

# Secondary Mathematics Teachers' Beliefs About Teaching and Learning: Some Significant Factors

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The espoused beliefs of 465 secondary mathematics teachers in Greek State secondary schools regarding the teaching and learning of mathematics were the focus of this study. The data for this investigation were collected using a 34 items questionnaire. There is evidence from this study that there are teachers who may be assumed to espouse a 'constructivist or contemporary orientation', teachers who may be assumed to espouse a 'dynamic problem-driven orientation', teachers who may be assumed to espouse 'traditional-static' and 'traditional-mechanistic' beliefs, and teachers who espouse a 'cooperative orientation' to mathematics learning and mathematics teaching. It was also found that teacher characteristics, such as, gender, teaching experience, position held and postgraduate qualifications possessed, significantly influence teachers' beliefs about mathematics and the teaching-learning process.

Teachers' beliefs influence their classroom practices, the beliefs are formed early and beliefs about teaching are well established by the time a prospective teacher starts attending University classes. It is therefore instrumental to mathematics educators and researchers, as well as mathematics education administrators and curriculum designers, to understand the impact teachers' beliefs have on their everyday cognitions and classroom practices.

In this study we have endeavoured in an attempt to explore and chart the complex topology of mathematics teachers' beliefs regarding the teaching and learning of mathematics. Attitudes and beliefs have attracted a considerable interest in recent research studies (McLeod, 1989, 1992; Lester and Garofalo, 1987; Leder, 1993). Pajares (1992) argued that knowledge and beliefs are inextricably intertwined and that individuals' beliefs strongly affect their behaviour and Hollingworth (1989) reported that the way teachers implement new methods or programs in their classrooms relates to whether their beliefs are congruent with the proposed new methods or programs. Pajares (1992) argued that beliefs are prioritised according to their connections to other cognitive and affective structures. In this study the complex topology of mathematics teachers' beliefs regarding mathematics learning and teaching has been explored and documented.

Ernest (1989) noted that the term 'beliefs' is not an isolated construct but it consists of the mathematics teachers' beliefs system, values and ideology. He claimed that beliefs should rather be thought of as 'implicitly held philosophies' (p. 20) and distinguished three philosophies of mathematics among the many variations possible (a) *The dynamic - problem solving view*: Mathematics is a continually expanding field of inquiry and its results are open to revision. It is also a field of creativity and invention and a cultural product, (b) *The Platonist view*: Mathematics is a set of monolithic and immutable structures and truths, and a static but unified body of expert knowledge. Mathematics is not created but discovered, and (c) *The instrumentalist view*: Mathematics is consisting of an accumulation of useful but unrelated facts, rules and skills to be mastered in the pursuit of some not clearly defined end.

Thompson (1992) reported that the findings of studies investigating the relationship

between mathematics teachers' espoused beliefs and enacted beliefs have not been consistent. Some studies have found a high degree of agreement between mathematics teachers' espoused beliefs and their instructional practice whereas some other studies have reported 'sharp contrasts' (Thompson, 1992, p.137).

Attitudes and beliefs have attracted a considerable interest in recent research studies (McLeod, 1989, 1992; Leder, 1993). Various researchers have put a number of definitions forward over the past two decades. "Beliefs" has been a particularly difficult term to define in the educational and psychological literature and a number of researchers have offered definitions. The definition McLeod (1992) put forward was considered sufficient for this research study:

Beliefs are largely cognitive in nature, and are developed over a relatively long period of time. Emotions, on the other hand, may involve little cognitive appraisal and may appear and disappear rather quickly...Therefore we can think of beliefs, attitudes and emotions as representing increasing levels of affective involvement, decreasing levels of cognitive involvement, increasing levels intensity of response, and decreasing levels of response stability. (p. 579)

A number of studies conducted by Australian researchers have investigated various aspects of teachers' beliefs, e.g. how teachers' beliefs impact on teachers' daily practices (Buzeika, 1996); encouraging reflection on their teaching practices (Malone, 1995); providing alternative models for mathematics teaching (Malone, 1995; Malone et.al., 1997); espoused primary and secondary teachers' beliefs about mathematics and the learning and teaching of mathematics (Howard, Perry & Lindsay, 1997; Perry, Howard & Conroy, 1996; Perry, et. al., 1999; Nisbet & Warren, 2000).

