefs about the nature of mathematics, mathematics learning, and mathematics teaching that reflect a combination of traditional and constructivist perspectives to varying degrees.

In most cases, as also found by Raymond (1997), the teachers’ beliefs about the nature of mathematics were more traditional than their beliefs about mathematics learning and teaching. The majority of the teachers viewed mathematics as a subject with a fixed body of knowledge that consists mainly of rules, procedures, and computations. For these teachers, doing mathematics involves applying mathematical rules, algorithms, and computations. Only three teachers indicated the belief that mathematics was dynamic, a way of thinking, and a problem solving subject (Section 5.1).

Unlike the teachers’ beliefs about the nature of mathematics, in general, the teachers had a mix of traditional and constructivist beliefs about mathematics learning and mathematics teaching. All eight teachers believed that doing drill exercises to master skills was important in learning mathematics. For them, a clear and thorough explanation of rules, procedures, and demonstration of worked examples was necessary before assigning students any mathematical task. Despite their traditional beliefs, the majority of the teachers believed, to varying degrees, that problem solving, use of manipulative materials, students’ active engagement in learning activities, exploring and investigating mathematical ideas, and collaborative group work were effective learning strategies. They also believed that providing activities that encouraged students’ active participation and investigation of mathematical ideas was an important teaching strategy. However, the responses of some teachers indicated their lack of understanding of constructivist use of teaching strategies such as group work and problem solving (Sections 5.2 and 5.3).

Among the three categories of beliefs, teachers’ beliefs about mathematics learning and mathematics teaching are most closely related. Teachers who held constructivist beliefs about mathematics learning had similar views about mathematics teaching and vice versa (Sections 5.1, 5.2, 5.3, and 5.4).

6.1.2 Inconsistencies between teachers' beliefs and practice

Earlier studies show varying degrees of inconsistencies between beliefs and practice. Some show a high degree of consistency (e.g., Cross, 2009; Stipek at el., 2001), while others show a significant level of discrepancy (e.g., Cooney, 1985; Jorgensen et al., 2011; Raymond, 1997). Similar to Cooney (1985), Jorgensen et al. (2011), and Raymond (1997), this study revealed that teachers' mathematical beliefs were not fully consistent with their instructional practice. The degree of inconsistency between beliefs and practice also differed from teacher to teacher (Section 5.4).

Generally, inconsistencies were found between beliefs and practice of the teachers who held constructivist or a mix of traditional and constructivist beliefs (see Figure 5.7). However, the instructional practice of the teachers who held traditional beliefs about the nature of mathematics, mathematics learning, and mathematics teaching were found to be highly consistent with their beliefs. In most cases, the teachers' instructional practices were more traditional than their beliefs.

Despite the range of beliefs teachers held, in general, they were observed to use a similar traditional pattern in their instructional practices (Section 5.3): normally starting the lesson by telling what the lesson was about, then explaining the content with some demonstration of worked examples and giving students questions similar to the demonstrated examples. Similar to Mohamed's (2006) findings in relation to teaching English, the teachers spent a remarkably high amount of their class time on explanation and demonstration of worked examples.

Although group activities were frequently used, they were used traditionally in that teachers often gave students questions similar to those demonstrated to complete in groups before assigning individual exercises. Unfinished exercises during the lesson were normally assigned as homework.

The mismatch between beliefs and practice can be explained, as Ernest (1989) argues, by factors that inhibit or promote teachers' instructional practice. Similar to a number of earlier studies (e.g., Bolden & Newton, 2008; Cooney, 1985), in this study the teachers reported various factors limiting their instructional practice.

The inconsistencies observed between beliefs and practice may also be partially due to the psychological strengths of conflicting beliefs: traditional beliefs may be “psychologically central” or “core beliefs” (Green, 1971) due to the traditional nature of the teaching environment; constructivist beliefs may be psychologically peripheral and held with less strength, making them less evident in their practice. Inconsistencies may also be due to teachers’ lack of understanding of how constructivism is enacted in the classroom.

6.1.3 Factors affecting instructional practice

Earlier studies (e.g., Barkatsas & Malone, 2005; Bolden & Newton, 2008; Cooney, 1985; Jorgensen et al., 2010; Raymond, 1997) have identified a number of factors affecting teachers’ instructional practice. Similarly, in this study, teachers indicated national assessment practices, school and parents’ pressure, the nature of textbooks, time constraints, teacher accountability for students’ performance in tests, coordination meetings, teaching and learning resources influencing their instructional practice. Among these factors, national assessment practice was shown to be particularly influential (Sections 5.4.1 and 5.4.2).

