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RESEARCH ARTICLE

The association between teachers' mathematical beliefs, teacher characteristics and student achievements at the junior secondary level of education in Sri Lanka

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Abstract: Mathematics teachers' beliefs and their effects on student achievements have been studied in other countries for the past many decades. However, there is a limited understanding of mathematics teachers' beliefs and student achievements in Sri Lanka. Therefore, the current study attempts to explore associations between teachers' mathematical beliefs, their characteristics and student achievements. To achieve this purpose three main objectives have been set: 1. To identify the association between the beliefs of mathematics teachers and teacher characteristics such as years of experience of teaching, highest educational qualifications in mathematics, and professional qualifications; 2. To assess the relationship between teacher characteristics and student achievements; 3. To identify the relationships between different types of teacher beliefs and student achievements. Data were collected from 50 mathematics teachers who teach Grade Seven classes in the Central Province of Sri Lanka. The sample included one teacher each drawn from a stratified random sample of 50 schools based on school type and ethnicity. The study revealed that teachers with professional qualifications in teaching have better mathematics beliefs than teachers without professional qualifications. The former is more confident in working under stressful conditions and more self-efficacious about teaching specific mathematical competencies. The study further revealed that teacher beliefs related to all three dimensions, considered in the study are not significantly associated with student achievements. Implications of these findings for policy, practice and further research in mathematics education are identified and recommendations for improving mathematics education at the junior secondary level are highlighted.

Keywords: Mathematics teachers, teacher beliefs, teacher characteristics, student achievements, teacher self-efficacy.

INTRODUCTION

Recent research identified many issues related to mathematics achievements of students, curricular reforms and implementation, teaching, learning and assessments at the secondary level of education in Sri Lanka (Athurupana *et al.*, 2011; Keppetigoda, 2017). These issues include students' low achievements, disparities in achievements by gender, urban-rural difference, type of the school and province, as well as shortcomings in curriculum design and implementation. Currently, the Sri Lankan education system is geared towards implementing major reforms during the coming years to address such issues and to transform the education system to suit the needs of the 21st century. The success of educational reforms depends on many factors and teacher beliefs and practices play a pivotal role in implementing reforms in curriculum, teaching, learning and assessments (Handal & Herrington, 2003). Therefore, it is opportune to identify teacher beliefs of mathematics education and to assess their implications for teaching, learning and students' achievements.

The range of teachers' mathematics beliefs is vast and each teacher may hold a wide range of beliefs about learners, teachers, teaching, learning, schooling, resources, and support that they receive, their teaching efficacy and curriculum (Handal, 2003). Clark & Peterson (1986) postulate that teacher beliefs acts as a filter through which teachers make their decisions

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rather than their pedagogical knowledge or curriculum guidelines. Handal & Herrington (2003) argue that these beliefs may be strong enough to either facilitate or slowdown curricular reforms. Many teachers hold behaviourist beliefs that have strong implications for the successful implementation of constructivist oriented curricular reforms (Handal & Herrington, 2003). Therefore, studying teachers' beliefs, their influences on student learning and achievement as well as the implementation of curricular reforms are important for improving teaching and learning in mathematics.

Mathematics curricula at the junior secondary level of Sri Lanka are aligned with the standards specified by the National Council for Teachers in Mathematics (NCTM) which are considered as international benchmarks in mathematics education (McCaul, 2007). NCTM (2000) specifies two main categories of standards that include content standards and process standards. Five content standards highlight the specific subject contents or the knowledge components (number and operations; algebra; geometry; measurement; data analysis and probability) to be included in secondary school mathematics curricula. In addition to that, there are five process standards (problem-solving; reasoning and proof; making connections; oral and written communication; uses of mathematical representation) that are essential components of the mathematics learning process. Mathematics teachers have to focus on both content standards and process standards (Schoenfeld, 2002) in their teaching and they require appropriate working conditions, classroom environments and constructivist teaching practices (Handal & Herington,2003; Schoen *et al.*, 2019) in their classrooms. Therefore, in this study, we have focused on three main strands of teachers' beliefs of teaching mathematics; students related limitations affecting teaching and self-efficacy in teaching mathematics and their association with the teacher characteristics and student achievements. Concerning teacher beliefs of teaching mathematics, we focus on teachers' beliefs of their workload and working conditions and the use of constructivist practices of teaching which provide opportunities for students to achieve both content and process standards. Secondly, the teachers' beliefs of student-related limitations affecting teaching and finally the teachers' self-efficacy beliefs in teaching Mathematics and teaching specific competencies required to achieve the standards set out in the curriculum. We also considered the fact that the Mathematics teacher population in Sri Lanka is heterogeneous in terms of their academic and professional qualifications and years of experience. Therefore, in this paper, our purpose is to assess the associations among teacher beliefs; teacher characteristics; (the teachers' years of experience of teaching; their highest educational qualifications in mathematics; their professional qualifications) and students' achievements in mathematics. The findings of this study will be useful for making recommendations to improve teaching-learning practices in the mathematics classrooms, curricular reforms and teachers' professional development.

To achieve the above purpose three main research objectives have been set:

1. To identify the association between the beliefs of mathematics teachers and teacher characteristics such as years of experience of teaching, highest educational qualifications in mathematics, and professional qualifications;
2. To assess the relationship between teacher characteristics and students achievements;
3. To identify the relationships between different types of teacher beliefs and students achievements.

LITERATURE REVIEW

Research suggests that both attitudes and beliefs of teachers drive their classroom actions and influence the teacher change process (Nespor, 1987; Pajares, 1992; Peck & Tucker, 1973; Richardson, 1994). Teacher attitudes and beliefs, therefore, are important considerations in understanding classroom practices and conducting teacher education designed to help prospective and in-service teachers develop their thinking and practices.

