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The Mathematical Beliefs and Practice of Primary Teachers and Factors that Limit Belief-Practice Consistency

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Abstract

Like many mathematics curricula, the Maldives mathematics curriculum encourages constructivist approaches to teaching and learning. Research indicates that teachers' mathematical beliefs can be a major challenge in implementing the curriculum. This article describes a multiple case study into urban and rural Maldivian primary teachers' mathematical beliefs and instructional practice. Survey, interview, and observational data from eight teachers across four schools were analysed. Findings show that teachers' instruction was more traditional than their beliefs and those assessment methods strongly influenced teacher practice. Parental pressure, the nature of textbooks, time limitations, teacher accountability for their students' performance in tests, and teaching and learning resources were also found to influence and constrain practice. Implications for curriculum implementation and improving practice include the need to align elements of the system (in particular, assessment policy and practice and teaching resources) with constructivist approaches.

Keywords: Teacher beliefs, instructional practice, assessment methods, Maldives curriculum

1. INTRODUCTION

Changing teachers' beliefs and practice is a major challenge in implementing reforms (Battista, 1994; Prawat, 1992). Due to the strong link between instructional beliefs and practice, teacher education and professional development programmes need to focus on changing teachers' beliefs rather than focusing only on methodology (Cross, 2009; Swan & Swain, 2010). However, the relationship between beliefs and practice is not always straightforward due to the constraints teachers face in their daily practice (Bolden & Newton, 2008; Thompson, 1984). Efforts to improve teachers' professional practice should, therefore, not only focus on changing beliefs but also on understanding and minimising factors that influence how beliefs are put into practice.

Most of the research on teachers' mathematical beliefs and practice has been conducted in developed countries. There is a strong need to explore these beliefs and practice of teachers in developing countries because many of these countries, such as Maldives, are undergoing educational reforms influenced by learning theories such as constructivism (Bimbola & Daniel, 2010; Chiu & Whitebread, 2011). The successful implementation of curriculum reforms is largely in the hands of teachers, and how the teachers practise reform ideas is based on how much they believe in them (Battista, 1994).

Understanding the mathematical beliefs of Maldivian teachers along with factors that influence their practice is very important as the country is undertaking major curriculum reform with the introduction of the revised curriculum to some schools in 2012 and the full implementation across the system by 2015. Existing practice in primary schools has shown a heavy reliance by mathematics teachers on textbooks produced by the Educational Development Centre. Assessment based on the textbook materials is developed internally by teachers and a subject coordinator. Assessment results are reported to parents at the end of each term. A constructivist approach to teaching and learning plays a key role in the reformed curriculum which envisions the development of individuals who are keen to seek, apply, and create knowledge (Educational Development Centre, 2011). According to the

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curriculum, learning mathematics should develop students' "problem solving, reasoning, creative, logical and critical thinking skills" (p. 18). With teachers largely responsible for implementing these reforms, challenges to implementation include aligning teacher beliefs with the ideas behind the curriculum reform and minimising constraints that limit translating these beliefs into practice.

The following research questions, guiding the study reported here, were part of a wider study (Adam, 2012):

1. What beliefs do upper primary Maldivian 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 a constructivist approach?
3. What inconsistencies, if any, exist between upper primary teachers' mathematical beliefs and their instructional practice and what factors influence any inconsistencies?

In this article, we first summarise what is known about teacher beliefs and the relationship between teacher beliefs and practice. We then present information about, and findings from the study, and conclude with a discussion of implications of the study findings.

1.1 Teacher's beliefs and practice

Research suggests that beliefs are formed as a result of experience (Pajares, 1992). Teachers' beliefs about mathematics may have originated from their own experience of learning mathematics at school (Beswick, 2012; Lortie, 1975). When pre-service teachers enrol in teacher education programmes they already have strong beliefs about how to teach and learn (Berry, 2004; Kagan, 1992), which are then shaped by their own teaching and learning experiences (Beswick, 2005). The information gained through teacher education and professional development programmes has been found to have little effect on teacher beliefs, as the information is filtered through teachers' existing belief structures and previous experiences, with each teacher forming their own unique pedagogies (Higgins & Parsons, 2009; Kagan, 1992).