## Methodology

### *The Instrument*

A 34 items researcher - designed questionnaire was the instrument for this investigation. In developing the questionnaire items, we drew on previous research findings about teacher beliefs issues in mathematics education (Van Zoest, 1994; Howard, Perry & Lindsay, 1997). The investigation examined the espoused and enacted beliefs of secondary mathematics teachers, working during 1999-2000 in State High schools in Greece and covered the following areas: subject demographics such as gender, age, length of teaching experience, position held, postgraduate studies, beliefs about mathematics, mathematics learning and mathematics teaching. On the survey, a Likert-type scoring format was used - teachers were asked to indicate the extent to which they agreed (or disagreed) with each statement presented. A five point scoring system was used - strongly disagree (SD) to strongly agree (SA). A score of 1 was assigned to the SA response and a score of 5 to SD. The survey contained three subsets of items: Beliefs about Mathematics (6 items), Beliefs about Mathematics Learning (7 items) and Beliefs about Mathematics Teaching (21 items). A space was also provided for teachers to comment on any aspect (of each part) of the instrument and its items.

### *Participants*

Six hundred survey forms were sent to a random selection of grade 7-12 mathematics teachers in Greece. The return rate was 78% and the resulting sample comprised 465 (276 males, 145 females, 44?) mathematics teachers in 39 Greek State High Schools. The

returned surveys reflected a reasonably well-balanced distribution of grade level experience.

### *Data Analysis*

Data from the questionnaire responses regarding beliefs about mathematics, mathematics teaching and mathematics learning were analysed using SPSS<sub>win</sub>. A Principal Component Analysis (PCA) was used in order to interrogate the 34 questionnaire items for a typology of teachers' espoused beliefs. The significance level was set at .05.

## Results

### *Principal Component Analysis*

It could reasonably be expected that teachers' beliefs about mathematics, mathematics learning and mathematics teaching would be linked in various ways. A Principal Component Analysis (PCA) was used in order to interrogate the 34 questionnaire items investigating: *Beliefs about Mathematics (BM: 6 items)*, *Beliefs about Mathematics Learning (BML: 7 items)* and *Beliefs about Mathematics Teaching (BMT: 21 items)*, for a typology of teachers' espoused beliefs. Given the exploratory nature of the study and guided the scree plot and the interpretability of the factors, a five factor, orthogonal solution was accepted after the extraction of principal components and a Varimax rotation. The solution accounted for 35% of the variance, and 22 of the 34 items were used to delineate the factors. A final confirmatory factor analysis (Table 1) was carried out, following the elimination of psychometrically "poor" items. Variables loading on more than one factor have been eliminated. The extraction method used was Principal Component Analysis and the rotation method was a Varimax with Kaiser Normalization. The rotation converged in 7 iterations.

Six items loaded on Factor 1, 6 items loaded on Factor 2, 3 items on factor 3, 3 items on factor 4 and 4 items loaded on Factor 5 (Table 1). The naming of factors was guided by the nature of the items associated with each factor. The factors are as follows:

Teachers, whose beliefs are expressed by *factor 1*, can be assumed to espouse a *socio-constructivist or contemporary orientation* to mathematics, mathematics learning and mathematics teaching. They believe that they should create problematic situations for learners, that mathematics learning is enhanced by activities, which build upon students' experiences, that students are rational decision makers and that mathematics learning is enhanced by challenging activities within a supportive environment. Teachers, whose beliefs are expressed by *factor 2*, can be assumed to espouse a *dynamic problem-driven orientation* to mathematics, mathematics learning and mathematics teaching. They believe that challenging activities within a supportive environment enhances mathematics learning and that mathematics is the dynamic searching for models and problems and their results are open to review.

Teachers, whose beliefs are expressed by *factor 3*, can be assumed to espouse *static - transmission orientation* to mathematics, mathematics learning and mathematics teaching. Teachers in this category believe that mathematics is computation, that mathematics is a

Table 1  
*Factors related to views of mathematics, mathematics teaching and mathematics learning*