According to Green (1971), a belief is a proposition that is accepted as true by the individual holding the belief. Richardson (1996) defined beliefs as "psychologically held understandings, premises, or propositions about the world that are felt to be true" (p. 103). It is a psychological concept that differs from knowledge which implies an "epistemic standard that requires some evidence to back up the claim which is agreed upon as true by a community of people" (p. 103). Although this type of definition is prevalent in the literature, Beswick (2005) points out that there is no one agreed-upon definition for beliefs. Following Beswick (2005) the term beliefs in this research refer to "anything that an individual regards as true" p.39

Nespor (1987) postulated that beliefs are likely to be far more influential than knowledge in determining how individuals make sense of their world and are likely to be stronger predictors of individual behaviour. Teachers' belief systems reflect their personal theories about the nature of knowledge which influence teachers' curriculum

decision making and teaching approaches (Pajares, 1992). According to Thompson (1984), teachers' beliefs seemed to be "manifestations of unconsciously held views or expressions of verbal commitments to abstract ideas that are related to a general ideology of teaching". Therefore, understanding beliefs and how they relate to the behaviours, actions and decision making of teachers is necessary for improving teaching-learning, teacher professionalism and implementing curricular reforms.

Teachers' mathematical beliefs can be conceptualised as an individual perspective on how one engages in mathematical tasks and pedagogical practices (Schoenfeld, 1985). Following Handal (2003), in the current study, we define teachers' mathematical beliefs as those belief systems held by teachers on the teaching and learning of Mathematics. Ernest (1991) classified mathematics teachers' beliefs systems into three categories; the teacher beliefs of mathematics as a subject for study, the teacher beliefs of the nature of mathematics teaching and the teacher beliefs of the learning of mathematics. According to Handal & Herrington (2003) these beliefs represent implicit assumptions on curriculum, teaching and learning, assessment, students and knowledge. In the current study, we define the term teachers' mathematical beliefs as 'what the teachers regard as true in their engagement with mathematical tasks and pedagogical practices.' Accordingly, we have focused on mathematics teachers' beliefs of mathematics teaching, students related limitations affecting teaching and self-efficacy in teaching mathematics.

Conceptualisations of teachers' Mathematical beliefs

Handal (2003) states that each teacher may hold a wide range of beliefs about learners, teachers' teaching, learning, schooling, resources, and support that they receive, their teaching efficacy and curriculum. There are many different conceptualisations of teachers' mathematics beliefs in the literature (Ernest 1991; Handal, 2003; Clark *et al.* 2014; Schoen & Lavenia, 2019). Ernest (1991) identified three main philosophical conceptions of Mathematics held by teachers, namely; the instrumental view, Platonist view, and the problem-solving view. In the instrumental view, mathematics is conceptualized as a collection of rules and skills that are to be used for the attainment of a particular goal. The Platonist view conceptualizes mathematics as a static but unified body of certain rules. The problem-solving view conceptualizes mathematics as a continuous process of inquiry that always remains open to revision. However, more recent literature, for example, Clark *et a*l. (2014) and Schoen *et al.* (2019) posit that a growing number of studies on Mathematics teachers' beliefs of teaching and learning indicate a tendency to organise those beliefs roughly into two categories. Beliefs that reflect behaviourist transmission theories of learning and the teaching practices that support such theories is one such category. The other category reflects conceptualisations of mathematics learning and knowing in terms of conceptual understanding, problem-solving, reasoning, and sense-making which require ambitious teaching practices to such learning (Clark *et al.*, 2014; Voss *et al.*, 2013). In this paper we use the term 'Behaviourist Transmissionist Conceptualization' (BTC), to denote the above category one and the term 'Constructivist Sense-Making' (CSM) to denote category two.

According to Vose (2013) behaviourist transmissionist theories and practices that support them imply that learning is a process of information transmission and students are more or less passive recipients. Teachers who strongly hold beliefs aligned with BTC, therefore, may focus on students mastering mathematical facts and procedures during instruction and devote less time to developing students' conceptual understanding. Teaching practices associated with this conceptualisation emphasize repetition, automaticity and skill mastery. In contrast to such emphases of BTC, teachers' beliefs that align with CSM acknowledge broader and more complex conceptualisations of mathematical knowledge and proficiency, including conceptual understanding, strategic competence, reasoning and sense-making (Kilpatrick, 2001 cited in Clark (2014: p.250). Such beliefs conceptualise learning as knowledge construction which involves an active process of synthesizing preconceptions and prior knowledge with the content to be learned at hand. Clark *et al.* (2014) further state that teachers who hold these beliefs may utilise teaching practices that require students' active involvement with challenging mathematical tasks that are geared to deepening students' conceptual understanding.

Relationships among teacher beliefs, instructional practices and students achievements

Handal & Herrington (2003) state that although many studies suggest that there is a relationship between teacher beliefs and instructional practices, the causality is not established. Some studies suggest teachers' beliefs influence instructional practices (Cross, 2009; Cambell *et al.*, 2014) while others suggest instructional practices influence teacher beliefs (Pajares, 1992). However, Thompson (1984) and Pajares (1992) show that the relationship between teacher beliefs and their classroom practices is highly complex and dialectical. Guskey cited in Cobb *et al.,* (1990) argued that changed practice leads to changed beliefs. But in contrast to that Cobb *et al.,*

(1990) concluded that beliefs and practice influence one another and develop together rather than relating to each other in a linear causal way. Beswick (2007) argues that teacher beliefs are context-bound. The relative centrality of beliefs of an individual may vary from context to context. Teacher's beliefs held about specific groups of students in one context may differ from the beliefs held in another context (Beswick, 2007). According to Clark *et al.* (2014), changing teacher beliefs through mathematics courses and teaching methods courses is not a simple and straightforward task. To facilitate change in teacher beliefs teacher education programmes should include specific 'programmatic mechanisms' (Scheonfeld, 2002). Clark *et al.* (2014) also conclude that teacher beliefs are associated with factors external to teacher education such as race and gender of the teacher. Therefore, they suggest teacher education programmes need to create opportunities for the participants to discuss their experiences of teaching in different contexts. Recent research has also found relationships between teachers' beliefs of teaching and learning mathematics and students' achievements (Love & Kuger, 2005). Polly *et al.* (2013) observed that researchers have found empirical relationships between specific instructional practices and students learning outcomes. Such instructional practices reflect a student-centred view of teaching mathematics, in which students engage in higher order tasks that are supported by teachers who use questioning and modify instruction based on students' mathematical thinking (National Council for Teachers of Mathematics, 2000). Fennema *et al.* (1996) and Polly *et al.* (2013) found that students in classrooms whose teachers held more student-centred beliefs to teaching mathematics have statistically significant gains in mathematics achievements in curriculum-based assessments. Polly *et al.* (2013) further observed that there were significantly lower gain scores on curriculum-based assessments among students whose teachers had reported teacher-centred beliefs and practices.