Many researchers 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 (e.g., Ernest, 1989; Handal, 2003; Kuhs & Ball, 1986; Perry, Howard, & Tracey, 1999; Raymond, 1997). Teachers' beliefs about the nature of mathematics refer to their views regarding the discipline of mathematics as a whole (Ernest, 1989). Beliefs about mathematics learning include perceptions about students' roles and how students learn (Thompson, 1992). Thompson describes teachers' beliefs about mathematics teaching as their views about their own role in the classroom, their choice of classroom activities, and the instructional strategies they prefer. Green (1971) suggests that some beliefs are more strongly held than others and proposed that in any given system of beliefs, there may be *primary* beliefs, and other beliefs that are derived from these primary beliefs. Beliefs about the nature of mathematics are seen as the most important of the three categories of beliefs (Ernest, 1989; Raymond, 1997), Ernest arguing that beliefs about the nature of mathematics provide a basis for beliefs about mathematics learning and mathematics teaching.

Teachers hold a range of mathematical beliefs, and researchers have categorised these in various ways (e.g., 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* beliefs. "Connectionist" teachers believe that teaching strategies and methods that focus on establishing connections within mathematics is important. Teachers who believe mathematics to be collections of separate rules and procedures are described as having "transmission" style beliefs. The "discovery" category refers to teachers who believe in the ability of learners to discover mathematical ideas. As many recent reforms in mathematics education have been influenced by constructivist learning theories, much of the recent research on teacher beliefs distinguishes between teachers' *constructivist* beliefs and *traditional* 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's (2005) and Perry et al.'s (1999) surveys about teachers' mathematical beliefs and Raymond's (1997) criteria for the categorisation of teachers' beliefs and practice identify a number of elements of constructivist and traditional beliefs in relation to the nature of mathematics, mathematics teaching, and mathematics learning. Constructivists view mathematics as a way of thinking and solving problems, with knowledge being constructed by students. In a constructivist classroom, students actively engage in the teaching and learning process. The teacher's role is to create the learning environment and guide and facilitate learning rather than give step by step

procedures. In a traditional approach, mathematics is seen as a fixed discipline with a set of established rules and procedures. The teacher's role is mainly to explain procedures and provide students with drill exercises to master skills.

Inconsistencies between the beliefs held by teachers are common, including inconsistencies in beliefs across and within the categories of the nature of mathematics, of learning, and of teaching. Many teachers hold beliefs that have a mixture of elements of constructivist and traditional views (e.g., Alamu, 2010; Askew et al., 1997; Cross, 2009; Thompson, 1984; Whitehouse, 2003). The study by Whitehouse found that among 59 secondary school teachers who completed a questionnaire designed to measure traditional and constructivist beliefs, none described beliefs that were consistently traditional or constructivist. Similar results were found in a study exploring the beliefs, knowledge, and practice of sixteen primary mathematics teachers in the Solomon Islands (Alamu, 2010). In addition, teachers' beliefs are not always consistent across the categories of the nature of mathematics, mathematics learning, and mathematics teaching (Barkatsas & Malone, 2005; Raymond, 1997). For example, in her case study of an elementary mathematics teacher's beliefs and practice, Raymond (1997) found that the teacher held largely traditional beliefs about the nature of mathematics while her beliefs about mathematics learning and mathematics teaching were non-traditional.

As teachers often hold a range of beliefs between "fully traditional" and "fully constructivist", various descriptive labels have been used to indicate different combinations or positions within this range. For example, Raymond (1997) describes five categories (*non-traditional*, *primarily non-traditional*, *even mix of traditional and non-traditional*, *primarily traditional*, and *traditional*), and Sang et al. (2009) four (*constructivist profile*, *mixed constructivist/traditional profile*, *mixed low constructivist/traditional profile*, and *traditional profile*). The differences in teachers' beliefs can be interpreted as "stages of a developmental process, individual cognitive differences, or simply due to differences in socio-economic status, educational systems, or cultural environments" (Handal, 2003, p. 50).

That teachers' beliefs and practices are interrelated is widely accepted; however, there appears to be no direct or simple relationship between teachers' beliefs and practice (Liljedahl, 2008; Wood & Cobb, 1991). Research indicates that teachers' mathematical beliefs do influence their approach to teaching (e.g., Barkatsas & Malone, 2005; Beswick, 2012; Brady, 2014; Cooney, 1985; Pajares, 1992; Philipp, 2007; Roesken, Pepin, & Toerner, 2011; Speer, 2005). Some studies have indicated a high degree of consistency between beliefs and practice (e.g., Cross, 2009; Stipek, Givvin, Salmon, & MacGyvers, 2001), while others identify discrepancies between them (e.g., Bolden & Newton, 2008; A. Sapkova, 2013). No previous studies into Maldivian teachers' mathematical beliefs and practice have been found. However, the practice of Maldivian secondary school English teachers has been found to be not wholly consistent with their beliefs (Mohamed, 2006). These teachers projected themselves as "modern" teachers who believed in student-centred methods of instruction, but were found to use a traditional approach to teaching.