Assessment practice was found to be associated with most of the other factors limiting teachers’ instructional practice. For example, teachers’ responses during the interviews indicated that parents expect them to base lessons on textbook and workbook materials as the students are assessed from these materials by pencil and paper tests. The coordination meetings were to ensure that teachers covered the same content materials. This was because the students in parallel classes were given uniform tests at the same point in time. Similarly, a number of teachers indicated that the time available was insufficient for them to include activities that encouraged students’ active participation and for them to investigate mathematical ideas.

According to Harlen (2008), assessment leads the curriculum and methods of instructional practice when schools and teachers have pressure on assessment results. Current assessment practice in the Maldives seems to be having similar effects on teachers’ instructional practice, encouraging them to focus on tests practising for them rather than teaching for understanding.

6.2 Implications of the findings

For the study teachers to properly implement the curriculum and/or constructivist practice, a number of recommendations are offered.

First, the Maldives curriculum strongly encourages students to explore, seek and construct knowledge. It emphasises the development of students' problem solving, reasoning, creative and critical thinking skills, and discourages learning mathematics by rote memorisation (Chapter One). However, this study shows that teachers had traditional beliefs to different degrees which were inconsistent with the curriculum or a constructivist approach (Chapters Four and Five). For the most traditional of the teachers, there may need to be a considerable amount of change in their beliefs for them to change their practice as these teachers not only held traditional beliefs, but also viewed their traditional practice of teaching as being very successful. Therefore, these teachers need to be engaged in professional development programmes that transform beliefs.

For teachers to transform their beliefs as Swan (2007) suggested, they must be provided with opportunities to observe instructional practices which are different from their own practice. They have to think critically about what alternative teaching methods and strategies they can use to best improve students' learning. Professional development programmes that help teachers to make their implicit beliefs explicit, re-examine their practice, and provide opportunities to try new practice and reflect on them were reported to be successful in changing teachers' beliefs and practice (Duran et al., 2009; Kagan, 1992; Rosenfeld & Rosenfeld, 2008; Swan, 2007; Swan & Swain, 2010).

Additionally, teachers need to experience mathematics as a logical, creative, dynamic, and problem driven subject. The study teachers' most traditional beliefs were about the nature of mathematics, and these beliefs were closely related to their instructional practice (Sections 5.1 and 5.5). Therefore, it is recommended that teachers' views about the nature of mathematics be actively challenged. Literature shows that to change teachers' views about the nature of mathematics, and for them to teach mathematics in constructivist ways, teachers must be taught mathematics in the same manner during their own learning, particularly during teacher education, or professional development programmes (e.g., Handal, 2003). This is because a teacher's beliefs about subject-matter, teaching, and learning are strongly influenced by their own experience of learning mathematics (Kagen, 1992; Thompson, 1984).

Similarly, for teachers to implement constructivist teaching, they need the knowledge and skills to implement such practice. Some of the teachers' responses indicated their lack of understanding of what constructivist teaching involves. Teachers should be aware that it is the learning environment and the classroom culture as well as particular set of strategies and the nature of tasks set that leads to constructivist teaching. Therefore, these teachers need to be engaged in programmes that provide pedagogical content knowledge.

Apart from teachers' beliefs and pedagogical content knowledge, the study identified a number of other factors that had strong influence on instructional practice. The current assessment practice has been shown to have a powerful impact on teachers' practice. This finding suggests using alternative methods of assessing students' learning if teachers are to implement the curriculum as intended. It is highlighted in the curriculum (EDC, 2000b) that teachers should be aware that students may not understand mathematics by rote learning. However, if school tests mainly focus on assessing students' computational skills and their ability to apply algorithms, the findings indicate that the focus of instructional practice will also be on practicing these skills and algorithms. As a participant teacher stated, it may not be possible to assess one thing and teach a different thing.