Teachers' self-efficacy beliefs in mathematics teaching and students achievements

The theoretical foundation of the concept of self-efficacy is found in the social cognitive theory of Albert Bandura (1977; 1997) who defined self-efficacy as "beliefs in one's capabilities to organise and execute the courses of action to produce given attainments." Accordingly, Tschannen-Moran *et al.* (1998) defined teacher efficacy as a teacher's "Judgement of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated." Henson (2001) asserts that students of self-efficacious teachers outperformed students in other classes. Perera & John (2020) in their study of teachers' self-efficacy beliefs for teaching mathematics have examined a model relating math teaching self-efficacy with the teacher and student outcomes and concluded that teacher self-efficacy beliefs for teaching mathematics were positively associated with class levels of mathematics achievements, teachers job satisfaction and interactional quality.

Factors associated with teacher beliefs

Research indicates that teachers acquire their beliefs of mathematics teaching during their school days where they sit in classrooms with teachers for thousands of hours (Thompson, 1984). Richardson (1996) asserts that teachers' beliefs are a result of both socialization in the profession and experiences as students in schools. Clark *et al.* (2014) investigated possible influences on mathematics teachers' beliefs and concluded that there are statistically significant relationships between teachers' beliefs and teachers' mathematical knowledge, special education certification, race, gender, and the percentage of their students with free meals status. Zakaria *et al.* (2012) identified that there was no significant difference between less experienced and more experienced teachers in the beliefs towards the nature of mathematics; mathematics teaching and mathematics learning.

The above review indicates that teachers' mathematical beliefs have been studied over the past three decades or more by researchers in different parts of the world. They have found that the study of teacher beliefs in mathematics is useful in reforming teaching and learning in mathematics classrooms, teacher professional development and shaping further research. The research also suggests that the relationship between teacher beliefs and instructional practices is inconclusive. The relationship is complex and dialectical in nature and the teacher beliefs and practices tend to develop together. Teacher beliefs also depend on the context of teaching. The review also indicates that there is a relationship between teacher beliefs and student achievements. Teacher beliefs based on constructivist practices in teaching indicated significant positive gains in students' achievements while the teacher beliefs based on transmission approaches to teaching indicated lower gains in students achievements. Researchers have also found that there are significant relationships between teachers' self-efficacy beliefs, class level student achievements and instructional quality. Moreover, the researchers have identified factors affecting teacher beliefs such as their mathematical knowledge, gender, race and years of experience in teaching. Informed with this research based knowledge, in the current study we

attempt to investigate the associations between teacher beliefs, students achievements and selected teacher characteristics in the Sri Lankan context.

METHODOLOGY

Data for this study was collected through survey research conducted in the Central Province of Sri Lanka using a questionnaire which was administered in person by trained enumerators to 50 mathematics teachers who teach Grade seven classes in selected schools.

Sample

The sample was selected by choosing one teacher each from a stratified random sample of 50 schools on the basis of school type and ethnic type. Out of the 50 teachers, 30 were females and 20 were males. These teachers were grouped according to the number of years of teaching experience, their highest educational qualification and their professional qualifications. Tables 1-3 set out the profiles of the respondents respectively according to their teaching experience, highest educational qualifications and professional qualifications.

The majority of mathematics teachers (56%) in the sample have less than 10 years of experience and 44% are having less than 5 years experience in teaching (Table 1). This situation might affect the teaching learning process adversely if the majority of the less experienced teachers are also without professional qualifications. According to Table 2, the majority of mathematics teachers are GCE (A/L) qualified while 34% are graduates who belong to different subject streams. Out of the graduate teachers, only 16% have offered mathematics as a subject in their first degree. Furthermore, there is a considerable percentage of teachers who are without professional qualifications (22%) while the professionally qualified

Table 1: Respondents' profile based on teaching experience

Teaching Experience	Frequency	Percentage
1 – 5 years	22	44
5 – 10 years	06	12
More than 10 years	22	44
Total	50	100

Table 2: Respondents' profile based on the highest educational qualifications

Educational Qualification		Frequency	Percentage
G.C.E. (O/L)		02	04
G.C.E. (A/L)		31	62
Degree*	Mathematics	08	16
	Biology	01	02
	Commerce	05	10
	Arts	02	04
	Education	01	02
	Sub-Total	17	34
Total		50	100

Table 3: Respondents' profile based on professional qualifications

Professional Qualification	Frequency	Percentage
Trained Teacher Certificate	19	38
National Diploma in Teaching	12	24
Postgraduate Diploma in Education	03	06
Bachelor of Education	05	10
None of the above qualifications	11	22
Total	50	100

teachers bear different categories of professional qualifications offered by different institutions (Table 3). The heterogeneity of the mathematics teachers in terms of their experiences, professional and educational qualifications increases the importance of this type of study since these differences may affect teacher beliefs and students achievements.

For further analysis, the categories of degree holders were collapsed into two categories, namely 'mathematics, and 'non-mathematics graduates'. Non-mathematics graduates include Biology, Commerce, Arts and Education graduates.

Instruments

A questionnaire, comprising questions adapted from Mathematics Teacher Questionnaire of the 2000 National Survey of Science and Mathematics Education (Weiss *et al.*, 2001) and Mathematics teacher questionnaire of IEA Trends in International Mathematics and Science study 2011 (Mullis *et al.*, 2012; Martin & Mullis, 2012), was used to gather information on the mathematics teachers demographic data and their views on a range of factors affecting teaching and learning in their classrooms.