Literature shows that 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, Grootenboer, Niesche, & Lerman (2010) note that the beliefs reflected in teachers' instructional practice are more "real life" as they are affected by other concerns of the classroom. The nature and focus of assessment is known to affect teacher practice (Harlen, 2007, 2008). This and other factors affecting instructional practice are reported to influence teachers' beliefs (e.g., Beswick, 2005; Kagen, 1992; Pajares, 1992; Wood & Cobb, 1991) (summarised in Figure 1).

Inconsistencies between teachers' beliefs and practice could indicate that factors other than mathematical beliefs affect instructional practice, with many factors potentially leading to misalignment between beliefs and practice (e.g., Barkatsas & Malone, 2005; Bolden & Newton, 2008; Cross, 2009; Jorgensen et al., 2010; Mohamed, 2006). Such factors include the expectations that students, parents, other teachers, school management, and society have about mathematics teaching. Lack of resources, time constraints, curriculum materials, national schooling system processes, and assessment policies are also found to influence the translation of beliefs into practice. Inconsistencies between beliefs and practice may also be due to teachers lacking the necessary pedagogical skills and knowledge to translate beliefs into practice (Thompson, 1992), particularly teachers can find constructivist teaching approaches difficult to implement (Muijs & Reynolds, 2005).

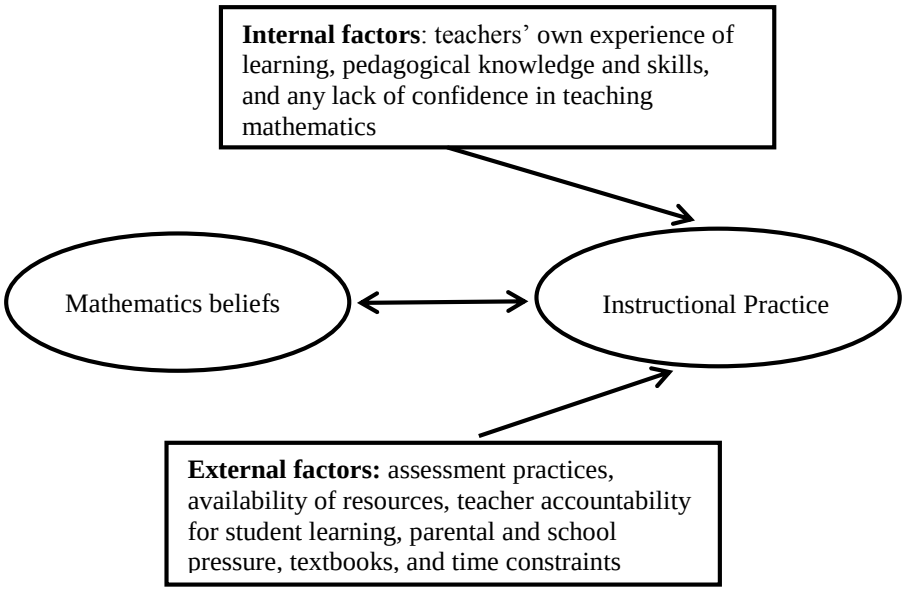


Figure 1: Relationship between mathematics beliefs, teaching practice, and factors affecting them.

In summary, much is known about teacher beliefs about mathematics, mathematics learning, and effective mathematics teaching, knowledge that is important for informing policy and teacher development and policy implementation. Many teachers hold a range of constructivist and traditional beliefs within and across these three areas. Links between beliefs and practice are known to be indirect and complex and susceptible to influence by a range of factors. However, little of the research leading to these understandings has been conducted in developing countries, despite such countries increasingly adopting educational reform including constructivist curricula. Understanding factors likely to limit or enhance the success of curriculum reform is vital for the students, teachers, teacher educators, and policy makers of these countries. Furthermore, we have found no reported studies that have examined the beliefs and practices of mathematics teachers across urban and rural schools using in-depth case study.

Next, we describe our study in which such teachers' beliefs and practices were examined in the light of factors that could constrain belief-practice alignment.

