

Teaching mathematics and science in early childhood: prospective kindergarten and primary school teachers' beliefs

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ABSTRACT

The main objective of the present study is to investigate preservice teachers' beliefs regarding mathematics and science learning and their teaching at the pre-school level. Participants were 93 prospective kindergarten teachers and 80 prospective primary school teachers who completed a questionnaire designed for the purpose of the study. It was revealed that both groups of student teachers believe that teaching mathematics and science at kindergarten differs from primary school. Carrying out inquiry activities and practicing teaching approaches that implement experimentation were proposed as being the best ways of presenting mathematics and science concepts to young children. The findings of this study raise implications for teacher professional development that may assist in developing better practices in mathematics and science early childhood education

KEYWORDS

Beliefs, mathematics teaching and learning, science teaching and learning, student teachers, early childhood

RÉSUMÉ

Cette recherche a pour objectif de décrire et d'analyser les croyances de futurs enseignants à l'égard de l'enseignement-apprentissage des mathématiques et des sciences au niveau préscolaire. Les résultats sont issus d'un questionnaire, élaboré pour les besoins de cette recherche, auprès de 93 futurs enseignants de l'école maternelle et de 80 futurs enseignants du primaire. Ces enseignants croient que l'enseignement des mathématiques et des sciences est différent en maternelle et en primaire. Des activités de recherche et des approches pédagogiques qui mettent en œuvre l'expérimentation ont été proposées comme étant les meilleures façons d'enseigner les concepts mathématiques et scientifiques aux jeunes enfants. La discussion de ces résultats soulèvent des implications tant pour le développement professionnel de futurs enseignants que pour le développement des meilleures pratiques au sujet de l'éducation des enfants d'âge préscolaire en mathématiques et en sciences.

MOTS-CLÉS

Croyances, enseignement-apprentissage des mathématiques, enseignement-apprentissage des sciences, futurs enseignants, école maternelle, enfants d'âge préscolaire

INTRODUCTION

During the last two decades research into the professional development of primary school teachers has increased considerably. These studies emphasize that effective professional development is one of the most important components in improving mathematics and science education for children, especially the younger ones (e.g., Franke et al., 1998; Van Driel, Beijaard & Verloop, 2001; Craven, 2002; Bartholomew, Osborne & Ratcliffe, 2004; Sarama & Dibiase, 2004; Zacharos et al., 2007). Teachers' approaches to teaching (i.e., how they teach) and the conceptions they hold about teaching (i.e., what they believe about teaching) have led to an extensive amount of literature, which has provided new insights into the ideas that teachers hold about mathematics, science teaching and learning, subject matter, their role in the classroom, and their students. Most of these studies, however, have focused predominantly on teachers who are already in the primary or early secondary classrooms (e.g., Thompson, 1992; Munby, Cunningham & Lock, 2000; King, Shumow & Lietz, 2001; Van Driel et al., 2001; Levitt, 2001; Wallace & Kang, 2004; Hagevic et al., 2010) and prospective primary or secondary teachers (e.g., Mellado, 1998; Ball, 1990; Craven, 2002; Macnab & Payne, 2003; Bleitcher & Lindgren, 2005; Gencer & Cakiroglu, 2007; Howes, 2008). Thus, an interesting area of research with contribution to the improvement of teacher education and their

professional development might be the area of prospective kindergarten and primary school teachers' beliefs about mathematics and science teaching.

Prospective teachers' learning is mainly achieved through two main components according to current teacher education programs in Greece, as well as worldwide: the first one is the mathematics and science courses that student teachers attend at higher education institutions, where basic knowledge about teaching mathematics and science is constructed. Similarly important is the classroom experience they gain from their school practicum placement, where they teach mathematics and science. Both components are important for the development of prospective teachers' learning and, therefore, should be integrated.

THEORETICAL FRAMEWORK

Researchers have pointed out that beliefs about teaching and learning are well established by the time prospective teachers enter teacher preparation programs (Pajares, 1992; Richardson, 1996). These beliefs are notoriously resistant to change and they affect teacher practices and their students' learning (Ball, 1990; Schuck, 1996; Tillema, 1998; Hill, 2000; Levitt, 2001; Craven, 2002) however, they are more open to change in preservice teachers (Woolfolk Hoy & Burke-Spero, 2005). In particular, research has shown that the previous experiences of students as mathematics or science learners, in the classroom, affect their behaviors and performance as primary school mathematics teachers (Meredith, 1993; Mellado, 1998; Eaton & Kidd, 2004). Many teachers, for example, believe that mathematics is a set of facts and that memorizing these facts is an appropriate route to learning mathematics or science (Garet et al., 2001). Similarly, studies on specific aspects of science teachers' beliefs have revealed that although teachers may express cognitions about the teaching and learning of science, which are consistent with more 'modern' ideas (e.g., constructivist ideas), their actual classroom behavior is more or less 'traditional' (Mellado, 1998; Van Driel et al., 2001). Other researchers have also found that preservice teachers draw on their own learning experiences when discussing mathematics and science teaching (Brand & Wilkins, 2007; Zacharos et al., 2007). It seems that teachers are very persistent in holding models of teaching formed during their own schooldays which mould their classroom practices. In science and mathematics education, research revealed that teachers are reluctant to use new ways of teaching proposed during their teacher preparation programs in spite of evidence for the effectiveness of these methods (Meirink et al., 2009).