According to a number of researchers (e.g., Black & Wiliam, 2008; Harlen, 2007), if reforms in education are to change practice, assessment must be changed accordingly. Literature suggests that, with reform in education, teachers should be given more responsibility for assessing their students (e.g., Padilla, 2005). Assessment should be a part of the learning process, therefore, and should focus on obtaining information about the process of learning rather than about the products (Black & Wiliam, 2008). It should include multiple indicators of learning, and should be linked to the context of teaching and learning (Padilla, 2005).

Furthermore, the current practice of coordination meetings limit teachers' choice of learning activities as the focus of these meetings was to ensure that they cover uniform content each week (see Chapters One and Four). This study clearly indicates a need to change the way coordination meetings are conducted. Teachers require flexibility to adapt curriculum materials if they are to provide learning activities that enable students to explore and construct knowledge through active engagement as encouraged by the Maldives curriculum (EDC, 2011a; EDC, 2000b).

Finally, the findings show that the nature of the textbooks currently being used limits implementation of the curriculum. The Ministry of Education provides textbooks, and teachers are expected to follow them (see Chapter One). Teachers spent a remarkably high amount of their class time explaining and demonstrating textbook examples on the board, and the rest of the time students spent completing textbook exercises both individually and in groups. If teachers are to both implement the curriculum and follow the textbook, textbooks must be well aligned with the curriculum.

Although the above recommendations are specifically to help the study teachers to implement the curriculum as intended, it is important to note that because the schools and islands for the study were carefully chosen as "typical" it is likely these sorts of changes are needed more generally to ensure the type of practice encouraged by the curriculum is implemented. Moreover, the uniform assessment practice, and the expected use of the textbook by primary teachers in the Maldives further suggests that the findings are more generally applicable.

6.3 Limitations of the study

Care was taken at every stage of the study to ensure the findings were trustworthy. For example, during interviews, teachers were asked about questions to ensure their responses to the belief questionnaire were interpreted correctly. Questions were asked to explore their viewpoints about the instructional strategies and specific actions observed during lesson observations. Similarly, in the questionnaire, teachers described their typical lesson and, during their interviews, were asked whether the observed lessons were typical of the way they taught. During the process of analysing data, some participants were contacted by telephone and emailed for clarification of issues and to get additional documents such as test papers. However, as with any other study, with the strengths, there are limitations to be acknowledged.

One of the limitations of this study was its small sample size. While acknowledging this limitation, it is important to note that the study was not aimed at generating a theory or to make statistically valid generalisations. The aim was to select a sample that was large enough to provide a representative set of data but small enough to be manageable. However, given more time and resources, a larger sample may have obtained richer, in-depth, and diverse set of data.

In addition, each teacher was observed three times within a period of two weeks as the timeframe available for data collection did not permit more observations over a longer period. Three observations is only a small sample of each teacher's lessons and thus may not fully represent the general practice of the teachers. In addition, teachers "may behave in some atypical fashion when they know they are being observed" (Patton, 2002). Increasing the numbers of lesson observations over a longer period of time would have enhanced the reliability of the findings.

Furthermore, for each of the participant teachers, all three observations took place with one class. Teachers' practice may differ from class to class due to different classroom environments and different groups of children. Therefore, individual teacher observations in different classes would have increased the trustworthiness of the findings.

Finally, each teacher was interviewed once. According to Hancock and Algozzine (2006), a one-off interview is often unsatisfactory as responses need further probing or clarification after reflection and analysis of transcripts. Therefore, follow up interviews would have improved the study.

6.4 Areas for further research

Some of the possible limitations of this study, including ways to minimise them to improve reliability and trustworthiness, are highlighted in Section 6.3. This section (6.4) describes only the potential for future studies related to mathematical beliefs and practices.

This study shed light on Maldives primary teachers' mathematical beliefs and practices. It also raised a number of unanswered questions related to the topic. The study shows teachers' instructional practice is not only influenced by their mathematical beliefs but also by a number of other factors such as assessment practice and nature of textbooks. However, it is not clear to what extent these factors inhibit implementation of the curriculum. How are these factors related to each other? What are the inconsistencies between curriculum and assessment practice? Research on the factors influencing teachers' instructional practice is required to further confirm and explore the ways they influence teachers' beliefs and practice or limit implementation of curriculum.