2. THE STUDY

A multiple case study approach was chosen as it allows an in-depth exploration of beliefs and practices and enables the comparison of cases to identify differences and similarities. To include both city and rural schools typical in the Maldives, *purposeful* sampling (Patton, 2002) was used to select eight teachers from four schools - two schools from the capital, and two from a rural island. Each teacher constituted a separate case. All participants were locally trained Maldivians teaching mathematics in grades 5, 6, or 7. These teachers had taught mathematics for a minimum of one year in the study school as it was assumed such experience would mean they would be more familiar with the school culture and local community in which they were teaching than those with less experience. Of the eight teachers, six were female and two male. All held advanced certificate or diploma level elementary school teaching qualifications. Two had taught for less than five years, four between five and ten years, and the other two had over ten years' teaching experience.

Data were collected in the second half of the first semester of the school year so that the teachers' established practice with each class could be observed. To determine teachers' beliefs, data were collected using a self-reporting questionnaire (Denscombe, 2010; McMillan, 2008) which included both open and closed questions. Open questions were used to allow the respondents "to reflect the full richness and complexity of their views" (Denscombe, 2010, p. 166). The closed items were included as these would allow the beliefs and practices of each teacher to be categorised and compared easily. Teachers were given a week to complete the questionnaire to allow them time to reflect on the questions and how they wanted to respond. All items were reviewed, discussed, and trialled prior to use.

Information about the teachers' practice was drawn from observing each teacher three times in their normal practice as they worked with their own class on three separate days. During each observation a running record was made (Good & Brophy, 2003) and an audio recording taken to capture the dialogue between the teacher and the students. Specific attention was paid to aspects of teaching that indicated a constructivist or transmission style of teaching. Teachers' lesson plans for the observed lessons, samples of students' work during these lessons, and selected test papers were also collected to help examine the teachers' instructional practices.

A semi-structured interview (King & Horrocks, 2010; Newby, 2010) was conducted with each teacher within two days of their last lesson observation. For each participant, the questionnaire was collected and lesson observations completed before conducting the interview to ensure that the questionnaire and observation data would not be affected by the interview questions and discussion. The interviews were used to explore in more detail the written accounts provided in the questionnaire and teacher's thoughts and view-points related to the instructional strategies used and pedagogical decisions made during the observed lessons. The interview questions were also trialled prior to use.

To analyse the data, first, each individual teacher's beliefs and practice were separately analysed. Next, a cross-case analysis to investigate the differences and commonalities between the teachers' results was undertaken (Merriam, 1998). Both of these analysis stages involved identifying themes existing in the data, and constructing and interpreting categories. All audio-recordings were listened to multiple times and field notes of observations and interviews were read and re-read to get a general sense of the data (Creswell, 2008). The text from the questionnaires, the transcription of interviews, and field notes of observations related to each case were then divided into segments, and labelled with codes which described the segments (Denscombe, 2010). Once the whole text related to a case was coded, a list of codes was compiled, and examined for similarities among codes. Similar codes were then grouped into themes. The emerging themes for individual teachers were compared with elements of traditional and constructivist views drawn from literature for categorisation of individual teachers' beliefs about the nature of mathematics, mathematics learning, and mathematics teaching. The code lists constructed during within-case analysis were compared across cases for their similarities and differences. Categories of codes and their themes, along with evidence, were then put into matrices to facilitate cross-case analysis. Main themes were identified by identifying the codes that occurred most frequently across cases, were unique, and had most evidence to support them (Creswell, 2008). Lastly, individual cases were re-analysed using the final themes.

3. RESULTS

Findings from the individual cases and the cross-case analysis are reported here. In order to answer the research questions, results are discussed in relation to the participants' views on the nature of mathematics, mathematics learning, and mathematics teaching, and the teachers' instructional practice. Teachers' beliefs and practice are compared. All the names have been altered, and the first letter of each name indicates the school where each teacher is working (for instance Aisha and Aini taught at school A). Schools A and B are urban schools, and C and D, rural schools.

3.1 The nature of mathematics: A fixed body of knowledge or a way of thinking and problem solving?

The teachers' descriptions of "what mathematics is" has revealed a range of beliefs between the two distinct perspectives of considering mathematics as a fixed body of knowledge and computation, and as a way of thinking involving problem solving. Five of the eight teachers saw mathematics as a fixed entity. Dean and Dhakir 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. For example, Dhakir stated: A 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.