The current study utilises 71 items belonging to three main dimensions that include beliefs of mathematics teaching in the classroom (two subscales with 17 items), beliefs of student-related limitations affecting teaching (one subscale with 7 items), and self-efficacy beliefs in teaching mathematics (seven subscales with 47 items). A four-point scale of 1-4 was used in each of the subscales and negative statements were reverse coded before analysis. Table 4 indicates the subscales, sample items and rating scales used in each dimension of the questionnaire.

A semi-structured interview schedule was also used in the overall study. The teachers' responses to a question asked on the teacher beliefs of student learning and achievements in mathematics is used to supplement the quantitative analysis of the association between teachers beliefs and students' achievements. Interview data were analysed using the constant comparative method (Merriam, 2009). Quantitative data were analysed using SPSS version 26.0.

Validity and reliability were tested before administering the questionnaire by conducting a pilot study. The results of the reliability estimates show acceptable measures, with Cronbach's alpha values ranging between 0.749 and 0.966. Piloting of the questionnaire with selected groups of Grade 7 mathematics teachers, and the follow-up discussions held with them helped us to better adapt and validate the questionnaire to the Sri Lankan context. Class level mark sheets of the first term test conducted in the year 2019 by the Provincial Education Department of the Central Province were also collected from the teachers in the sample. The data were analysed using SPSS and Excel software and one-way ANOVA analysis and relevant post hoc tests.

Table 4: Main dimensions, subscales and sample items of the questionnaire

Dimension	Name of the subscale and the key question	Sample items	Rating scale
Beliefs of mathematics teaching in the classroom	Teacher workload and working conditions Indicate the extent to which you agree or disagree with each of the following statement. (10 items)	• There are too many students in this class. • I have too many administrative tasks. • I feel too much pressure from parents	1=Agree a lot; 2=Agree a little; 3=Disagree a little; 4=Disagree a lot
	Use of constructivist practices in teaching How often do you do the following in teaching this class? (7 items)	• Link new content to students' prior knowledge • Ask students to explain their answers.	1=Every or almost every lesson 2=About half the lessons 3=Some lessons 4=Never
Beliefs of student related limitations affecting teaching,	Students related limitations affecting teaching In you view, to what extent do the following limit how you teach this class? (7 items)	• Students lacking prerequisite knowledge or skills • Disruptive students	1=Not at all; 2=Some; 3=A lot 4=always
Self-efficacy beliefs in teaching mathematics	Self-efficacy in teaching mathematics in general In teaching mathematics how would you characterise your confidence in doing the following? (10 items)	• Inspiring students to learn mathematics • Adapting my teaching to engage students' interest • Assessing student comprehension of mathematics	1=Very high; 2=High; 3=Medium; 4=Low
	Self-efficacy in teaching specific mathematical competencies How well are you prepared to teach the following mathematical competencies relevant to grade 7? (38 items pertaining to 6 content standards)	• e.g. A: Numbers • Solves simple problems using the factors and multiples of numbers. • Analyses the different ways of representing a number	1=Very well prepared; 2= Somewhat prepared; 3= Not well prepared 4=Not prepared

DATA ANALYSIS AND FINDINGS

Data analysis and findings are presented according to the three stated objectives of the study and organised under three main subheadings, namely, the association between teacher beliefs and teacher characteristics, the association between teacher characteristics and student achievements, and the association between teacher beliefs and students achievements.

The association between teacher beliefs and teacher characteristics

As shown in Table 5, there are slight differences between the mean values of teacher beliefs concerning all three dimensions and related subscales. A one-way Analysis of Variance (ANOVA) was conducted to determine the significance of the difference between the mean mathematics beliefs among the teachers with different

Table 5: Mean of mathematics beliefs according to teachers' teaching experience

Teaching Experience	Mathematics beliefs dimensions															
	Dimensions							Beliefs towards mathematics teaching in the classroom*		Beliefs of students related limitations affecting teaching						Self-efficacy beliefs of teaching mathematics*
	Subscales	Teachers' workload and working conditions		The use of constructivist practices in teaching								Self-efficacy beliefs in teaching specific mathematical competencies		Self-efficacy beliefs in teaching in general		
	N	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1–5yrs	22	2.55	0.55	3.19	0.46	3.02	0.29	2.82	0.53	3.59	0.35	3.28	0.50	3.38	0.41	
5-10yrs	06	2.47	0.49	3.05	0.46	2.81	0.35	3.02	0.39	3.66	0.40	3.12	0.48	3.53	0.42	
>10yrs	22	2.70	0.51	3.30	0.47	2.84	0.38	2.93	0.60	3.71	0.35	3.20	0.48	3.47	0.37	

* Based on the sum total of responses in each subscale in the dimension

Table 6: ANOVA of mathematics beliefs according to teachers' teaching experience

Mathematics beliefs		Sum of Squares	df	Mean Square	F
Beliefs towards mathematics teaching in the classroom					
Teachers' workload and working conditions	Between Groups	0.369	2	0.184	0.663
	Within Groups	13.068	47	0.278	
	Total	13.437	49		
The use of constructivist practices in teaching	Between Groups	0.343	2	0.172	0.792
	Within Groups	10.183	47	0.217	
	Total	10.526	49		
Beliefs towards mathematics teaching in the classroom	Between Groups	0.450	2	0.225	1.942
	Within Groups	5.447	47	0.116	
	Total	5.897	49		
Beliefs of students related limitations affecting teaching					
	Between Groups	0.814	2	0.407	1.387
	Within Groups	13.792	47	0.293	
	Total	14.605	49		
Self-efficacy beliefs of mathematics teachers					
Self-efficacy beliefs in teaching Mathematics	Between Groups	0.127	2	0.064	0.262
	Within Groups	11.411	47	0.243	
	Total	11.539	49		
Self-efficacy beliefs in teaching specific mathematical competencies	Between Groups	0.160	2	0.080	0.621
	Within Groups	6.061	47	0.129	
	Total	6.221	49		
Self-efficacy beliefs of mathematics teachers	Between Groups	0.147	2	0.074	0.484
	Within Groups	7.158	47	0.152	
	Total	7.305	49		

levels of teaching experience. It is revealed that these differences were non-significant at $p<0.05$ (Table 6).