The present study involved eight teachers from four schools. With the exception of one school, no significant difference was observed between the schools regarding the beliefs of the participant teachers (see Figure 5.7). The two teachers who had only traditional beliefs about nature of mathematics, mathematics learning, and mathematics teaching were from same school. The difference observed in these teachers' beliefs may be due to differences in school culture or context of teaching. This raises questions about the extent to which the school culture recruited traditionalist teachers. What impact does teacher training have on teachers' beliefs? What beliefs did Maldives pre-service teachers have before they joined schools as teachers and how did their beliefs change over the years as they practiced in constrained environments of schools? Exploring answers to these questions has implications for teacher education, policy makers, and professional developers.

6.5 Summary

This study has shown that curriculum reform alone does not guarantee changes in classroom practice. In order to implement a revised curriculum, teachers' beliefs need to be compatible with the ideas in the curriculum. Reform often requires teachers to abandon unwanted beliefs and practice. Moreover, factors that are perceived to be limiting teachers' practice need to be identified and removed. This makes teachers' beliefs and practice an important area for research, specifically with respect to reforms in the curriculum.

In the Maldives, the effective implementation to the recent reform to the curriculum requires classroom practice to change: this, in turn requires an understanding of teachers' beliefs and current practice. This study, therefore, explored and examined primary teachers' beliefs, practice, and factors influencing their practice. The study revealed that some teachers had constructivist beliefs about teaching and learning mathematics, which are compatible with the curriculum. However, in general their practice did not reflect constructivist beliefs. Assessment was shown to be very influential on the teachers' instructional practice and was associated with of most of the other factors such as teacher accountability for students' results, and parents' and school's pressure to follow textbook. The study suggests removing barriers that limit teachers' practice. In particular, it shows the importance of changing current assessment practice in the Maldives. The findings also show that for teachers to implement the curriculum as intended requires changing their beliefs to be compatible with it.

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APPENDICES

Appendix A: Belief Questionnaire

Part 1: Biographical Data

Name: ……………………………………………………………………………………………

Age: ……………………………………………………………………………………………

Gender: ……………………………… School: ……………………………………………………

Class: ……………………………………………………………………………………………

Number of years of teaching: ………………………………………………………………………

Number of years of teaching children at key stage two (Grade 4 – 6): ………………………………

My Highest Mathematics qualification:

……………………………………………………………………………………………………

……………………………………………………………………………………………………

My Teaching qualification:

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Recent Professional Development on mathematics teaching I have had:

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Part 2: Primary Mathematics Teachers' Belief Questionnaire

Please take some time over next the few days to write your personal opinion about the following questions. Please write your answer as fully as possible.

Nature of mathematics

1. How would you describe what mathematics is like to someone who has never heard of mathematics before?

2. What do you think mathematicians do when they do maths?

Mathematics learning

3. How do you think children **learn** mathematics best?

4. In what ways do you have an impact on students' learning of mathematics in your teaching?

5. The following statements describe teachers' beliefs about mathematics learning. Please circle your response to the statements.

	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
a) Mathematics learning is enhanced when students work in groups.	1	2	3	4	5
b) Using textbooks and worksheets for practice is important in mathematics learning.	1	2	3	4	5
c) Engaging in repeated practice for mastery of skills is a critical part of mathematics learning.	1	2	3	4	5
d) Working alone in silence is an important part of mathematics learning.	1	2	3	4	5
e) In order for students to learn mathematics they need to be presented with problems, questions or situations that force them to think differently.	1	2	3	4	5
f) Students learn mainly from teachers' explanation.	1	2	3	4	5
g) Learning is enhanced when students explain and demonstrate their solutions to others.	1	2	3	4	5
h) Teachers are more responsible for students learning than the students	1	2	3	4	5
i) Aactive participation in learning activities that enable students to create their own version of knowledge is critical for learning mathematics.	1	2	3	4	5

Mathematics teaching

6. In your opinion what are the effective ways of **teaching** mathematics?

7. Describe your typical way of teaching a mathematics lesson? (If I was to visit your class, what would I normally see happening during the lesson?)

8. What supports you to teach in this way?

   a.

   b.

   c.

9. Is there anything that limits your ability to teach in the way you would like to, and if so what are they?

   a.

   b.

   c.

10. The following statements describe teachers' beliefs about mathematics teaching. Please circle your response to the statements.

