TEACHERS' BELIEFS AND KNOWLEGE RELATED TO THE CYPRUS MATHEMATICS CURRICULUM REFORM

Marilena Pantziara[1,3], Marianna Karamanou[2] and George Philippou[3]

[1]Cyprus Pedagogical Institute, [2]Ministry of Education and Culture,

[3]Univeristy of Nicosia

This paper presents some results of a larger study that investigates teachers' knowledge, beliefs, practices and enjoyment/confidence related to a mathematics curriculum reform. Data were collected from 100 in-service primary teachers through a questionnaire referring to teachers' background information, their beliefs, their enjoyment/confidence and their knowledge of the new mathematics curriculum. Findings revealed the existence of three factors concerning teachers' enjoyment/confidence, their traditional beliefs, and their inquiry-oriented beliefs. A description for teachers' knowledge of the new curriculum is presented. Correlations existed between their beliefs and their enjoyment/confidence.

Keywords: Teachers, knowledge, beliefs, curriculum reform.

INTRODUCTION

Cyprus launched a curriculum reform in 2004 and started implementing it since September 2011. As far as the new mathematics curriculum is concerned, the target was to move from traditional teaching of mathematics to more progressive approaches. It is, therefore, pertinent investigating the factors that can affect the successful implementation of the mathematics reform.

In mathematics education, a considerable body of research (Ernest, 1989; Stipek, 2001; Tompson, 1992; Wilkins, 2008) underpin the importance of teachers' knowledge, beliefs and attitudes in their effectiveness and their choice of instructional practices, and as a consequence their disposition towards the implementation of innovation. In this respect, we developed a study to investigate teachers' knowledge, beliefs, practices and enjoyment/confidence related to the new mathematics curriculum. In this paper we focus on teachers' beliefs, their enjoyment/confidence about mathematics and its teaching and their knowledge of the new mathematics curriculum.

BACKGROUND AND AIMS

Teachers' knowledge

Prior research refers to several factors that influence teachers' instructional practices and, therefore, the implementation of a new mathematics reform (Charalambous & Philippou, 2010; Handal & Herrington, 2003; Manouchehri & Goodman, 2000). We based our research on the model proposed by Ernest (1989) on teacher knowledge, beliefs and attitudes, as it represents an attempt to understand psychological factors underpinning the impact of curriculum innovation on mathematics teachers. A key

difference in Ernest's model and other related models like Shulman's (1986) is the inclusion of beliefs and attitudes in the model.

Ernest (1989) suggests that teachers' knowledge of mathematics constitutes of several components: (a) pure subject matter knowledge that the teacher needs in order to teach mathematics; (b) knowledge of teaching mathematics which involves pedagogical knowledge of the subject, and curriculum knowledge. Pedagogical knowledge of mathematic refers to teacher's knowledge of approaches to school mathematics like awareness of different ways of presenting mathematics and knowledge of students' methods, conceptions and errors. Curriculum knowledge refers to the knowledge of the curricular materials which mathematics instruction is carried out and assessed; (c) knowledge of other subject matter, which provides a knowledge of mathematics uses and applications (d) knowledge of organization for the teaching of mathematics, which refers to the knowledge of organising the mathematics instruction in individual work, co-operative groups, and to the management of practical activities; (e) knowledge of the students and school and (f) knowledge of education. In this paper we present results related to teachers' knowledge of teaching mathematics and particularly their curriculum knowledge.

As Ernest (1989) states, teachers' beliefs of mathematics and mathematics teaching were also found to influence teachers' instructional practices. More specifically, two teachers may have similar knowledge of mathematics but may teach using different methods and procedures due to their different beliefs of mathematics and mathematics teaching. The importance of beliefs and their impact on teaching has also been emphasized by several authors (Hannula, Evans, Philippou, & Zan, 2004; Stipek et al., 2001; Tompson, 1992; Wilkins, 2008).