The relationship between teacher beliefs and their years of experience in teaching

It is difficult to identify the reasons behind this uniformity of beliefs among teachers with different levels of teaching experience without further investigation. Teacher beliefs of workload and working conditions may depend on both the school context and teacher-related factors. Teachers' beliefs of the use of constructivist teaching practices will depend on the teacher education and professional development and the teacher's assumptions and philosophy of teaching. Teachers' self-efficacy beliefs of teaching mathematics may also depend on similar and context-related factors.

Table 7: Mean of mathematics beliefs according to teachers' highest educational qualification

Highest Educational Qualification		N	Mathematics beliefs dimension														
			Subscales		Teachers' workload and working conditions		The use of constructivist practices in teaching		Dimension-1 Beliefs towards mathematics teaching in the classroom*		Dimension-2 Students related limitations affecting teaching		Self-efficacy beliefs in teaching specific mathematical competencies		Self-efficacy beliefs in teaching in general		Dimension-3 Self-efficacy beliefs of teaching mathematics*
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
G.C.E. (O/L)		02	2.75	0.07	3.36	0.91	2.84	0.31	2.86	0.61	3.63	0.53	3.34	0.94	2.83	0.01	
G.C.E. (A/L)		31	2.74	0.48	3.17	0.49	2.95	0.32	2.93	0.45	3.71	0.34	3.12	0.48	3.42	0.39	
Degree	Maths graduates	08	2.69	0.32	3.11	0.66	2.90	0.31	2.87	0.43	3.75	0.35	3.21	0.55	3.58	0.35	
	Non-Maths graduates	09	2.40	0.52	3.29	0.32	2.79	0.44	2.44	0.70	3.57	0.37	3.26	0.52	3.58	0.36	
Total		50	2.54	0.45	3.20	0.49	2.84	0.38	2.64	0.61	3.65	0.36	3.24	0.52	3.58	0.34	

The relationship between teacher beliefs and their highest educational qualifications

Table 7 indicates that there is not much difference between the teachers' beliefs according to their highest educational qualification. The teachers who possess G.C.E. (A/L) qualifications held better beliefs of students related limitations affecting teaching (mean = 2.93, SD = 0.45) as compared to the other groups of teachers.

According to the one-way Analysis of Variance (ANOVA) (See Table 8) there were no significant differences in the teacher beliefs towards mathematics teaching in the classroom, student-related limitations affecting teaching and the self-efficacy beliefs of the mathematics teachers according to their highest educational qualification.

However, there was a significant difference between the beliefs of teachers on the workload and working conditions ($F(3, 46) = 3.310$, $p = 0.028$) according to their highest educational qualification.

Further analysis of Post Hoc Multiple Comparisons (Tukey HSD- Honestly Significant Differences) showed that there is a significant difference between the Non-Mathematics graduate teachers' beliefs of workload and working conditions and those of teachers with

Table 8: ANOVA of mathematics beliefs according to teachers' highest educational qualification

Mathematics Beliefs		Sum of Squares	df	Mean Square	F	Sig. p
Beliefs towards mathematics teaching in the classroom						
Teachers' workload and working conditions	Between Groups	2.386	3	.795	3.310	0.028
	Within Groups	11.051	46	.240		
	Total	13.437	49			
The use of constructivist practices in teaching	Between Groups	0.210	3	0.070	0.312	0.816
	Within Groups	10.316	46	0.224		
	Total	10.526	49			
Dimension -1 Beliefs towards mathematics teaching in the classroom	Between Groups	0.115	3	0.038	0.304	0.823
	Within Groups	5.783	46	0.126		
	Total	5.897	49			
Beliefs of students related limitations affecting teaching						
Dimension- 2 Beliefs of students related limitations affecting teaching	Between Groups	0.956	3	0.319	1.073	0.370
	Within Groups	13.650	46	0.297		
	Total	14.605	49			
Self-efficacy beliefs of mathematics teachers						
Self-efficacy beliefs in mathematics teaching in general	Between Groups	0.149	3	0.050	0.201	0.895
	Within Groups	11.389	46	0.248		
	Total	11.539	49			
Self-efficacy beliefs in teaching specific mathematical competencies	Between Groups	0.259	3	0.086	0.666	0.577
	Within Groups	5.962	46	0.130		
	Total	6.221	49			
Dimension-3 Self-efficacy beliefs of mathematics teachers	Between Groups	1.103	3	0.368	2.725	0.055
	Within Groups	6.203	46	0.135		
	Total	7.305	49			

Table 9: Mean of mathematics beliefs according to teachers' professional qualifications

Professional Qualification	Mathematics beliefs dimensions														
	Dimensions	Beliefs towards mathematics teaching in the classroom						Students related limitations affecting teaching		Self-efficacy beliefs of teaching mathematics					
	Subscales	Teachers' workload and working conditions		The use of constructivist practices in teaching		Dimension-1		Dimension-2		Self-efficacy beliefs in teaching specific mathematical competencies		Self-efficacy beliefs in teaching in general		Dimension-3	
	N	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
With professional qualifications	39	2.74	0.45	3.21	0.49	2.92	0.34	2.83	0.56	3.71	0.35	3.21	0.49	3.45	0.39
Without professional qualifications	11	2.13	0.49	3.25	0.39	2.91	0.37	3.12	0.46	3.43	0.32	3.30	0.48	3.38	0.37

G.C.E. (A.L.) qualifications (MD = 0.54, p = 0.016). The mean value of non-mathematics graduate teachers' beliefs of workload and working conditions were less than that of other categories of teachers (Table 7). The reason behind these differences in beliefs can be due to the differences in the school contexts where the teachers teach and the teacher's level of confidence in working under unfavourable conditions as well as the teacher's recognition of the effects of such conditions on their teaching.

The relationship between teacher beliefs and their professional qualifications

As shown in Table 9, the teachers who possess professional qualifications held more favourable beliefs towards mathematics teaching in the classroom (mean = 2.92, SD = 0.34) and self-efficacy beliefs in teaching specific mathematical competencies (mean = 3.71, SD = 0.35) in comparison to the teachers who are without professional qualifications. The difference between the two groups is significant at $p<0.05$. The beliefs of student-related limitations affecting the teaching of teachers without professional qualifications teachers (mean = 3.12, SD = 0.46) have a higher mean than professionally qualified teachers (mean = 2.83, SD = 0.56). However, the difference between the two groups is not significant at $p<0.05$.