Beena, Binesh, and Chanda all shared similar conceptualisations. For example, Beena stated "numbers" as the first thing that came to her mind when thinking about mathematics. She saw "symbols" and "calculations" as important parts of mathematics. For her, problem solving is applying mathematical facts, rules, and algorithms to answer mathematical problems presented as text. Binesh had a similar view for school mathematics. She believed mathematics was dynamic for mathematicians, but not 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"*

Aisha and Cala also believed that mathematics involves rules, facts, and procedures. However, they believed mathematics was not limited to these, but was also dynamic, expanding, and problem driven. They believed problem solving and thinking were important aspects of mathematics. For example, Aisha described mathematics as:

> *"…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."*

Cala believed memorising facts was essential in learning mathematics. At the same time she believed "logical thinking" and "problem solving" were significant elements in mathematics.

By comparison, Aini had constructivist beliefs about the nature of mathematics. According to her, "mathematics is a study about problem solving." She believed that mathematics was all about finding solutions that 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.

3.2 Mathematics learning: Rote learning or exploration and active engagement?

Again, teachers indicated holding beliefs consistent with both contrasting perspectives. Views included that students learn mathematics best both by doing repetitive practice and through active engagement in learning activities. Dean and Dhakir believed that students learn mathematics through listening to teachers' explanations, by observing teachers' demonstrations of worked examples, and then doing repetitive practice of similar problems:

> *"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". (Dhakir)*

This traditional view was reflected in these teachers' instructional practice. For example, in Dean's and Dhakir's classes, students spent between 50 and 65 percent of class time listening to, and watching, teacher demonstrations. In all of their observed lessons, Dean and Dhakir gave students drill exercises after demonstrating worked examples on the board and students then spent 20 to 35 percent of class time working individually on these. In Dean's and Dhakir's classrooms, when group work was used, virtually no discussion among students was noticed. Typically, one of the group members worked on the task while others watched. In some groups, students took turns – when one student finished a calculation, another student would do the next one, while the rest of the group would watch. Dean describes his view of the purpose of group work:

> *"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 themselves about what they learnt during the explanation. If there are students who didn't understand a part [of] the explanation, these discussions will help them to learn."*

Dean and Dhakir emphasised that it was vital for students to do all of the textbook and workbook exercises. They believed that students completing practice worksheets and extra calculations was also necessary if students were to learn a concept thoroughly. Likewise, Beena, Binesh, and Chanda believed that students listening to and watching the teacher's explanation, doing drill exercises, and using textbooks were crucial. Typical mathematics questions from these classrooms are shown in Figures 2a and 2b.

Beena highlighted the importance of doing drill exercises for memorisation and mastery of skills. Her response indicates the importance that she places on using the textbook and workbook for practice for mathematics learning:

> *"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]… 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".*

a

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

b

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

Figure 2: (a) Group task given to Dean's Class; (b) Individual task given to Dean's class.

Beena, Binesh, and Chanda also believed that students' active participation and working in groups exploring, problem solving, and investigating mathematical ideas were important for understanding mathematics. 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. Binesh gave her students group activities, but none of the tasks given encouraged discussion, exploration, or investigation of mathematical ideas (e.g., See Figure. 3). 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. However, how these activities were used focused on getting right answers rather than facilitating students' communication of their thoughts and ideas.

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: $-10xy$

Figure 3: An example and calculations used in Binesh's teaching

Aisha, Aini, and Cala 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 other's explanations enhanced students' learning. Aini stated that students understand better when teachers provide them with a situation to discuss and interact with each other:

> *"Students learn through practical works, through interactive discussions. They learn well from each other's explanations [rather] than from teachers' explanations . . . sometimes they need to debate about how to solve difficult problems". (Aini)*

Aisha, Aini, and Cala also believed rote learning was necessary for mathematical learning, but they did not think it was important to closely follow the textbook.

The observed teaching of Aisha, Aini, and Cala was not consistent with their stated beliefs about mathematics learning. While Aisha and Cala demonstrated a mix of traditional and constructivist practice, Aini's observed practice was traditional, with the only learning activities Aini provided for her students being drill exercises. In contrast, Aisha and Cala provided their students with activities to do in small groups. Students in their classes also used manipulative materials and engaged in discussions while doing their work, but no activities that encouraged student problem solving, investigation, or exploration were observed. Students followed their teacher's step-by-step guide when working on activities; the activities focused on obtaining "right" answers.