Item	Item description	Loading
<i>Factor 1:</i>		
<i>A contemporary socio-constructivist orientation to mathematics, mathematics teaching and mathematics learning</i>		
24	It is important for students to be provided with opportunities to reflect on and evaluate their own mathematical understanding	.594
14	Ignoring the mathematical ideas generated by the students can seriously limit their learning	.594
32	The education system should be preparing critically thinking citizens who are able to utilise their mathematical skills	.583
17	Mathematics teachers should be fascinated with how students think and intrigued by alternative ideas	.482
16	Teachers should encourage their students to strive for elegant solutions when they solve problems	.385
1	Justifying the mathematical statements that a person makes is an extremely important part of mathematics	.306
<i>Factor 2:</i>		
<i>A dynamic problem-driven orientation to mathematics, mathematics teaching and mathematics learning</i>		
13	Mathematics learning is enhanced by challenging activities within a supportive environment	.650
30	The comprehension of mathematical concepts by students should correspond to their cognitive development and it should be a decisive factor in the content sequence to be taught	.608
34	Teachers should respect the mathematical knowledge of their students, which is consisting of a nexus of experiences, beliefs, attitudes, representations, concepts, strategies, connections, values, judgements and emotions	.558
6	Mathematics is a beautiful, creative and useful human endeavour that is both a way of knowing and a way of thinking	.463
19	Teachers always need to hear students' mathematical explanations before correcting their errors.358 problems and their results are open to review	.447
<i>Factor 3:</i>		
<i>A static-transmission orientation to mathematics, mathematics teaching and mathematics learning</i>		
7	The most effective way to learn mathematics is by listening carefully to the teacher explaining a mathematics lesson	.718
2	Mathematics is a static and immutable knowledge with objective truth	.675
28	The role of the mathematics teacher is to transmit mathematical knowledge and to verify that learners have received that knowledge	.637
<i>Factor 4:</i>		
<i>A mechanistic-transmission orientation to mathematics, mathematics teaching and mathematics learning</i>		
12	The memorisation of mathematical facts is important in mathematics learning	.623
27	Teachers or the textbook-not the student-are the authorities for what is right or wrong	.602
10	Mathematics knowledge is the result of the learner interpreting and organising the information gained from experiences	.532
<i>Factor 5:</i>		
<i>A collaborative orientation to mathematics, mathematics teaching and mathematics learning</i>		
20	An effective way to teach mathematics is to provide students with interesting problems to investigate in small groups	.551
11	Students are rational decision makers capable of determining for themselves what is right and what is wrong	.536
33	All students are able to be creative and do original work in mathematics	.469
8	Students can learn more mathematics together than by themselves	.447

static and immutable knowledge with objective truth, and that the role of the mathematics teacher is to transmit mathematical knowledge and to verify that learners have received that knowledge. Teachers whose beliefs are expressed by factor 4, can be assumed to espouse a *mechanistic - transmission orientation* to mathematics, mathematics learning and mathematics teaching. They believe that the memorisation of mathematical facts is important in mathematics learning, that teachers and the textbooks are the authorities for what is right or wrong. Teachers, whose beliefs are expressed by factor 5, can be assumed to espouse a *cooperative orientation* to mathematics learning and mathematics teaching. They believe that an effective way to teach mathematics is to provide students with interesting problems to investigate in small groups and that students are rational decision makers capable of determining for themselves what is right and what is wrong.

### Teacher Characteristics and Their Influence on Teachers' Beliefs

Data were collected on five teacher characteristics, namely, gender, years of teaching experience at Junior High school, years of teaching experience at Senior High school, position held and postgraduate qualifications possessed. One-way analyses of variance and linear contrasts were performed in order to examine if the five beliefs factors relating to mathematics, mathematics teaching and mathematics learning, varied according to these characteristics.

#### *Gender*

The independent samples t-test showed that gender was significant for one of the five factors – Factor 1, a *contemporary socio-constructivist orientation to mathematics, mathematics teaching and mathematics learning* ( $t_{421}=-3.3$ ,  $p=.001$ ). The mean factor score for female teachers (0.23) was significantly higher than for the male teachers (-0.10). It could be argued that female teachers in this study placed more emphasis on a socio-constructivist view of mathematics, mathematics teaching and mathematics learning than did the male teachers.

#### *Years of Experience at Junior High School*

The ANOVA summary table showed that years of experience at Junior High school was significant for one of the five factors - Factor 1 ( $F_{(2, 421)}=3.514$ ,  $p=.031$ ). It could be argued that teachers with experience at Junior High school (Years 7-9), placed more emphasis on a socio-constructivist view of mathematics, mathematics teaching and mathematics learning than did teachers with experience at other levels. By examining the linear term, which is also significant across the years of experience at Junior High school, it can be concluded that the contemporary socio-constructivist orientation to mathematics, mathematics teaching and mathematics learning increases consistently between the inexperienced teachers category (0-6 years of experience) and the experienced teachers category (7-15 years of experience). It could be argued (by using the means plot) that the contemporary socio-constructivist view of mathematics, mathematics teaching and learning (factor 1) was more prevalent among experienced teachers and veteran teachers (16+ years of experience) than among inexperienced teachers.

### *Years of Experience at Senior High School*

Years of experience at Senior High school was not a significant variable for any of the factors, suggesting that teachers' beliefs about mathematics, mathematics teaching and mathematics learning were not significantly influenced by their experience at Senior High school level (Years 10-12). By examining the linear term, which is significant for Factor 2 across the years of experience at Senior High school, it can be concluded that the dynamic problem-driven orientation to mathematics, mathematics teaching and mathematics learning increases consistently across teachers' experience categories. It could also be argued (Figure 1) that the dynamic problem-driven orientation to mathematics, mathematics teaching and mathematics (Factor 2) was more prevalent among veteran teachers than among inexperienced teachers and experienced teachers.