According to Table 10, there are significant differences between the beliefs towards teachers' workload and working conditions ($F(1, 48) = 15.370$, $p = 0.000$), and self-efficacy beliefs in teaching specific mathematical competencies of the mathematics teachers ($F(1, 48) = 5.846$, $p = 0.019$) based on teachers' professional qualifications. Professionally qualified mathematics teachers have reported better beliefs than the teachers without professional qualifications on workload and working conditions (M = 2.74) and self-efficacy in teaching specific mathematical competencies (M = 3.71). The findings imply that teachers' professional training has a positive effect on their beliefs. This situation signifies the need to enhance the professional qualifications of mathematics teachers. In the next section, teacher's

Table 10: ANOVA of mathematics beliefs according to teachers' professional qualifications

Mathematics Beliefs		Sum of Squares	df	Mean Square	F	Sig.
Beliefs towards mathematics teaching in the classroom						
Teachers' workload and working conditions	Between Groups	3.259	1	3.259	15.370	0.000
	Within Groups	10.178	48	0.212		
	Total	13.437	49			
The use of constructivist practices in teaching	Between Groups	0.010	1	0.010	0.045	0.832
	Within Groups	10.516	48	0.219		
	Total	10.526	49			
Beliefs towards mathematics teaching in the classroom*	Between Groups	0.001	1	0.001	0.004	0.947
	Within Groups	5.897	48	0.123		
	Total	5.897	49			
Beliefs of students related limitations affecting teaching						
	Between Groups	0.063	1	0.063	0.208	0.651
	Within Groups	14.543	48	0.303		
	Total	14.605	49			
Self-efficacy beliefs of mathematics teachers						
Self-efficacy beliefs in teaching in general	Between Groups	0.080	1	0.080	0.336	0.565
	Within Groups	11.459	48	0.239		
	Total	11.539	49			
Self-efficacy beliefs in teaching specific mathematical competencies	Between Groups	0.675	1	0.675	5.846	0.019
	Within Groups	5.546	48	0.116		
	Total	6.221	49			
Self-efficacy beliefs of mathematics teachers*	Between Groups	0.040	1	0.040	0.264	0.610
	Within Groups	7.266	48	0.151		
	Total	7.305	49			

* Based on the sum total of responses in each subscale in the category

self-efficacy beliefs of teaching specific competencies relevant to the six content standards in the curriculum are further analysed.

The association between teacher characteristics and teachers' self-efficacy beliefs in teaching specific competencies relevant to content standards

To understand the situation further the association between teachers' self-efficacy beliefs in teaching 38 mathematical competencies given in the Teacher Instructional Manual (TIM) of Grade 7 according to the six content standards (Numbers, Measurement, Algebra, Geometry, Statistics, Sets and Probability) and teachers' professional qualifications were examined using one-way ANOVA (see Table 11).

Table 11 indicates that there are significant differences between professionally qualified teachers and teachers without professional qualifications according to self-efficacy beliefs in teaching specific competencies related to four out of six content standards that are given

Table 11: ANOVA of self-efficacy beliefs in teaching specific mathematical competencies according to teachers' professional qualifications

		Sum of Squares	df	Mean Square	F	Sig.
1. Numbers						
1.1 Methodically simplifies expressions involving whole numbers.	Between Groups	1.596	1	1.596	8.601	.005
	Within Groups	8.904	48	.186		
	Total	10.500	49			
1.2 Adds directed numbers with an understanding of directions.	Between Groups	1.239	1	1.239	4.962	.031
	Within Groups	11.981	48	.250		
	Total	13.220	49			
1.3 Solves simple problems using the factors and multiples of numbers.	Between Groups	2.339	1	2.339	13.147	.001
	Within Groups	8.541	48	.178		
	Total	10.880	49			
1.4 Manipulates fractions under the operations of addition and subtraction.	Between Groups	1.239	1	1.239	4.962	.031
	Within Groups	11.981	48	.250		
	Total	13.220	49			
1.5 Shares resources fairly by applying the knowledge on ratios.	Between Groups	.927	1	.927	4.099	.048
	Within Groups	10.853	48	.226		
	Total	11.780	49			
1.6 Analyses the different ways of representing a number.	Between Groups	1.613	1	1.613	6.017	.018
	Within Groups	12.867	48	.268		
	Total	14.480	49			
2. Measurements						
2.1 Applies formulae to solve problems related to the perimeters of rectilinear plane figures.	Between Groups	1.239	1	1.239	5.957	.018
	Within Groups	9.981	48	.208		
	Total	11.220	49			
2.2 Inquiries into the amount of space taken up by cubes and cuboids.	Between Groups	2.236	1	2.236	7.697	.008
	Within Groups	13.944	48	.291		
	Total	16.180	49			
3. Algebra						
3.1 Describes the location of a certain place concerning two mutually perpendicular axes.	Between Groups	2.466	1	2.466	10.264	.002
	Within Groups	11.534	48	.240		
	Total	14.000	49			
4. Geometry						
4.1 Engages in the creation of models of square pyramids and triangular prisms.	Between Groups	1.701	1	1.701	5.798	.020
	Within Groups	14.079	48	.293		
	Total	15.780	49			

Continued-

Continued from page 252

4.2 Investigates the relationships between the properties of solids.	Between Groups	1.411	1	1.411	7.155	.010
	Within Groups	9.469	48	.197		
	Total	10.880	49			
4.3 Engages in creations while examining the properties of symmetric plane figures	Between Groups	.850	1	.850	4.226	.045
	Within Groups	9.650	48	.201		
	Total	10.500	49			

*Only the significant results at $p<0.05$ are indicated in Table 13.

in the TIM of Grade 7. Teachers without professional qualifications are less confident than professionally qualified teachers to teach most of the competencies in the content standards of Numbers (6/9) and some of the competencies belonging to the content standards of Measurements (2/8), Algebra (1/5) and Geometry (3/11) while there are no significant differences between the two categories of teachers self-efficacy beliefs in teaching competencies belonging to the content standards of Statistics and Sets & Probability (See Table 11).