Teachers' beliefs about mathematics, teaching and learning

According to Ernest (1989) "beliefs" consist of the teacher's system of beliefs, conceptions, values and ideology. Beliefs develop over time on the basis of related experiences, while the affective dimension of them influences the role and the meaning of each belief in the belief system (Wilkins, 2008). Teacher's beliefs consist of assumptions about the discipline of mathematics, and about the teaching and learning of mathematics. Teachers' beliefs about the discipline of mathematics constitute the "rudiments of a philosophy of mathematics" (Thompson, 1992, p. 132), while their beliefs about the teaching and learning of mathematics may include the role of the teacher and the students in the teaching and learning situation, classroom activities, instructional approaches, mathematical procedures and the acceptable outcomes of instruction (Handal & Herrington, 2003; Thompson, 1992).

Many teachers may have more traditional beliefs about the discipline of mathematics and its teaching. These beliefs include that mathematics is a static body of knowledge which involve a set of rules and procedures that are applied to produce one right answer. Then knowing mathematics means to be skilful in performing procedures without necessarily understanding what they represent (Stipek et al., 2001;

Thompson, 1992). In this traditional standpoint the teacher is in full control of the mathematics learning, providing students with a step by step instruction and allocating problems for practicing the procedure (Stipek et al., 2001; Tompson, 1992). The inquiry based beliefs include a dynamic view of mathematics, a problem centred view, a continually changing field of human creation and invention, open to revision (Stipek et al., 2001; Thompson, 1992). Inquiry-based beliefs refer to students' engagement in activities to construct their own knowledge, to reason, to be creative, to discover the knowledge and to communicate their ideas. The teacher shares the control with students playing a facilitator role, encouraging students to fulfil their own learning aims and construct meaning by themselves.

Teachers with more traditional beliefs were found (Stipek et al., 2001) to be more close to the entity theory of ability, supporting the view that ability is stable and immutable, leaving no room for development and minimizing the importance of effort. On the contrary, teachers with inquiry-based beliefs may be associated with an incremental view of ability in which the ability is amenable to change and increase with learning and effort (Cury, Elliot, Fonseca & Moller, 2006). As far as students' motivation is concerned, several studies (Patrick, Anderman, Ryan, Edelin, & Midgley, 2001; Stipek et al., 2001) showed that teachers with more traditional beliefs value the importance of extrinsic motivation, while teachers' with more inquiry-based beliefs value the importance of intrinsic motivation.

Apart from beliefs, Ernest (1989) includes in the model teachers' attitudes towards mathematics and its teaching, such as liking, enjoyment and interest in mathematics, and also teachers' confidence in their own ability in mathematics and its teaching. In Ernest model, the interrelationship between knowledge, beliefs and attitudes is not explicitly addressed (Wilkins, 2008). However, studies (Karp 1991 in Wilkins, 2008; Stipek et al., 2001) found that teachers with more traditional beliefs are less confident and enjoy mathematics less than teachers who are related to more inquiry-based beliefs.

A considerable amount of studies has led researchers to consider teachers' beliefs as an important mediator in curriculum implementation (Charalambous & Philippou, 2010; Handal & Herrington, 2003; Tompson, 1992). It is assumed that in order for teachers to implement a curriculum reform their beliefs must be somehow aligned to the basic philosophical beliefs underlying the reform (Handal & Herrington, 2003).

Cyprus reform and the new role for the teacher

In September 2011, the new mathematics curriculum started to be implemented and is expected to be in full operation by June 2017. It follows current trends in education, presenting mathematics as a dynamic tool for thought (Cyprus Ministry of Education and Culture, 2010).

The new mathematics curriculum has been designed according to four principles: (a) students should be involved in mathematical investigations, which enhance their curiosity and interest, related to already existing knowledge, based on real life

situations and interdisciplinary questions, (b) emphasis should be paid on problem-solving, (c) ICT as an integral part of mathematics education and (d) students experiences will be enriched through pedagogically rich examples, that arise from the active engagement with meaningful mathematical problems and concepts (Cyprus Ministry of Education and Culture, 2010). These principals are to a great extent congruent with inquiry-based mathematics instruction (NCTM, 2000; Wilkins, 2008).

For the effective implementation of the new curriculum , the role of the teacher in the mathematics classroom shifts from the traditional instruction in which the teacher transmits to students pieces of mathematical information to a more demanding role. While students engage in investigations, the teacher is expected to create "a community of inquiry" in which the students comfortably exchange ideas and justify their views (Manouchehri & Goodman, 2000; Wilkins, 2008).