3.3 Beliefs about mathematics teaching: Telling and demonstrating or guiding students?

As for the beliefs about mathematics learning, the analysis of teachers' responses regarding mathematics teaching revealed two contrasting themes. The first was the belief that teaching is about telling and demonstrating procedures to students, and assigning exercises to practise the intended skill or memorise the procedures. The second theme was 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.

Dean and Dhakir believed that the teacher's role was to explain and deliver knowledge from the textbook. They believed that teachers should plan instruction based on the students' textbook and workbook, and should verify that students receive the knowledge in these books. Also, they strongly believed that teachers should thoroughly explain mathematical rules and procedures before giving students mathematical problems. Dean and Dhakir believed that step-by-step algorithms need to be explained before assigning learning tasks. They viewed the student's 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. This approach to teaching is evident from the following extract from one of Dean's lesson plans (Figure 4). Although the section begins with asking students to solve a fraction question without prior explanation, allowance is not made for students to explain their current thinking or to share responses. Instead, teacher explanations, student listening, and student practice of a range of fraction question types are emphasised in the plan.

	15 mins 20 mins 10 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. 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. 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.	Students will give the answer. Students attentively listening to the explanation and answer the question asked by the teacher while explaining.

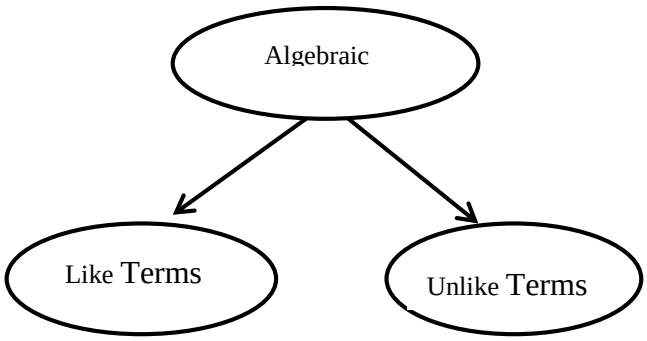
Figure 4: A section from Dean's lesson plan

The questionnaire and interview responses indicated that Aisha, Beena, Binesh, Chanda, and Cala all held 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 to transmit knowledge. However, the constructivist beliefs of these teachers were not strongly reflected in their instructional practice. Aisha, Beena, Binesh, Chanda, and Cala all spent on average more than 50 percent of their class time explaining the mathematical content, with some teachers providing students with small group activities and materials to use. Aisha's, Beena's, and Cala's students were more actively involved in learning than those of the other teachers, with student-to-student discussions observed during small group activities in their lessons. However, the tasks provided did not appear to challenge the students or encourage exploration or investigation of mathematical concepts. Students were not observed to be puzzled by or having to try to work out how to arrive at a solution.

Aini described the teacher's role as that of a 'facilitator', believing that the teacher's responsibility was to "provide a learning environment for students." She believed having students use manipulative materials and working collaboratively in small groups to be effective teaching strategies. However, she was not observed facilitating learning situations where the students took an active role in learning. For example, in the following episode, Aini

reminds students of definitions and tells the class (without explanation) that to simplify algebraic expressions, 'like terms' are needed:

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!
Ahmed:	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.

In summary, overall the participant teachers' beliefs about the nature of mathematics and observed instructional practice were more traditional than their beliefs about mathematics teaching and mathematics learning.

3.4 Factors affecting teachers' instructional practice

The teachers were asked about factors that inhibited or promoted translation of their beliefs into practice. The analysis 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 for teaching and planning for teaching, school culture, curriculum material to be covered, and the expectations of students' parents. Each will be discussed in turn.

All of the teachers indicated that the way students were assessed - by paper and pencil tests alone - played a significant role in shaping their instructional practice. Many believed that they did not have the flexibility to assess students in a different way, particularly as many felt directly accountable to others for students' achievement in the assessments. For example, Aini who believed in constructivist teaching and learning, identified paper and pencil tests and exams as a major limitation to her instructional practice, because as well as providing assessment of students' progress, test results were used as the main indicator of the effectiveness of teaching:

> *"Things are very much based on exams. Students are evaluated by tests. 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".*

Similarly, Aisha's questionnaire and interview responses indicated that she thought it was not necessary for students to do all of the workbook exercises or for the teacher to instruct solely from the textbook. However, her instructional practice was based on the textbook, and students were regularly assigned exercises from the workbook in class and for homework:

> *"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".*

According to Beena, teachers should not teach things that were not to be 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*".