Given the importance of beliefs with respect to teaching behaviors, several researchers have investigated teachers' beliefs about mathematics and science and the teaching of those subjects. With regard to mathematics, it has been suggested that teachers' beliefs about teaching and learning mathematics, as well as mathematics

in general, are in a dialectic relationship with teaching practices (Thompson, 1992). In particular, Thompson (1992) stresses the importance of taking into account two kinds of teachers' beliefs: the beliefs about mathematics and the beliefs about mathematical teaching and learning. These two kinds of beliefs are evidently linked to content knowledge and pedagogical content knowledge and, as Thompson explains, may play a crucial role in influencing the instructional practice of teachers. For example, early childhood teachers are often uncomfortable about mathematics, view necessary mathematics as only 'counting, adding, subtracting, and knowing shapes, and have little or no knowledge of the standards of mathematics (Copley, 2004). Similar findings were observed in a survey of prospective early childhood teachers: they considered mathematics as a difficult subject to teach and admitted that they felt most comfortable teaching reading and other language-oriented skills. In addition, their knowledge, beliefs and teaching strategies focused on computational skills rather than problem solving, and they seemed to demonstrate more authority-based, teacher-centered instruction rather than observing and listening to their students' solutions (Johnson, 1999). A similar picture of student teachers generally insecure with mathematical ideas and very much dependent on official guidance is also revealed in Macnab and Payne's study (2003). In this study, first and final year primary student teachers in Scotland tend to be unadventurous in their teaching of mathematics, which they consider unexciting and compared to other curricular areas difficult and worrying. Overall, teachers' inadequate preparation in mathematics may be the answer to why mathematics appears to be an area that teachers often ignore (Kilpatrick, Swafford & Findell, 2001).

Van Driel et al. (2001) raise similar issues in relation to the way science and science education is viewed: generally speaking, an emphasis is usually put on lectures to convey science content as well as technical training for the acquisition of practical skills. Similarly to mathematics, science is seen as a collection of facts, theories, principles and rules to be memorized and practiced rather than designing situations and activities which enable students to learn actively. In a study of classroom observations and interviews with a science teacher, Munby et al. (2000) stressed that science is also viewed as compartmentalized into subdisciplines and as preparatory to studying science at a more advanced educational level. This image of science appears to originate in teachers' early experiences and is reinforced by the structure of school science with its prescribed curriculum. The beliefs of a prospective elementary teacher about science teaching and learning as well as the tensions she experienced in thinking about science teaching and learning are also examined by Bryan (2003). It was found that the teacher's beliefs guided her practice and that she preferred teaching strategies that were based on transmission of knowledge from teacher to student. This didactic and teacher-centered orientation, when teaching science, allowed her to maintain control and gave her the certainty she needed to function in the classroom. The maintenance of order and

strict control of students' instructional activities, when teaching science in order to be effective teachers, was found to be a common belief among pre-service science teachers in Turkey (Gencer & Cakiroglu, 2007). Although these pre-service teachers expressed positive efficacy beliefs regarding the teaching of science, they believed in the necessity of a stricter approach in the management of the instruction.

Despite opportunities to reflect upon their classroom practices, teachers seem to remain unable to reframe classroom situations in their teaching. In some cases teachers feel constrained either by conventions condoned by the school, including classroom structure, time management, lesson sequencing, or by the demands that the curriculum imposes (Munby et al., 2000; Van Driel et al., 2001). These aspects constitute a unique 'school science culture' of teaching (Munby et al., 2000) that sets boundaries to the scientific inquiries teachers make of their teaching. In other cases, lack of adequate teacher preparation in subject content and its teaching permeates their mathematics and science teaching (Ball, 1990; Kilpatrick et al., 2001; Bleitcher & Lindgren, 2005), and mediates the implementation of innovative practice. If changes in mathematics and science instruction are not instituted, teachers may be prevented from involving students in activities that explore questioning, may deviate from exact procedures, from interpreting data and, in general, from obtaining a variety of explanations for problematic situations.

Research purpose

Mathematics and science education provides special challenges in the preschool setting. Mathematics and science, as already seen, are often perceived and presented as too formal, too abstract, and too theoretical, posing difficulties for children and their teachers. Even the instruction of those subjects has long been teacher-centred. Although this type of instruction is well - known as inappropriate for preschool children, science and mathematics education occur at the early childhood levels. While studies have long referred to teachers' beliefs about mathematics and science teaching in primary school, we know surprisingly little about prospective teachers' beliefs about mathematics, science and the teaching of these subjects in kindergarten. Considering that formal preschool and primary school settings are usually not well connected, and that there is limited research on connecting teachers' beliefs regarding teaching in these settings, this study focuses on prospective kindergarten and primary school teachers' beliefs that may provide new insights in to how mathematics and science teaching and learning is presented at an early age. In addition, reviewing and analysing prospective teachers' beliefs may reveal effective and ineffective attitudes.

Specifically, the research questions that guided this study are: a) How do prospective teachers view mathematics and science teaching? What teaching methods they say that they are likely to adopt? b) What are their beliefs about teaching mathematics and

science in early childhood education? Do these beliefs differ between kindergarten student teachers and primary school student teachers?