As far as knowledge is concerned, the new mathematics curriculum expects teachers to have the necessary subject matter knowledge and knowledge of teaching mathematics (Ernest, 1989), to understand the core mathematical ideas of the curriculum material, to recognize the relationships among concepts, to be able to reason mathematically and use multiple representations of new mathematical concepts. The teacher is expected to build on students' thinking around different investigations and to connect their thinking to specific mathematical concepts. As other studies revealed (Manouchehri & Goodman, 2000; Stipek et al., 2001) teachers need confidence in their ability to make sense of mathematics and students' solutions and strategies, while they must encourage and reward students' efforts to solve mathematical problems.

Several studies have stressed that many reforms fail due to teachers' lack of mathematics knowledge and knowledge of teaching mathematics or because their beliefs are not congruent with the beliefs supporting the reform (Manouchehri & Goodman, 2000; Stipek et al., 2001). It is therefore clear that teachers' knowledge and beliefs have a determinant role in the success or failure of the new Cyprus mathematics curriculum. In this respect the aim of this study was:

- To investigate teachers' beliefs about: (a) the nature of mathematics (procedures vs. thinking), (b) mathematics learning (correct answers vs. understanding), (c) control of the classroom (teacher's control vs. students' autonomy), (d) the nature of mathematical ability (fixed vs. developing), (e) motivation (extrinsic vs. intrinsic)
- To investigate teachers' confidence and enjoyment of mathematics and mathematics teaching.
- To examine teachers' knowledge of teaching mathematics and particularly the degree of teachers' level of awareness of the new mathematics curriculum.

METHOD

Data were collected through a questionnaire from 100 in-service teachers from primary schools in rural and urban areas in Cyprus. Part of these subjects had earlier participated in professional development programs focusing on the mathematics reform. The questionnaire administered comprised of five parts: (A) Teachers' background information, (B) teachers' beliefs, enjoyment/confidence, (C) teachers' knowledge of teaching and particularly their awareness of the new mathematics curriculum, (D) teachers' instructional practices, and (E) teachers' mathematical knowledge. Parts D and E of the questionnaire are not presented in this study since they are beyond the aims of this paper.

The first part of the questionnaire sought demographic data, including the subjects' educational background, such as the number of maths courses they took during their undergraduate studies and the number of seminars they attended during their careers related to mathematics education as well as the seminars they have attended specifically related to the new mathematics reform. Moreover, their experience in teaching mathematics and the class that they were teaching mathematics during the specific year were reported.

The second part comprised of items selected from the questionnaire by Stipek et al. (2001) that were related to teachers' beliefs and enjoyment/confidence about mathematics and teaching. Specifically they were 30 items measuring teachers' agreement on a 5 point Likert scale (1- strongly disagree, to 5-strongly agree). Each item was related to one of the two ends of bi-polar scale of each of six dimensions of mathematics: (a) the nature of mathematics (procedures vs. thinking), for instance: "The best way to understand math is to do lots of problems", "In every lesson teachers need to discuss how people use the math being taught to solve real-life problems"; (b) mathematics learning (correct answers vs. understanding), for instance: "Students who produce correct answers have a good understanding of mathematical concepts", "Childers' reasoning in their mathematical problem solving is more important to assess than whether they solve problems correctly"; (c) control of the classroom (teacher's control vs. students' autonomy), for instance: "It is important for teachers, not students, to direct the flow of a lesson", "Good teachers give students choices in their math tasks"; (d) the nature of mathematical ability (entity vs. incremental), for instance: "Mathematical ability is something that remains relatively fixed throughout a person's life", "Improvement should be a major consideration when grading students"; (e) motivation (extrinsic vs. intrinsic), for instance: "Giving rewards is a good strategy for getting students to complete math assignments", "If children aren't working, it is probably because the task is not very interesting"; (f) teachers' self confidence and enjoyment of mathematic, for instance: "I feel confident that I understand the math material I teach".

The third part of the questionnaire assessed teachers' knowledge of teaching and particularly their awareness of the new mathematics curriculum. The eight items measured teachers knowledge on, disagree or agree. Two spice items are: "According

to the new mathematics curriculum students should not come across many representations of a mathematical concept to avoid being confused" and "In the new mathematics curriculum an attainment target can be found in more than one class".