	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
a) Teachers should provide students with problem solving situations to investigate in small groups. Students understand mathematics when they engage in problem solving.	1	2	3	4	5
b) Teachers should explain thoroughly the mathematical rules and procedures before giving them mathematical problems.	1	2	3	4	5
a) Students should be given enough drill exercises (e.g. worksheets) to mastery the skills.	1	2	3	4	5
b) Teachers should plan instructions based on students' textbooks and workbooks, and should verify that students received the knowledge in these books.	1	2	3	4	5
c) Teachers should provide the students with manipulative materials for students to explore mathematical ideas and concepts themselves.	1	2	3	4	5
d) Teachers should listen to the students and seek elaboration of learners' responses.	1	2	3	4	5
e) Teachers should engage learners in situations that might bring about contradictions and then encourage discussions.	1	2	3	4	5

Mathematics Assessment and Evaluation

11.How do you assess and grade your students' mathematics learning?

12.How do you prepare your students for term tests and exams?

Thank you very much for answering this questionnaire.

Appendix B: Observation Schedule

Observations were recorded using the *Running Record* (Good & Brophy, 2003) method, and specific attentions were given to answering the following questions. The questions are based on constructivist strategies given by Pritchard and Woollard (2010), and Brooks and Brooks (1993).

I) What type of strategies does the teacher use and how?

1. Does the teacher encourage learner autonomy and initiative, if so how?
2. What teaching material does the teachers use and how?
3. Does the teacher take account of students' responses and make use of their prior knowledge?
4. Does the teacher find out learners' understanding of new ideas before teaching about them?
5. Does the teacher encourage dialogue among students and with the teacher?
6. Does the teacher ask open ended questions, and encourage students ask questions?
7. Does the teacher seek elaboration of learners' responses?
8. What scaffolding techniques does the teacher use?
9. What type of homework is given to students if any?
10. How does the teacher explain the content?
11. How much time does the teacher spend on explanation of content, demonstrating skills and procedures?

II) What type of activities are the students involved in during the class?

1. Do the learners engage in learning experiences that encourage them to explore and discuss in groups?
2. Do the students ask questions to each other and from the teacher, and what type of questions do they ask?
3. Do the students learn by rote?
4. Do the students work in silence most of the time?
5. What type of practice sums do the students do?

Appendix C: Interview Schedule

Teachers will be asked to elaborate on or provide detailed accounts of points they made in response to the questions in the questionnaire. Also, questions will be asked about teachers reasons about their actions and behaviour of the observed lessons. Probes will be used to obtain responses or for additional information.

Questions regarding teachers' response to belief questionnaire

1. How would you describe what mathematics is like to someone who never heard of that before? *Please elaborate on the points you made in response to the written questions.*
2. What do you think mathematician do when they do mathematics? *Please elaborate on the points you made in response to the written questions.*
3. How do you think children learn mathematics best? *Please elaborate on the points you made in response to written questions.*
4. In what ways do you have impact on students' learning of mathematics?
5. What do you think is the role of
   a. Mathematics teacher
   b. Students
6. In your opinion what are the effective ways of teaching mathematics? *Please elaborate on the points you made in response to the written questions.*
7. How do you teach mathematics?
8. What supports you to teach in this way? *Please elaborate on the points you made in response to the written questions.*
9. What limits you being able to teach in the way you would like to teach mathematics? *Please elaborate on the points you made in response to the written questions.*
10. How do you assess and grade your students? *Please elaborate on the points you made in response to the written questions.*
11. How do you prepare your students for term tests and exams? *Please elaborate on the points you made in response to the written questions.*

Questions about teacher actions and behaviour of the observed lessons

(Questions will be based on lesson observations)

Typical questions:

Why did you introduce the mathematical ideas in the way you did?

How did you help students to understand the new work?

How did you decide whether students understand the new work?

Appendix D: Participant information and consent form (sample)

VICTORIA UNIVERSITY OF WELLINGTON FACULTY OF EDUCATION

Letter of Explanation for Teachers

Research project: Primary teachers' mathematical beliefs and their instructional practices in the Maldives

Researcher: Mohamed Shameem Adam, School of Education Policy and Implementation

Dear Sir/Madam:
I am a student studying for my Master of Education at Victoria University of Wellington, New Zealand. Before studying at the University I worked at the Maldives College of Higher Education as an assistant lecturer. I also taught in a school in the Maldives, and was the Head of Mathematics in that school for two years.

I am inviting you to be a participant of my research study.