Many teachers highlighted the pressure they had to improve test results. Some stated that they had to retest if students had lower marks than expected:

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

Cala thought that the assessment practice in her school did not encourage teaching using problem solving and thinking skills, particularly as, according to Cala, the students were not assessed to find out if they could apply mathematical knowledge in real life.

Factors other than assessment also appeared to limit translation of constructivist-style teacher beliefs into practice. Despite participants acknowledging that individual teachers decided how they conducted their lessons and the types of learning activities given to students, all mentioned that the topics and practice exercises from the workbook or textbook to be given to students (e.g., Figures. 5a and 5b) were decided in weekly subject coordination meetings, limiting teachers' freedom to vary their instructional practice.

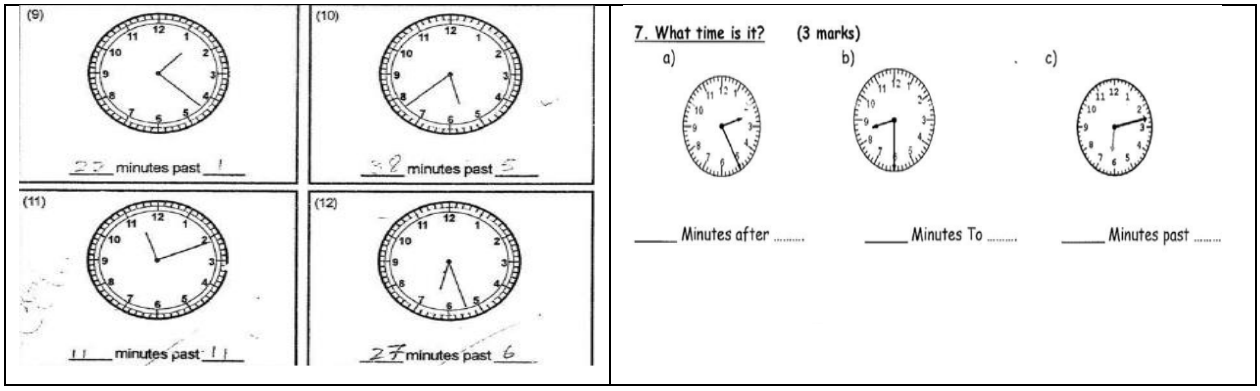


Figure 5: a) An abstract from student workbook (Naseer & Adam, 2007, p. 93); b) A question that appeared in the first term test

The teachers' responses indicated time constraints 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:

> *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*.

Similarly, Beena, Cala, and Chanda thought that they needed more time than was available to them if they were to include activities for students to more actively engage in the learning process.

4. DISCUSSION

Limitations of the study included that there were only eight teacher participants across three year levels, that stated beliefs and actual beliefs can vary, and that only a small number of lessons were observed for each teacher. However, the consistency found across cases regarding the nature of beliefs, the types of practice, teachers' reliance on routine skill-based mathematics questions and textbooks, and the limiting effect of assessment practices are strong indications that traditional practice and beliefs are likely to be commonly found in Maldivian mathematics classrooms.

Most of the study teachers held very traditional beliefs about mathematics, viewing it as fixed, procedural, and involving applying facts and procedures in computations. Only one teacher regarded reasoning and problem solving as a fundamental aspect of mathematics. The teachers' beliefs about the nature of mathematics were more traditional than their beliefs about mathematics learning and teaching, which was similar to what Raymond (1997) found. However, teachers' practice was also largely traditional in nature. For example, the teachers who held traditional beliefs about the nature of mathematics also regarded teacher demonstration of worked examples and drill exercises for mastery of skills as important in mathematics teaching and learning. Hence, the results of this study further support the notion that teachers' beliefs about the nature of mathematics provide a basis for their beliefs about mathematics teaching and learning (Ernest 1989), and therefore shape their instructional practices (Beswick, 2006; Cross, 2009; O. Sapkova, 2011).

Links between the beliefs about the nature of mathematics, beliefs about teaching and learning mathematics, and instructional practice provide useful insight for teacher education and implementation of educational reforms. The study teachers' most traditional beliefs were about the nature of mathematics. Therefore, it is recommended that as part of educational reform, 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 initial teacher education or professional development programmes (Handal, 2003). The results from this study suggest that initial teacher education and professional development programmes in the Maldives need to provide teachers with experiences that challenge traditional beliefs of mathematics and of mathematics teaching and learning, experiences that enable them to experience mathematics as a logical, creative, dynamic, and problem driven subject.