RESULTS

The analyses of the data revealed that teachers had various experience of teaching and educational background (table 1). The great majority of the teachers had more that 10 years of experience, while 66% had graduate degrees. 24% of these teachers had participated in professional seminars focusing on the mathematics reform. In Cyprus dissemination of information related to the new reform might take place in schools, since informed teachers are expected to inform their colleagues.

Experience	Education		
	Undergraduate studies	Postgraduate	Phd
1-5 years	1	11	0
6-10 years	6	12	0
11-15 years	12	14	1
15-20 years	6	20	1
20 -more	6	9	0
(N=99) 1 missing	**31**	**66**	**2**

Table 1. Teaching experience and mathematical background

Regarding the first and second questions of the study, principal component analysis (PCA) was conducted on the 30 items with orthogonal rotation (varimax). The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO = .72 ("good" according to Field, 2009), x^2 (276) = 795.42, p<.001, indicated that correlations between items were sufficiently large for PCA. After various analyses 6 items (4 items belonged to the entity vs. incremental dimension and two items to the control vs. autonomy group) were deleted due to their loadings on various factors or to their low loadings. We ended in three factors explaining 46.41% of the variance. Table 2 shows the factor loadings after rotation.

	Rotated factor loadings		
Item	**Confidence / Enjoyment**	**Traditional**	**Inquiry**
I think of myself as being good in mathematics.	.833		
I don't enjoy doing mathematics (reverse).	.822		
Math is my favourite subject to teach.	.801		
I enjoy encountering situations in my everyday life that require me to use math to solve problems.	.752		
I'm not competent enough in math to teach it beyond the elementary grades (reverse).	.647		
When my answer to a math problem doesn't match someone else's, I usually assume that my answer is wrong (reverse).	.631		
When I teach math I often find it difficult to interpret	.617		

students' wrong answers (reverse).			
The best way to understand math is to do lots of problems.		.807	
Students who aren't getting the right answers need to practice on more problems.		.711	
Students who finish their math work quickly understand the material better than students who take longer**.**		.681	
It is important for teachers, not students, to direct the flow of a lesson.		.653	
It is important for teachers to maintain complete control over math lessons.		.647	
Students who produce correct answers have a good understanding of the mathematics concepts.		.561	
The more students are concerned about grades and performance the more they learn.		.460	
Students who really understand math will have a solution quickly.		.451	
Giving rewards is a good strategy for getting students to complete math assignments.		.450	
Students will work hard on interesting and challenging math tasks, whether or not their work is graded.			.805
Improvement should be a major consideration when grading students.			.689
In every lesson teachers need to discuss how people use the math being taught to solve real-life problems.			.628
Children's reasoning in their mathematical problem solving is more important to assess than whether they solve problems correctly.			.602
The more students enjoy working on math tasks the more they learn.			.592
Effort should be a major consideration when grading students.			.584
There is usually one way to solve a math problem.			-.481
If children aren't working, it is probably because the task is not very interesting.			.429
Eigenvalues	5.50	3.19	2.40
% of variance	23.13	13.30	9.98
a	.85	.78	.63

Table 2. Summary of exploratory factor analysis results (N=100)

The items that cluster on the same factor suggest that factor 1 represents teachers' enjoyment/confidence, factor 2 represents traditional beliefs of mathematics and its teaching, and factor 3 represents inquiry-oriented beliefs of mathematics and its teaching. As it was assumed, the traditional view of mathematics comprised of dimensions for which high scores were presumed to be associated with traditional theory of mathematics and its teaching. Specifically, mathematics is a set of operations which are used to get correct solution to problems rather than tools of thought, the importance of getting the correct answer, the issue of teacher's control in the classroom and the development of students' extrinsic motivation. There were no

items referring to the entity theory in this factor. The inquiry view of mathematics comprised of dimensions for which high scores were presumed to be associated with inquired-oriented beliefs of mathematics and its teaching. Specifically the view of mathematics as a tool of thought and not as a set of operations, the importance of students' understanding and not just the correct answers, beliefs concerning the incremental ability of students in mathematics and the development of students' intrinsic motivation. There were no items referring to students' autonomy in the classroom.

Teachers in this study appeared to be rather confident and enjoyed mathematics (M=3.83), while their traditional views of mathematics were moderate (M=3.14), and their inquiry based views were higher (M=3.78) than their traditional views but not very high.