METHOD

Participants

The participants were undergraduate students who were enrolled in a 4-year elementary teacher education programme at a medium-sized state university in Thrace, Northern Greece. These students attended either the School of Education Sciences in Pre-School Age or the Department of Primary Education, both departments belonging to the Faculty of Education Sciences. They all had passed a highly competitive entrance examination in order to enter the university. After the completion of their studies, they were to be recruited as kindergarten teachers and primary school teachers, respectively. Kindergarten teachers (nursery and kindergarten years) and primary school teachers (Years I to 6) in Greece need to teach language, mathematics and science, whereas gym, arts and music courses are occasionally taught by specialists. Hence, all participants will teach mathematics and science when they teach in kindergarten and primary schools.

The students were randomly assigned to two samples, one referred to as the mathematics one and the other as the science one (see Table I). Each sample was presented with a questionnaire regarding mathematics and a questionnaire regarding science, respectively.

The mathematics sample included 173 participants, of which 93 were prospective kindergarten teachers and 80 were prospective primary school teachers. The student population was typical for an elementary teacher certification programme: it was predominantly female (88%) with a mean age of 20 years and 3 months. Eighty-four students - 41 kindergarten student teachers and 43 primary school student teachers - were enrolled in the 4th semester and eighty-nine students - 52 kindergarten student teachers and 37 primary school student teachers - attended the 8th semester. At the time of the study, the 8th semester students had each completed at least one course in mathematics and one course in science, whereas the 4th semester students had attended mainly methods and pedagogical classes and had not been introduced to any mathematics and science courses. It was considered important that students' beliefs be sought at the very beginning of their semesters, and thus the participants were surveyed within the first few weeks of both semesters.

TABLE 1*Number of participants assigned to the mathematics and science samples*

	Mathematics Sample		Science Sample	
	Primary School teachers	Kindergarten Teachers	Primary school teachers	Kindergarten teachers
4th semester	43	41	33	50
8th semester	37	52	46	41
Total	80	93	79	91
	N = 173		N = 170	

The science sample included 170 participants, of which 91 studied to become kindergarten teachers and 79 studied to become primary school teachers. Similarly to the mathematics sample, the typical student who participated in the science sample was a female (87,6 %) in her early 20s (mean age 20 years and 2 months). Among the participants, 83 were 4th semester students (50 kindergarten student teachers and 33 primary school student teachers) and 87 8th semester students (41 kindergarten student teachers and 46 primary school student teachers).

Instrument

For the purpose of the study, two questionnaires – one regarding mathematics and a second regarding science – were designed by the authors. The questionnaires aimed to elicit information about the beliefs of prospective kindergarten and primary school teachers regarding mathematics and science as well as their beliefs regarding teaching these subjects at kindergarten. More specifically, the mathematics and the science questionnaires consisted each of a total of 19 questions, of which 11 were close-ended questions, 5 were open-ended ones and 3 were initially close-ended that needed further quantification. In the close-ended questions, the participants were mainly asked to score some statements presented on a 5-point Likert-type scale ranging from (1) *strongly agree* to (5) *strongly disagree* or were asked to indicate their choices among given ones (mainly two responses out of many possible ones). The open-ended questions –because of their nature- did not seem to influence the students to respond one way or another, and they have been shown to result in a broad range of responses that can be scored using scales developed by the authors.

Questions in both questionnaires referred to two main topics. In the first topic student teachers' beliefs regarding mathematics and science as well as their teaching, in general, within the school context were explored (e.g., Q3: 'What do you think is the main aim of mathematics/science teaching and learning at school?', Q8: 'What do you anticipate the role of the teacher is when teaching mathematics/science at school?'). Questions in the second topic aimed to reveal the beliefs of the participants regarding

teaching mathematics and science at the kindergarten level, in particular (e.g., Q12: ‘What do you think is the main aim of mathematics/science teaching and learning at the kindergarten?’, Q16: ‘What are the major problems a teacher may face when teaching mathematics/science at kindergarten?’).

Procedure

Participants were told that a survey was to be given and that the survey results would be used during a class discussion later in the semester. Participation in the study was voluntary and anonymous, and participants were also told that if they did not wish to participate they could simply not fill in the questionnaires. A letter informing the participants about the aim of the study was given with the questionnaire.

To maximise the number of students’ responses, the questionnaires were administered during their classes and collected at the same time. They were given approximately 20 minutes to read and fill in the questionnaires which were then collected by a student, again insuring the anonymity of the responses. Of those surveyed, 173 returned a completed mathematics questionnaire and 170 returned a completed science questionnaire, yielding 91% and 91,89 % participation response rates, respectively.

RESULTS

The results are presented in two main sections. The beliefs of the participants regarding teaching mathematics and science at school, in general, are described in the first section, whereas their beliefs with reference to teaching mathematics and science at the kindergarten level are presented in the second section.