The above findings imply the urgent need to make every mathematics teacher in service a professionally qualified teacher and to increase the capacity of teacher education institutions to produce more teachers with professional qualifications through initial teacher education programmes in mathematics.

The association between students achievements and teacher characteristics

Table 12: Descriptive statistics of class level term test scores of students according to teachers' years of experience

Years of Experience	Mean	Standard Deviation
1 – 5 years	29.43	9.84
5 – 10 years	32.13	10.73
More than 10 years	33.12	12.86

Table 13: ANOVA of mean scores of students according to the years of experience of the teacher

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	153.932	2	76.966	0.595	0.556
Within Groups	6082.006	47	129.404		
Total	6235.938	49			

As shown in Table 13, it can be observed that the student mean scores have slightly increased according to the years of experience of the teacher. A one-way ANOVA was used to determine the significance of the differences in mean scores of students among the three groups (Table 13). It is revealed that there was no significant difference between the mean scores of the students ($F(2, 47) = 0.595$, $p = 0.556$) according to teachers' years of experience.

Table 14: Descriptive statistics of scores of students according to teachers' highest educational qualification

Highest Educational Qualification		Mean	Standard Deviation
G.C.E. (O/L) & (A/L)		33.92	11.76
Bachelor's Degree	Mathematics	31.58	10.61
	Other subjects	32.53	13.78

According to Table 14, it can be observed that there is not much difference between the mean scores of the students based on teachers' highest educational qualification.

Table 15: ANOVA of mean scores of students according to teachers' highest educational qualification

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	674.534	2	337.268	2.850	0.068
Within Groups	5561.401	47	118.328		
Total	6235.938	49			

It is revealed that there is no significant difference between the mean scores of the students (F (2, 47) = 2.850, p = 0.0.068) according to teachers' highest educational qualification at $p<0.05$ (Table 15).

Table 16: Descriptive statistics of scores of students according to teachers' professional qualifications

Professional Qualifications	N	Mean	Standard Deviation
With professional qualifications	31	31.13	10.49
Without professional qualifications	09	25.37	8.73

According to Table 16, the mean scores of the teachers who possess professional qualifications (mean = 31.13, SD = 10.49) was higher than the mean scores of the teachers who do not have professional qualifications (mean = 25.37, SD = 8.73).

Table 17: ANOVA of mean scores of students according to teachers' professional qualifications

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	231.419	1	231.419	2.248	0.142
Within Groups	3912.177	38	102.952		
Total	4143.596	39			

A one-way Analysis of Variance (ANOVA) revealed that there is no significant difference between the students' mean scores of the teachers who possess professional qualifications and the teachers who do not have professional qualifications (F (1,38) = 2.248, p = 0.142).

Overall results of this analysis indicate that students' achievements are independent of teacher characteristics. Students' achievements seem to be affected by many other intervening variables.

The association between teacher beliefs and students' achievements

A one-way Analysis of Variance (ANOVA) revealed that there are no significant associations between the three dimensions of teacher beliefs considered in the study (the teacher beliefs of mathematics teaching, student-related limitations affecting teaching and self-efficacy in teaching mathematics) and the students' achievements.

The above findings on the association between teacher beliefs and students' achievements lead us to examine the teachers' responses to a question asked in the qualitative interview. The question was, 'What do you think about students' mathematics learning and achievements in your class and what are the reasons for that situation?

Most of the teachers who responded to the above question were of the view that there are poor achievers in their classrooms and there are many specific reasons for low achievements among students. However, teachers rarely referred to teacher-related factors such as their self-efficacy beliefs and the teaching methods that they use in their responses. Only a few teachers reflected upon the drawbacks in their teaching and suggested that their methods of teaching and the working conditions might affect student learning. For instance, one teacher suggested:

> ."I think if I could use different teaching methods, I can gain the students' attention. For that, we need more instruments and facilities."
>
> Teacher 130/1346

Many of the teacher responses suggested that they believe poor achievement is mostly due to students' lack of prior knowledge, parents' ignorance or lack of support from the home environment and lack of facilities in schools. One such teacher articulated the situation in her mathematics class as follows:

> "The children coming from the primary do not have the basic mathematical concepts. Some students can't even write numbers correctly. Some students can't read word problems; they can sometimes give the correct answer if we read the problem for them. Individual differences also matter in the perception of mathematical concepts. Clever students could understand at the very first instance, and then others can't understand anything. We have to deal with both groups at the same time."
>
> - Teacher 0103

The teacher's response illustrates how the students' lack of prior knowledge, difficulties in reading and writing and also classroom conditions affect mathematics teaching and learning in her classroom. Here the implication is that mathematics teachers need to pay more attention to the students with this type of weaknesses and incorporate adaptive teaching methods and differentiated teaching in their classrooms.

DISCUSSION

In this study, the results revealed that the teacher sample is heterogeneous in terms of teachers' years of experience, highest educational qualifications and professional qualifications. However, there is no significant difference between the less-experienced teachers and the more-experienced teachers in the three dimensions of mathematics beliefs and mean scores obtained by the students at the class level. Similarly, teacher beliefs were independent of the highest educational qualifications that they possessed except for teacher beliefs of workload and working conditions. However, the study revealed that teachers who possess professional qualifications in teaching have better mathematics beliefs than the teachers who do not possess professional qualifications. They are more confident in working under stressful conditions (such as mathematics classrooms with a large number of students, content overload in the curriculum, teaching overload, lack of enough time for preparation, and excessive parental pressures etc.) compared to the other teachers. Professionally qualified teachers are also more self-efficacious about teaching specific mathematical competencies belonging to four out of the six content standards of the mathematics curriculum. Further analysis revealed that teacher beliefs considered in the study are not significantly associated with students' achievements. In the analysis of qualitative data related to a question asked about teachers' views on students' achievements and related factors, it has emerged that teachers seem to believe, student-related limitations and the teachers' working conditions contribute more to the students' poor achievements in mathematics than the teacher-related factors such as their methods of teaching and self-efficacy.