This study also revealed that most of the teachers' beliefs about mathematics teaching and learning were not fully consistent with their instructional practice, a result similar to Cooney's (1985), Jorgensen et al.'s (2010), and A. Sapkova's (2013) studies in the contexts of more developed countries and Mohamed's (2006) study of Maldivian English teachers. For example, some of the study teachers believed it important to provide students with activities that encourage them to explore and investigate mathematical ideas, but such activities were seldom or not seen in their observed instructional practice. Similar to Gregg's (1995) observations, the study teachers spent most of their instructional time explaining to the whole class and then assigning drill exercises to practise what was explained.

This study also found that the teachers' instructional *practices* were generally more traditional than their beliefs about mathematics teaching and learning. 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. Inconsistencies were mostly found between the beliefs and practice of the teachers who held constructivist or a mix of traditional and constructivist beliefs. The factors identified as affecting the teachers' instructional practice indicate that Maldivian school contexts favour traditional teaching. Teachers may find constructivist beliefs more difficult to implement due to the constrained nature of the school environment (e.g., shared planning, school and parental expectations) and other factors limiting their practice (assessment and textbook styles, potential implications of student assessment results).

Among many factors, the study results indicate that teachers' instructional practice was guided to a great extent by maximising 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 for students; rather, the emphasis was on memorising mathematical procedures, rules, and symbols on which they were to be assessed. Students were believed to be good at mathematics if they could apply the procedures even without knowing the reasons for using them. Current assessment practice in the Maldives appears to lead the delivered curriculum and methods of instructional practice, consistent with Harlen's (2007, 2008) discussion about the potential impacts of assessment. This study has provided evidence that teachers are acting in contradiction to their beliefs because the school or social context is unfavourable to these beliefs. For development of constructivist teaching in line with reformed curricula and, through this, for curriculum implementation, it appears vital and urgent that national and school contexts of mathematics teaching, constructivist teacher beliefs, and constructivist teaching practices are aligned. If reforms in education are to change practice, assessment must be changed accordingly (e.g., Black & Wiliam, 2008; Harlen, 2007). In particular, the study results indicate that aligning assessment practices with the content and goals of the curriculum is essential. The assessment literature suggests that, with reform in education, teachers should be given increased responsibility for assessing their students (e.g., Padilla, 2005). Assessment should be a part of the learning process, and should focus on obtaining information about the process of learning

rather than about the products (Black & Wiliam, 2008). Furthermore, assessment should include multiple indicators of learning and should be directly linked to the context of teaching and learning (Padilla, 2005).

The findings from this study add to existing literature on teachers' mathematical beliefs and practice by examining in depth case study comparison of mathematics teachers from across city and rural areas. The study results show that teachers' instructional practice is not only influenced by their mathematical beliefs but also by a number of contextual factors such as assessment practice and the nature of textbooks. Teachers from both urban and rural schools were similarly influenced. This study provides evidence that teacher practice is largely shaped by assessment practice when teachers are responsible for the outcome of the assessment or student results. However, it is not clear to what extent assessment practice and other factors inhibit implementation of the curriculum or how these factors may be interrelated. It would also be helpful to identify specific inconsistencies between curriculum and assessment practice. Further research could examine these issues and other factors influencing teachers' instructional practice to delve deeper into the influence of teachers' beliefs and practice on curriculum reform and implementation.

5. CONCLUSION

Curriculum reform alone does not guarantee changes in classroom practice. Reform often requires teachers to abandon undesirable beliefs and practices. In the Maldives, the effective implementation of the recent curriculum reform requires classroom practice to change; this, in turn, requires an understanding of teachers' beliefs and current practice. This study has revealed that some teachers held constructivist beliefs about the teaching and learning of mathematics compatible with the curriculum. In general, however, the study teachers' practice did not reflect constructivist beliefs. Assessment practice, teacher accountability for students' test results, and parents' and schools' pressure to follow the textbook seemed to encourage and ensure traditional approaches to teaching and learning. The study findings suggest that barriers that limit effective teaching practice that is consistent with the intended curriculum should be removed. In particular, assessment practice and textbook styles must be aligned to the intentions of the curriculum if it is to be implemented as anticipated. The findings also show that for teachers to implement the curriculum as intended and for students to experience this curriculum, changes in teacher beliefs about mathematics and mathematics teaching and learning are needed.

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