Teaching Mathematics and Science

Aims of teaching and learning mathematics and science

Prospective teachers were initially asked to identify the aims of teaching and learning mathematics and science at school. Various responses were given which were classified into 5 distinct categories as seen in Table 2. Great emphasis was put on the idea of scientific knowledge and creativity as well as on reasoning acquisition and inquiry for mathematics teaching and learning. With regards to the mathematics sample, statistically significant differences were found in the responses of the participants ($F(1,168)=18,735$, $p<.01$). In particular, prospective primary school teachers see mathematics as a process that should help to answer questions, promote the reasoning acquisition of students (68,1%) and provide scientific knowledge (45,2%). Prospective kindergarten teachers believe that the main aim of teaching and learning mathematics at school is to expand the scientific inquiry of students (76,6%) and expressed this view with statements like

TABLE 2**Percentage of prospective teachers' responses regarding the aims of teaching and learning mathematics and science**

	Teaching and learning			
	Mathematics		Science	
	Primary School teachers	Kindergarten Teachers	Primary school teachers	Kindergarten teachers
Scientific knowledge and creativity	45,2	39,9	20,3	20,9
Skills development	8,4	15,3	35,4	49,5
Reasoning acquisition and inquiry	68,1	76,6	69,6	58,2
Physical environment awareness and development of positive attitudes towards it			35,4	45,1
Other / Don't know		8		

Note: Participants were allowed to indicate more than one choice

'look at something that is already there and see it in a new way' or 'facilitate discovery'. A great percentage of kindergarten student teachers, however, mentioned that mathematics teaching should aim at deep conceptual understanding (39,9%) making references to school's responsibility of 'content acquisition' and 'feeding students scientific knowledge'. It is also surprising that only a few participants referred to mathematics teaching as including activities in which students can practice and perfect skills related to mathematics. No differences were found across semesters.

With regards to the science sample, statistically significant differences were observed in the responses of the participants ($F(1,165)=23,926, p<.05$). Both prospective teachers and kindergarten teachers put great emphasis on the idea of reasoning acquisition and inquiry (69,6 % and 58,2%, respectively), on skills development (35,4% and 49,5%, respectively), as well as on the promotion of physical environment awareness¹ in order to develop positive attitudes towards it (35,4% and 45,1%, respectively), for science teaching and learning at school. Statistically significant differences concerning the study levels of participants were also indicated. In particular, students of the 8th semester (59,8 %) seem to consider the environment awareness of children and their development of positive attitudes towards it as the main goal of science teaching, revealing greater percentages compared to their colleagues of the 4th semester (20,5%) ($t=23.181, df=168, p<.001$). Similar trends were found among the 8th and 4th semester prospective teachers for skills development (51,7% and 33,7%, respectively) ($t=9,128, df=168, p<.001$).

¹ This option was only given by the participants in the science questionnaire.

Teaching approaches

Great consensus was observed in the responses of the participants, when asked to choose the three most important approaches (out of 9 alternatives), which lead to effective mathematics and science teaching and learning at school (see Table 3). The development of positive attitudes in children towards mathematics is considered particularly important, whereas the cross-thematic knowledge approach and the use of experiments and materials are not considered greatly important. For a great percentage of prospective kindergarten teachers the development of children's early mathematical ideas (55,9%) leads to successful mathematics teaching and learning. On the other hand, not so many prospective primary school teachers believe that children have adequate views prior to being taught mathematics (23,8%), showing that there is some discrepancy between the two groups of prospective teachers ($t=10.625$, $df=171$, $p<.001$), which will probably be depicted later on when using children's prior knowledge in the classroom. Generally, participants –mainly the kindergarten student teachers - view mathematics teaching and learning as not being constrained by precise methods or

TABLE 3

Percentage of prospective teachers' responses regarding the most important approaches in effective mathematics and science teaching and learning

Approaches in effective teaching and learning	Mathematics		Science	
	Primary School teachers	Kindergarten Teachers	Primary school teachers	Kindergarten teachers
Use of experiments and materials	15	7,5	57	83,5
Use of play	27,5	38,7	41,8	28,6
Cross-thematic knowledge approach	15	11,8	25,3	6,6
Integrate knowledge into daily life situations	28,8	39,8	64,6	57,1
Development of children's positive attitudes	61,3	50,5	21,5	30,8
Development of children's prior knowledge	23,8	55,9	26,6	29,7
Selection of appropriate activities	35	32,2	13,9	12,1
Knowledge transition from the teacher	46,3	34,4	41,4	32,3
Other	45,1	23,7		

Note: Participants were allowed to indicate more than one choice

anticipated outcomes, giving emphasis on children's active engagement in mathematics activities as well as the use of play in mathematics. Interestingly though, primary school student teachers believed that an important element for effective mathematics teaching and learning at school is the issue of presenting mathematical knowledge in hierarchical order. Although this option was not provided to participants, it was mentioned in the option 'other' mostly by the prospective primary school teachers who seem to be less encouraged to develop and refine mathematics concepts on their own compared to the prospective kindergarten teachers ($t=6.915$, $df=171$, $p<.01$).

In the science sample, the active involvement of children in experiments and the use of materials as well as the knowledge integration into daily life situations seem to be the most appropriate approaches for successful science teaching and learning for both prospective primary school teachers and kindergarten teachers. The degree to which they consider these approaches important, however, differs among prospective teachers. In particular, the use of experiments and materials is considered to be an approach of great significance for the great majority of prospective kindergarten teachers (83,5%) much more than the primary school teachers (57%) ($t=5.124$, $df=168$, $p<.001$). Prospective primary school and kindergarten teachers indicate knowledge integration into daily life situations as an important approach in science teaching and learning (64,6% and 57,1%, respectively). Prospective primary school teachers believe that the use of play and knowledge transition from the teacher (41,8% and 41,4%, respectively) are important approaches in science class, whereas prospective kindergarten teachers consider these approaches less important (28,6% and 32,3%, respectively). The cross-thematic knowledge approach is considered a less important approach in science by the prospective kindergarten teachers (6,6%) compared to primary school teachers (25,3%) ($t=4.628$, $df=168$, $p<.001$). The use of children's prior knowledge concerning science concepts and phenomena in the science teaching and learning procedure is considered as an essential approach for almost one out of three participants (26,6% and 29,7% for primary school teachers and kindergarten teachers, respectively).