As far as it concerns the relation between the three factors, the Pearson's product-moment correlation coefficient indicated a significant positive relationship between teachers' confidence/enjoyment and the inquiry-oriented beliefs of mathematics ($r=.276$, $p<0.5$) and also a significant negative relationship between teachers' confidence/enjoyment and traditional views of mathematics, ($r=-.247$, $p<0.5$). Even though the indices were small, it seems that teachers' scoring high on the inquiry based beliefs were more confident about teaching mathematics and enjoyed it more, while teachers scoring high on the more traditional views were less confident and enjoyed mathematics less.

Regarding the third question of the study concerning teachers' knowledge of teaching and particularly curriculum knowledge, Table 3 presents the percentage of teachers' by the number of questions in which they provided positive answers, out of the 8 items.

Number of positive answers	0	1	2	3	4	5	6	7	8
Percent of subjects	6.9	2.9	1	2	5.9	16.7	34.3	27	2

Table 3. Teachers' level of curriculum awareness (N=98, missing 2)

The results present a rather positive picture of these teachers' curriculum knowledge. Even though a small percentage (6.9%) lacks any knowledge of the new curriculum a considerable percentage (63.3%) seems to be well aware of significant issues and new trends (total of 6-8 positive responses).

Teachers' positive responses ranged between 73%-88% in 6 of the 8 items. Particularly 82% were aware that the new mathematics curriculum included attainment targets, indicative activities, enrichment activities and assessment tasks; 76% of the teachers were aware that students are not expected to reach an attainment target in the same pace, 88% were informed that an attainment target can be repeated in more than one grades, 73% and 82% were aware of the role of representations and how to deal with students' erroneous answers. Finally 81% said that addition and subtraction are conceptually connected therefore they must be taught jointly.

However, only 10% of the teachers responded positively to the item concerning the investigation stage, which is an important part of the didactical model suggested by the new curriculum. In this stage the students are expected to conjecture, investigate and discover the new mathematical concept. In addition, only 45% were aware of the use of enrichment activities in the mathematics class, which provides for differentiating instruction to cater for students of various mathematical abilities.
Pearson correlation was used to examine possible relations between teachers' curriculum knowledge and their different beliefs (traditional –inquiry based). No such relation was found, neither between teachers' curriculum knowledge, their experience and educational background.

DISCUSSION

The aim of this study was to examine teachers' beliefs, enjoyment/confidence and their acquaintance with the reformed curriculum at the outset of its implementation. Analysis of the data revealed the existence of three factors concerning traditional beliefs, teaching confidence and inquiry orientation. Similar to Stipek's et al. (2001) findings, the factor concerning traditional beliefs referred to the nature of mathematics, mathematics learning, control of the classroom and motivation. Items referred to the nature of mathematical ability were not included in this factor. Regarding teacher's inquiry-oriented beliefs another set of beliefs existed referred to the nature of mathematics, mathematics learning, the nature of mathematics ability and motivation. In this study teacher' inquiry-oriented beliefs found to be moderate, a result that policy-makers should take into consideration since, flourishing curriculum change will more probably occur when teachers' beliefs and curriculum reform goals are congruent (Handal & Herrington, 2003).

Similar to other studies (Manouchehri & Goodman, 2000; Stipek et al., 2001; Wilkins, 2008) teachers in this study who adopted more inquiry-oriented beliefs were more self-confident and enjoyed mathematics more than teachers who adopted more the traditional beliefs. More confident teachers may adopt beliefs and practices that require more decision-making and judgment.

Regarding teachers' acquaintance with the new curriculum the study reveals that even though teachers' curriculum knowledge (Ernest, 1989) is relatively high, some teachers lack awareness of significant components of the new curriculum, the use of investigation and enrichment activities in the classroom. In line with the suggestions of other studies (Charalambous & Philippou, 2010; Manouchehri & Goodman, 2000) teachers in Cyprus receive by the people responsible for the reform, systematic and sustained support targeting their knowledge of teaching mathematics (Ernest, 1989) in order to succeed in implementing the new mathematics curriculum.

Curriculum implementation is not a process that translates directly into the mathematics classroom. Teachers are the key players in a successful implementation of a curriculum reform. Therefore their knowledge and beliefs should be identified, analysed and improved in the process of the curriculum implementation.

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