The Research Project
As a part of my degree I am undertaking a research project leading to a thesis. The main purpose of my research is to identify and describe the types of beliefs primary teachers in the Maldives hold about teaching and learning mathematics, and to investigate the relationship between teachers' beliefs and their practice. Understanding teachers' beliefs and practice is important for designing and conducting professional development that aims at helping teachers to change their practice or to implement reform agendas such as reform in the curriculum.
The study involves four primary schools in the Maldives, and participants of the study will be trained teachers teaching mathematics in upper primary classes (grade 4-6) in these schools.

As a part of this research project, I would like to collect data about your regular teaching practice, and your beliefs about effective teaching. To do this, I start with a written questionnaire about your beliefs about mathematics teaching and learning. The questionnaire will be emailed to you, or will be given in person. If you prefer to get the questionnaire by email you may also return it by email; otherwise will be collected by the researcher. This questionnaire would take about half an hour to complete, however, in order for you to have enough time and space to think and reflect you will be given two to three days.

Second, I will observe and audio record two of your mathematics lessons. The focus of these observations is to find out your regular teaching practice as well as the role of your students in learning in the classroom. You will decide a time period (e.g., a week or few days) in which you will be willing to be observed. We will discuss about the topics and lessons you intend to teach in this period, and if you wish I will decide the two lessons for the observation, and prior notice will not be given to you before the observation. This is to minimise any specific preparation for the lessons as I wish to observe your regular practice of teaching. However, if you wishes to be informed a day or two before each observation, you will be informed accordingly.

Finally you will be interviewed after the two observations. The interview will take place at a time and site designated by you, and will be audio recorded. If possible the interview will be conducted the same day as the second observation, where not possible the interview will be conducted within a day or two. The purpose of conducting an interview after the observations is for me to explore more about practice I observed during the classroom observations, and also for you to elaborate more on responses given to the written questionnaire about mathematics teaching and learning. At the end of the interview, the main themes of what has been said will be checked with you to ensure accuracy.

Ethics Approval

In all research involving people it is important to obtain informed consent; that is, to provide all interested parties with clear information about what the research involves and to gain approval for participation in the research from those people. The first stage of this process is to gain ethical approval from the University by demonstrating that the intended research will be properly conducted and cause participants no ill effects.
This research project has been assessed and approved by the Victoria University Faculty of Education Ethics Committee under the following conditions.

- The participation in the research is voluntary. The participants can withdraw from the study at any time up to the final point of data analysis which is 15th July 2011 without giving a reason. There is no penalty for not participating or for withdrawing from participation at any stage.
- Written consents will be sought from principals, teachers, students, and parents or guardians of the students involved in the study.
- Data will be kept confidential, in a locked file or a password – protected folder and only my supervisors and I will have access to the research records. Any data collected will be destroyed three years after the conclusion of the research by shredding, or wiping of the audiotapes and computer files.
- The names of teachers, students, and the school will not be used in the study's report. Pseudonyms will be used. Only my supervisors and I will have access to the research records.

Results

The findings of the study will be the basis for my thesis. The thesis will be submitted for marking to the School of Education Policy and Implementation, and deposited in the University Library. Important findings may also be written up as articles for research journals or for presentation at international conferences.

The findings of the study will be shared with participants who desire it. This will be as a summary sheet of the result findings. Furthermore, upon request, I will be available to present the findings in the participating schools.

I hope that you will be able to assist me in this research study. If you have any question please contact me, or my supervisors for further information. Contact details are given below.

Thank you

Signature

Mohamed Shameem Adam
Email: mshameem_adam@hotmail.com
Phone: 0211888335

Dr Michael Drake (Supervisor)
Email: Michael.drake@vuw.ac.nz
Phone: 04 463 9668

Dr Robin Averill (Supervisor)
Email: robin.averill@vuw.ac.nz
Phone: 04 463 9714

VICTORIA UNIVERSITY OF WELLINGTON FACULTY OF EDUCATION

Consent form: Teachers

Research project: Primary teachers' mathematical beliefs and their instructional practices in the Maldives

Please tick those that apply

☐ I understand that my participation in this research is voluntary.

☐ I have been provided with adequate information relating to the nature and purpose of this research project, I have understood that information and have been given the opportunity to seek further clarification or explanations.