Identifying the teacher's profile and role

Prospective teachers' belief of mathematics and science as organisation, precision and facts, however, dominates their thinking of the specific abilities that a teacher should have when teaching mathematics and science on the one hand and a student should have when learning mathematics and science on the other hand. In particular, about 75% of prospective teachers from both departments in both samples support the idea of abilities on the part of the teacher when teaching mathematics and science: they refer to the ability of the teachers to help students understand mathematical concepts and facts, to offer variety in their teaching, to improve techniques, to feel comfortable with mathematics and science and make sure that students are cognitively engaged.

The idea that students should have specific abilities when learning mathematics and science is presented by almost half of the participants, who mainly mentioned the mental abilities of students and their interest in the subject.

The responses of prospective teachers regarding the role of the teacher when teaching mathematics and science reflects less of a didactic orientation and more of a modern constructivist orientation. More specifically, when asked to describe what the role of the teacher should be, the majority of the participants in the mathematics sample propose a well-supported environment that views the teacher as facilitator (51,3% and 47,3% for primary school teachers and kindergarten teachers, respectively), who assists students in clarifying new understanding of the concepts (37,5% and 35,5% for primary school teachers and kindergarten teachers, respectively) and fosters productive interactions. The great majority of the participants in the science sample suggest that the teacher should cooperate with children when teaching science (62% and 67% for primary school teachers and kindergarten teachers, respectively) and guide them in the learning process as facilitator (41,8% and 47,3% for primary school teachers and kindergarten teachers, respectively). Significant differences were not observed neither between students in the two departments nor between students across semesters for both samples.

Participants' beliefs about the role of the teacher are further supplemented with the question regarding what a teacher should do when students face difficulties in understanding mathematics or science concepts (see Table 4). Both prospective primary school and kindergarten teachers – in quite similar percentages (75% and 66,6%, respectively for the mathematics sample and 63,3% and 78%, respectively for the science sample) – believe that they should implement new types of activities, referring to the same unit and, thus, engage students in learning activities that challenge their ideas about particular mathematical or scientific concepts instead of repeating the unit (3,8% and 2,2%, respectively for the mathematics sample and 21,5% and 14,3%, respectively for the science sample) or proceeding to the next topic (1,2% and 0%, respectively for the mathematics sample and 0% for both groups in the science sample). A big number of teachers in the mathematics sample (17,5% and 20,4% for primary school and kindergarten, respectively) as well as in the science sample (25,3% and 30,8% for primary school and kindergarten, respectively) propose that they should allow enough flexibility for students to work and collaborate with other children for progress and assistance: they should provide opportunities for students to compare their views with other students and suggest small group interactions that promote inquiry and encourage debates and discussion. Many of these participants advocated the importance of group work and explicitly mentioned that it was the talking that was important. A considerable number of teachers in the science sample also propose that they should encourage students to experiment on their own (29,1% and 33% for

TABLE 4

Percentage of prospective teachers' responses regarding what a teacher should do in case a student has difficulties in understanding a mathematics or science concept

In case a student has difficulties in understanding a concept a teacher should:	Mathematics		Science	
	Primary School teachers	Kindergarten Teachers	Primary school teachers	Kindergarten teachers
Repeat the unit	3,8	2,2	21,5	14,3
Proceed to the next unit	1,2			
Try other activities in the same unit	75	66,6	63,3	78
Encourage student to experiment on his/her own	2,5	9,7	29,1	33
Encourage student to cooperate with other children	17,5	20,4	25,3	30,8
Other	1,1			

Note: Participants were allowed to indicate more than one choice

primary school and kindergarten, respectively). This opinion considers the experimental involvement of children to be a significant dimension of teaching and learning science at school. Significant differences in the responses of participants in both samples were only found among the 4th and 8th semester prospective kindergarten teachers ($F(1,87)=16,625$, $p<.01$ and $F(1,85)=19,132$, $p<.01$ for the mathematics and the science sample, respectively), with the younger students showing less flexibility in choosing solutions to the difficulties of students with the concepts.

Prospective teachers' preparation

Particular attention was paid to the way students refer to the relation between their preparation as teachers and the school practices. In particular, when asked to indicate the degree to which they feel prepared to teach mathematics or science as future teachers, the majority responded that they feel quite prepared with no significant differences between the students of the two departments ($t=.766$, $df=171$, $p=.444$ and $t=.756$, $df=169$, $p=.455$ for mathematics and science sample, respectively). However, the 8th semester students of both departments feel more prepared to teach mathematics and science compared to the 4th semester students. This applies to the 8th semester students of the participants in the mathematics sample (65,4%) compared to them of the 4th semester (53,1%) ($t=2.531$, $df=171$, $p<.05$). With regards to the science sample,

students of the 8th semester (59,8%) were found to feel more prepared to teach science compared to those of the 4th semester (41%) ($t=5.996$, $df=168$, $p<.05$).