The findings of this study are comparable with the findings of similar studies conducted in other countries. The current study did not find a significant association between teacher beliefs in mathematics and the teachers' years of experience. In a comparable study, Zakaria *et al.* (2012) also found that there was no significant difference between less experienced and more experienced teachers in the beliefs of mathematics teaching. The lack of significant association between teachers' years of experience and their beliefs in the current study can be further explained in terms of the findings of previous research which highlights the nature of teacher beliefs and the complexities surrounding the factors that affect their development. According to Thompson (1992) and Richardson (1996) teachers' beliefs are a result of socialization in the profession and their experiences as students in schools. Teachers' beliefs and instructional practices have a complex and dialectical relationship (Pajares, 1992; Thompson, 1984) and both develop together throughout their teaching career (Cobb *et al.*, 1990). Moreover, the teachers' beliefs are context-bound.

Current study did not find significant association between teacher beliefs and students achievements. However, according to the qualitative data analysis teachers appear to believe that student related limitations and teacher workload and working conditions affect the students' achievements. This is consistent with the findings of Mullis *et al.* (2012) who found an association between teacher beliefs of workload and working conditions and students' achievements.

Implications of the findings for policy, practice and research in mathematics education

The current study revealed that the teacher sample is heterogeneous in terms of teachers' years of experience, highest educational qualifications and professional qualifications. However, there is no significant difference between the less-experienced teachers and the more-experienced teachers in the three dimensions of mathematics beliefs and mean scores obtained by the students at the class level. Similarly, teacher beliefs were independent of the highest educational qualifications that they possessed except for teacher beliefs of workload and working conditions. However, the study revealed that teachers who possess professional qualifications in teaching have better mathematics beliefs than the teachers who do not possess professional qualifications. They are more confident in working under stressful conditions (such as mathematics classrooms with a large number of students, content overload in the curriculum, teaching overload, lack of enough time for preparation, and excessive parental pressures etc.) compared to the other teachers. Professionally qualified teachers are also more self-efficacious about teaching specific mathematical competencies belonging to four out of the six content standards of the mathematics curriculum. The findings imply that teachers' professional training has a positive

effect on their beliefs. This situation signifies the need to enhance the professional qualifications of mathematics teachers. They also bear implications for improving teacher education and professional development policies and practices.

Teacher belief categories in all three dimensions, namely, the teacher beliefs of mathematics teaching, student-related limitations affecting teaching and self-efficacy in teaching mathematics are not associated with students' achievements. However, in the analysis of qualitative data it has emerged that teachers appear to believe, student-related limitations and the teachers' working conditions contribute more to the students' poor achievements in mathematics than the teacher-related factors such as their methods of teaching and self-efficacy. These findings highlight the need for improving policies and practices of teaching learning and curricular reforms.

The heterogeneity of the qualifications of mathematics teachers and other findings related to teacher qualifications bear implications for improving policies and practices of teacher education and professional development. Teacher beliefs on student related limitations as well as working conditions and workload, further emphasise the need to improve policies, practices and research on teaching learning, curricular reforms and mathematics education. Specific recommendations for each of these aspects are made in the following section.

CONCLUSIONS AND RECOMMENDATIONS

The study revealed that teachers who possess professional qualifications in teaching have better mathematics beliefs than the teachers who do not possess professional qualifications. The former is more confident in working under stressful conditions and more self-efficacious about teaching specific mathematical competencies. The study also found that 22% of teachers are without professional qualifications. Mathematics teachers in the sample are heterogeneous in terms of years of experience, highest educational qualifications and professional qualifications. However, students' achievements in mathematics are independent of these teacher characteristics. Qualitative data also suggested that most teachers believe that students' poor achievements are related to teachers' working conditions and student-related limitations. All these findings bear implications for teacher education, professional development, teaching learning, curricular reforms and further research in mathematics education and therefore, the following recommendations are made.

Recommendations for initial teacher education and continuing education

Initial teacher education programmes and in-service teacher education programmes need to be strengthened to increase opportunities for prospective mathematics teachers and teachers already in service to obtain an adequate level of understanding and competencies in both mathematics and pedagogy. As a short term measure to improve the quality of mathematics teachers already in service, opportunities and incentives should be provided to teachers to upgrade their qualifications in mathematics through a system of credit based short term courses in mathematics conducted by the conventional universities, the Open University and the National Institute of Education. Teacher education programmes in mathematics education should be developed at the undergraduate level to improve initial teacher education in mathematics. We argue that it is time to take action to gradually develop all mathematics teachers in the teacher service professionally qualified graduates with specialised knowledge in both mathematics and pedagogy.

Recommendations for professional development

Short term in-service training programmes and continuing education programmes can also be used to enhance the quality of teaching of mathematics teachers of all categories. Teacher education programmes in mathematics education should be developed at undergraduate and postgraduate degree levels to provide adequate professionally qualified teachers with mastery in both content and pedagogy of mathematics to teach in the secondary (Grades 6-11) and collegiate levels (Grades 12-13) of education.

Recommendations for teaching and learning and curricular reforms of mathematics

Improve textbooks, syllabi and Teacher Instructional Manuals to provide opportunities for active learning and authentic learning to the students and to acquire process skills of mathematics. Encourage teachers to use adaptive teaching, both directive and student-centred methods as appropriate while providing individual support to the needy students. Moreover, the Ministry of Education

needs to improve the working conditions of mathematics teachers, provide at least a standard set of stimulating learning materials in mathematics for the students and necessary equipment for each school.

Recommendations for research in mathematics education

Researchers should study the potential factors affecting teacher beliefs in mathematics to develop viable strategies for changing teacher beliefs and awareness. Research (Schoenfeld, 2002; Clark *et al.*, 2014) suggests that simply giving teachers more mathematics or mathematics education will not necessarily influence teachers' beliefs and awareness. Therefore, researchers need to focus on questions like 'In what ways do teacher education and professional development programmes contribute to influence and change teacher beliefs to improve student learning in mathematics classrooms?' Similarly, it would also be useful to study the effects of teachers' mathematical knowledge on their classroom practices and students achievements.

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