☐ I understand that the research data will be kept secure and access to the data will be limited to the researcher and his two supervisors. I also understand that any information I provide will be destroyed three years after the conclusion of the research by shredding, or wiping of the audiotapes and computer files.

☐ I understand that research findings will be deposited in the University Library in the form of a thesis, and may be presented in academic or professional journals or at educational conferences.

☐ I understand that any information I provide will be kept confidential and will be reported only in an aggregated or non-attributable form. I also understand that the information I will provide will be used only for this research project and that any further use will require my written consent.

☐ I understand that this research project involves responses to a written questionnaire, an interview, and two classroom observations by the researcher. I also understand that classroom observations and the interview will be audio recorded, and at the end of my interview the important points will be summarized by the researcher so I can confirm that what I said is interpreted accurately.

☐ I understand that copies of my lesson plans for the two observed lessons will be requested as part of the research project.

☐ I understand that I will decide a time period (e.g., a week or few days) in which I will be willing to be observed. However, the exact lessons observed will be decided by the researcher.

☐ I understand that if I agree to participate in the research project, I have the right to withdraw from this project at any point before the completion of data analysis which is 15th July 2011. No reason for withdrawal from the research needs to be given. If for any reason I choose to withdraw from the research, any data already collected from or about me is to be destroyed and not used in the project. There is no penalty for not participating or withdrawing from participation.

I .... ☐ **AGREE** or ☐ **DO NOT AGREE** to participate in this research project.

Teacher's signature ____

Date _________________________________

A summary sheet on the results of this research will be provided to me if I tick the box on the consent form (below).

☐ I would like written feedback about the outcomes of this research.

Address to which the research findings should be sent

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TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

FACULTY OF EDUCATION

Letter of Explanation for Student

Research project: Primary teachers' mathematical beliefs and their instructional practices in the Maldives

This research has been assessed and approved by Victoria University Faculty of Education Ethics Committee.

Researcher: Mohamed Shameem Adam, School of Education Policy and Implementation

Dear Student:

I am a student studying for my Master of Education at Victoria University of Wellington, New Zealand. Before studying at the University I was a teacher in the Maldives.

As a part of my study I am doing a research project. The research project is about finding teachers mathematical belief and how they teach mathematics.

The study involves four primary schools in the Maldives, and participants of the study will be teachers teaching mathematics in upper primary classes (grade 4-6) in these schools, and students in their classes.

As a part of data collection, I am seeking permission to observe you in two of your mathematics class. The observation involves making notes about your teacher's interaction with you and other students. The observation also involves audio recording of your conversation with the teacher and other students. Any information or opinion you provide will be kept confidential, and published results will not use your name.

Your participation in the research is voluntary, and that either participation or non-participation will not affect your learning or grades in any way.

I hope that you will take part in this research study. If you have any question please contact me.

Thank you

Signature

Mohamed Shameem Adam
Email: mshameem_adam@hotmail.com
Phone: 0211888335

Dr Michael Drake (Supervisor)
Email: Michael.drake@vuw.ac.nz
Phone: 04 463 9668

Dr Robin Averill (Supervisor)
Email: robin.averill@vuw.ac.nz
Phone: 04 463 9714

VICTORIA UNIVERSITY OF WELLINGTON — FACULTY OF EDUCATION

Consent form: Student

Research project: Primary teachers' mathematical beliefs and their instructional practices in the Maldives

Please tick those that apply

☐ I understand that my participation in this research is voluntary. I understand that I do not have to help in this research study, and if I decide I can ask the researcher to stop observing me and recording any information about me or related to me.

☐ I have been given information that explains the purpose of this research project. I have understood that information and have been given the chance to ask questions about it.

☐ I understand that any information or opinions I provide will be kept confidential, and the published results will not use my name.

☐ I understand that the any data collected will be destroyed three years after the conclusion of the research.

☐ I understand that I have the right to withdraw from this project at any point before the completion of data analysis which is 15th July 2011. I don't have to give any reason if I want to withdraw from the research. If I withdraw the data related to me will be destroyed and will not be used in the project.

I .... ☐ **AGREE** or ☐ **DO NOT AGREE** to take part in this research project.

Student signature ____

Date ________________________________

A summary sheet on the results of this research will be provided to me if I tick the box on the consent form (below).

☐ I would like written feedback about the outcomes of this research.

Address to which the research findings should be sent

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