Teaching Mathematics and Science at Kindergarten

Differences in teaching mathematics and science at kindergarten and primary school

The great majority of the participants (about 90% and 74,7% for the mathematics and science samples, respectively) expressed the opinion that teaching mathematics and science at kindergarten differs from teaching mathematics or science at primary school: for the mathematics sample, this view is not affected neither by the department of origin ($t=.078$, $df=171$, $p=.770$) nor by the semester of the students ($t=2.927$, $df=171$, $p=.062$). On the contrary, for the science sample, this view is expressed much more by prospective kindergarten teachers (84,6%) than by prospective primary school teachers (63,3%) ($t=3.271$, $df=168$, $p<.005$). When asked to identify the differences in teaching mathematics and science at kindergarten and primary school, the participants referred to differences in: a) the teaching approaches from the part of the teacher, b) the children's age level and understanding, and c) the content of mathematics and science that leads to different levels of difficulty in mathematical and scientific concepts.

Aims of mathematics and science teaching at kindergarten

Moreover, more than half of the prospective primary school teachers in the mathematics sample (52,5%) believe that teaching mathematics at kindergarten primarily aims at preparing the young child for the primary school, whereas about 40% of the participants in the science sample believe the same for teaching science (see Table 5). Interestingly, one of the student teachers in the mathematics sample said: '*children learn skills at kindergarten whereas they start being taught mathematics at primary school*'. The above excerpt indicates that student primary school teachers not only could not fully estimate the work accomplished at kindergarten regarding teaching mathematics, but also developed a quite negative attitude towards teaching at kindergarten. The goals of inquiry and motivation development (35,2%) and reasoning development (51%), on the other hand, are greatly supported by prospective kindergarten teachers in the mathematics sample, who mainly believe that teaching mathematics at kindergarten provides young children with opportunities to look for unfamiliar, new concepts and phenomena as well as experience the struggles of finding explanations and solutions. Thus, there is a great difference between prospective primary school teachers and prospective kindergarten teachers ($t=5.691$, $df=171$, $p<.001$), with the first group viewing children's preparation for mathematics in primary school as the main aim of teaching mathematics at kindergarten.

Regarding the main aims of teaching science at kindergarten, the participants in the science sample express different beliefs. In particular, the goal of experience

TABLE 5

Percentage of prospective teachers' responses regarding the aims of teaching and learning mathematics and science at the kindergarten

Teaching and learning Mathematics and Science at kindergarten aim at:	Mathematics		Science	
	Primary School teachers	Kindergarten Teachers	Primary school teachers	Kindergarten teachers
Preparation for primary school	52,5	15,1	40,5	22
Inquiry / motivation development	31,3	35,2	54,9	45,6
Reasoning development	39,3	51	27,8	37,4
Skills development	2,5	3	32,7	29,7
Increase knowledge	5	4,3	6,3	16,5
Experience acquisition and practice into everyday situations	15	18,3	64,6	76,9
Physical environment awareness and development of positive attitudes towards it			60,8	70,3

Note: Participants were allowed to indicate more than one choice

acquisition and practice into everyday situations is supported by the great majority of both prospective primary school teachers (64,6%) and kindergarten teachers (74,9%). Moreover, the goal of physical environment awareness and development of positive attitudes towards it seems to be a significant goal for science teaching at kindergarten for both prospective primary school teachers (60,8%) and kindergarten teachers (70,3%), as well as the goal of inquiry and motivation development (54,9% and 45,6% for perspective primary school teachers and kindergarten teachers, respectively). On the other hand, the goal of reasoning development is mainly posed by the prospective kindergarten teachers (37,4%) compared to the prospective primary school teachers (27,8%). Although the increase of knowledge is not considered as a main goal of the majority of the participants, it is one of the priorities for science teaching at kindergarten for the prospective kindergarten teachers (16,5%) compared to the prospective primary school teachers (6,3%) ($t=3,623$, $df=168$, $p<.01$).

Teaching approaches at kindergarten

Carrying out inquiry activities and practicing specific teaching approaches that

implement discovery and experimentation as well as using play to teach mathematics and science were the main points raised by prospective teachers with regards to how mathematical and science concepts should be presented to young children (see Table 6). In particular, with regards to the mathematics sample, prospective kindergarten teachers mainly believe that young children should be allowed to experience discovery-based mathematics (70%), use toys (67,7%) to become familiar with concepts, share experiences and ideas with other children (22,6%) and connect what they already know to everyday practice (40,9%). With regards to the latter, many are more explicit about the idea of practical mathematics, as can be seen in Maria's comments: '*... mathematics needs to be connected to the real world in order for it to be meaningful*'. They seem to advocate the practical side of mathematics by seeing the meaningfulness of mathematics through its implementation and application to the real world. About 70% of prospective primary school teachers suggest the use of play as the most effective way to present mathematical concepts to young children and consider as less significant the experimentation and discovery activities (48,9%) compared to the prospective kindergarten teachers ($t=-2.883$, $df=171$, $p<.01$). Interestingly, the two groups of participants do not consider cross-thematic approaches similarly important ($t=2.247$, $df=171$, $p<.05$), with the prospective primary school teachers suggesting combining mathematics with other activities from other subjects, at a greater percentage (26,3%) than prospective kindergarten teachers. These findings indicate differences in teaching

TABLE 6

Percentage of prospective teachers' responses regarding the most effective approaches in teaching mathematics and science at kindergarten

Teaching approaches	Mathematics		Science	
	Primary School teachers	Kindergarten Teachers	Primary school teachers	Kindergarten teachers
Use of play	70	67,7	81	53,8
Experimentation and discovery	48,9	70	41,8	67
Connecting knowledge to everyday situations	30	40,9	63,3	73,5
Cross-thematic approaches	26,3	12,9	17,7	11,1
Knowledge transition from teacher	13,8	5,4	10,1	5,5
Cooperative team working	23,8	22,6	40,5	48,4

Note: Participants were allowed to indicate more than one choice

strategies that the participants would use as teachers in the future as well differences in what they expect other teachers to use.

For the science sample, the teaching approaches that are considered to be the most appropriate for teaching science seem not to be much different than those proposed by the mathematics sample for mathematics teaching at kindergarten. In particular, as shown in Table 6, the use of play is greatly supported by prospective primary school teachers (81%) compared to prospective kindergarten teachers (53,8%) ($t=9,833$, $df=168$, $p<.01$). On the other hand, the experimentation and discovery is mainly supported by the prospective kindergarten teachers (67%), at smaller percentages by the prospective primary school teachers (41,8%) ($t=17,891$, $df=168$, $p<.05$). Connecting knowledge to everyday situations also seems to be an effective approach in teaching science at kindergarten for both prospective primary school teachers (63,3%) and kindergarten teachers (73,5%).

Difficulties in mathematics and science teaching at kindergarten

Young children's difficulties in the understanding and application of mathematical and scientific concepts were the main problems future teachers believe they face in teaching mathematics and science at kindergarten level. This quite pessimistic finding reveals that participants in both samples do feel that young learners at kindergarten experience difficulties with mathematics (about 62% in the mathematics sample) and science (about 77% in the science sample). The reason of these difficulties, however, was not clearly mentioned. Table 7 provides the evidence separately for both samples. Inadequate teacher training was also highly considered as one of the major problems they may face at the kindergarten level: however, this was pointed out as a difficulty by almost half of the prospective kindergarten teachers (47,7%) and only by 28% of the prospective primary school teachers ($t=6.476$, $df=171$, $p=<.05$) for the mathematics sample. Similarly, in the science sample more than half of the prospective kindergarten teachers (53,8%) pointed out inadequate teacher training as the main difficulty in teaching and learning science compared to the prospective primary teachers (30,4%) ($t=8.713$, $df=168$, $p=<.05$). This finding suggests that future kindergarten teachers develop a sense of not feeling comfortable with their teaching and maybe this will prevent them from taking risks in their classrooms and from trying very different techniques when needed. Although most of the participants are comfortable with the mathematics and science content, they feel unsure of their knowledge of teaching practices. This is nicely exemplified in one prospective kindergarten teacher's comments, coming from the mathematics sample, who stated her not feeling comfortable, by saying: '*I know the concepts well, but I don't know the best way to teach it*'. This feeling speaks of the need for professional experiences early in the careers of prospective teachers.

TABLE 7

Percentage of prospective teachers' responses regarding difficulties when teaching mathematics and science at kindergarten

Difficulties	Mathematics		Science	
	Primary School teachers	Kindergarten Teachers	Primary school teachers	Kindergarten teachers
Children's difficulties in understanding particular mathematics or/and science concepts	57,8	65	79,7	73,6
Inadequate teacher training	28	47,7	30,4	53,8
Children's lack of interest	28,3	35,4	36,7	56
Children's weak attention	3,8	4,3	70,9	42,9
Don't know	15,2	7,6		

Note: Participants were allowed to indicate more than one choice

DISCUSSION AND IMPLICATIONS

The present study set out to investigate the ways in which student teachers conceptualize mathematics and science teaching and find out how their views evolve as they progress through an initial teacher education course. A particular emphasis was also put on teaching and learning mathematics and science at kindergarten level both on the part of future primary school teachers as well as on the part of future kindergarten teachers. Findings indicate that the beliefs of the participants regarding teaching mathematics and science at school seem to be, in some cases, affected by either their study levels or the department of origin. Moreover, similarities as well as differences in the responses between the science sample and the mathematics sample regarding mathematics and science teaching and learning at school, in general, and at kindergarten, in particular, were observed.

On the whole, the participants responded very positively to viewing mathematics and science learning and teaching at school as a significant process for preparing children to live in a rapidly changing world scientifically and technologically. The fostering of scientific knowledge and creativity as well as of reasoning inquiry and experimentation were proposed by both groups of participants as being the main aims of mathematics and science teaching and learning at school, acknowledging the importance of offering these learning opportunities within the educational system. Although participants similarly support the use of play, the use of children's early ideas and knowledge delivered by the teacher, differences were found in their beliefs regarding the approaches in

effective mathematics and science teaching. More specifically, the participants in the science sample place great emphasis on the use of experiments in science teaching as well as on the connection between scientific knowledge and everyday life practices. In addition, the significance they assign to the acquisition of experience and its practice into everyday situations seems to correspond to a modern idea of teaching and learning science according to which “science educators view their role as preparing students for helping students integrate what they have learned in the science classrooms into their daily lives” (Spektor-Levy, Eylon & Scherz, 2008, p. 462). On the other hand, participants in the mathematics sample greatly estimate the development of children’s positive attitudes towards mathematics, showing that they probably support the view that improvement will result in children’s mathematics understanding and performance if their attitudes towards mathematics change positively. Moreover, prospective teachers refer to the hierarchical presentation of mathematical knowledge as an approach that differentiates effective mathematics teaching and learning from effective science teaching and learning. The hierarchical view of mathematical knowledge – also found in Meredith’s study (1993) - is considered necessary for the development of pedagogical content knowledge in mathematics.

Similarly to the participants’ beliefs about the most important approaches in effective mathematics and science teaching and learning, our data regarding the role of the teacher when teaching mathematics and science reflect a quite modern constructivist orientation provided mainly by two points. First, they view the teacher as a facilitator, who assists students in clarifying their understanding of mathematics and science concepts, stimulates children’s thinking, promotes further inquiry and provides opportunities for students to compare their views with other students. This latter shows that prospective primary school teachers and kindergarten teachers recognize the importance of cooperative learning in school classes as an effective and successful process in attaining knowledge as well as cognitive skills. Second, they strongly support the idea that a teacher should use new activities, advanced ones when needed, referring to the same unit instead of repeating the unit in order for students to overcome difficulties in understanding mathematics or science concepts. However, the issue of the transmission of the teachers’ knowledge reveals the participants’ less constructivist views.

Results indicating the children’s involvement in experimental procedures for constructing scientific knowledge – in the case of science teaching and learning – as well as the importance of cooperative learning are extensively recognized as essential procedures in order to successfully achieve the learning goals in mathematics and science education. The interactions between the members of a group gives them the opportunity to work as active recipients of knowledge, when discussing information and exploring their own ideas about mathematics and science concepts, to develop

cognitive skills as well as reasoning acquisition and inquiry. The above mentioned findings correspond to the results of other researchers concerning mathematics and science teaching (Munby et al., 2000; Tsitouridou, 2003; Bartholomew et al., 2004; Howes, 2008).

Teaching mathematics and science at kindergarten is proposed to differ from teaching mathematics and science at primary school. Differences that were mainly attributed to teaching practices and the mathematics and science content depicted the importance they assign to the aims of mathematics and science teaching and learning at kindergarten. In particular, prospective primary school teachers, at great percentages, tend to favor the idea that teaching mathematics and science at kindergarten prepares young children for primary school. On the other hand, prospective kindergarten teachers put great emphasis on the development of inquiry and motivation within their mathematics and science teaching in the preschool age. Skills development was not proposed as being one of the main aims in mathematics and science teaching at kindergarten: instead this was mainly proposed as being one of the main aims at primary school.

Differences were observed between future teachers' beliefs regarding teaching mathematics or teaching science at the kindergarten. More specifically, teaching mathematics to very young children mainly aims at providing opportunities for inquiry and reasoning development as well as experience acquisition and practice. Teaching science at kindergarten mainly aims at young children becoming aware of the physical environment as well as at their inquiry development and connection to everyday situations. These findings highlight the importance of science teaching in promoting environmental awareness (Hodson, 2003). However, agreement was observed, on the whole, in the beliefs of the participants regarding the most effective approaches in teaching mathematics and science in the pre-school context. The majority of them seem to put great emphasis on the ideas of using play, experimentation and discovery for teaching mathematics and science at this age level. These findings further support the importance of play that has also been indicated in other studies (Sarama & Dibiase, 2004; Eshach, & Fried, 2005).

Lastly, prospective teachers' beliefs about their difficulties in teaching mathematics and science at kindergarten mainly referred to children's difficulties in understanding particular mathematics and science concepts as well as their own inadequate teacher training. This latter is in agreement with results of previous studies providing evidence that teachers of young children are often uncomfortable with mathematics, have limited knowledge of mathematics and especially with processes and thinking strategies of mathematics with young children (Copley, 2004). Given that early childhood educators' mathematical knowledge and dispositions are important to their children's mathematics learning (Perry & Dockett, 2008), the need for more work in mathematics education to

be done in both professional development and beginning teacher education for early childhood educators is clear. Findings from the present study may also be of particular importance as they reveal that future teachers' awareness may turn their difficulties and, in particular, their weakness in mathematics and science content into a positive fact. As Johnson (1999) argues, early childhood mathematics and science education cannot take place unless teachers are appropriately disengaged from their fears and anxieties in these areas. Therefore, teacher preparation needs to be further supported. However, teacher preparation focused on subject matter or methods courses only will neither necessarily overcome obstacles identified earlier nor improve mathematics and science instruction. What is needed is a new form of teacher education, where the development of subject matter knowledge and pedagogy are interrelated (Stoddart, Connell, Stofflett & Peck, 1993). This will ensure that teaching mathematics or science will involve meaningful organization of the subject content as well as its significance and connection to everyday life.

Finally, we wish to mention that the issue of prospective teachers' beliefs may be framed within one consideration. We argue that beliefs can play a crucial role in mathematics and science teaching and learning, but cannot and do not bring about change alone. We agree with Richardson (1996) and Pajares (1996) that practices and beliefs should be used together to gain a deeper understanding of beliefs. Teachers' existing knowledge, personal beliefs, and classroom practices should be taken into account in order to achieve significant changes in their professional development (Van Driel et al., 2001; Macnab & Payne, 2003; Zacharos et al., 2007). Moreover, according to Thompson (1992), good results are obtained when the goal is to make prospective teachers doubt their own beliefs. This is related to the importance of creating a reflective teacher, who ponders on his own practice and beliefs. Maybe the crucial point is to make prospective teachers continually look for changes and improvement in their mathematics and science teaching.

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