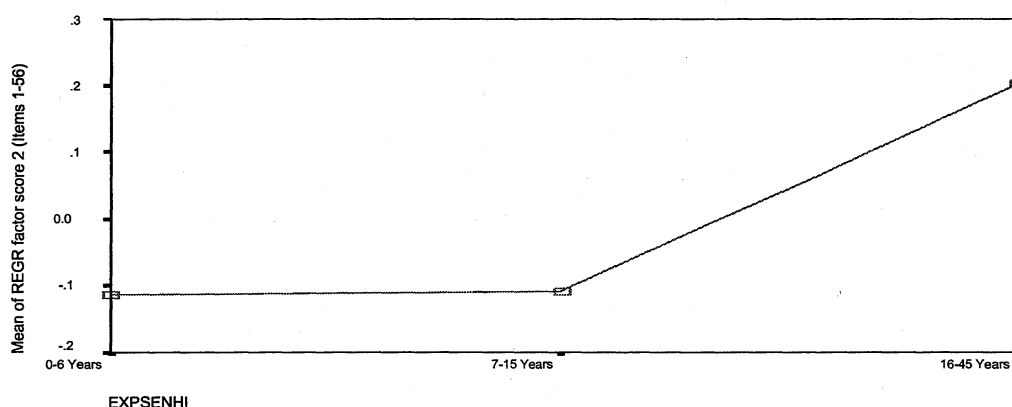


Figure 1. Means Plot (Experience at Senior High school).

### *Position Held*

The ANOVA summary table showed that a teacher's position (teacher, principal, consultant) was significant for two of the five factors - Factor 1, A contemporary socio-constructivist orientation to mathematics, mathematics teaching and mathematics learning ( $F(2, 412)=3.171, p=.043$ ) and Factor 3, A static-transmission orientation to mathematics, mathematics teaching and mathematics learning ( $F(2, 412)=4.919, p=.008$ ). By examining the Linear term which is also significant across the years of experience at Junior High school, it can be concluded that the contemporary socio-constructivist orientation to mathematics, mathematics teaching and mathematics learning decreases consistently between the principal and consultant categories of position held. It could be argued (by using the means plot) that the contemporary socio-constructivist view of mathematics, mathematics teaching and learning was more prevalent among teachers and principals than among consultants, and that the static-transmission orientation to mathematics, mathematics teaching and mathematics learning was more prevalent among consultants than among teachers and principals.

## Conclusion

The results of the factor analysis can be summarised as follows. There appears to be *two orientations* that are characteristic of secondary mathematics teachers' beliefs:

- A *contemporary - constructivist orientation*, consisting of the following (not mutually exclusive but complementary) views:

- The socio-constructivist view (factor 1)
- The dynamic problem driven view (factor 2)
- The cooperative view (factor 5)

- A *traditional - transmission - information processing orientation*, consisting of the following (not mutually exclusive but complementary) views:

- The static view (factor 3)
- The mechanistic view (factor 4)

Forty-three percent of the teacher participants in the study fell into the first of these categories and 57% into the second. This information suggests that contemporary ideas on teaching and learning, especially those with a constructivist orientation, have yet to be generally accepted and adopted among the Greek mathematics teacher community. Undoubtedly though, professional development efforts in Greece are taking hold – there can be no doubt that the above percentages would have been reversed if the data had been collected just a few years ago. It also appears that mathematics teachers' beliefs about mathematics cannot be separated from their beliefs about teaching and learning mathematics. These outcomes obviously have implications for professional development programs for mathematics teachers.

Another interesting feature of the outcomes of this study concerned teachers' characteristics and their influence on those teachers' beliefs. It was found that female teachers in this study placed more emphasis on a socio-constructivist view of mathematics, mathematics teaching and mathematics learning than did the male teachers. From data on teacher experience factors, it was concluded that a contemporary socio-constructivist orientation to mathematics, mathematics teaching and mathematics learning ability increases consistently between the inexperienced teacher and the experienced teacher categories. Linked with this finding was another indicating that the contemporary socio-constructivist view of mathematics, mathematics teaching and learning was more prevalent among experienced teachers and veteran teachers than among inexperienced teachers. The dynamic problem-driven orientation to mathematics, mathematics teaching and mathematics learning increases consistently across teachers' experience categories. We also argued that according to our data, the *dynamic problem-driven orientation to mathematics, mathematics teaching and mathematics* was more prevalent among veteran teachers, than between inexperienced teacher and experienced teachers. The position teachers held was a significant factor that was found to influence teachers' beliefs. It can be concluded that the contemporary socio-constructivist orientation to mathematics, mathematics teaching and mathematics learning decreases consistently between the principal and consultant categories. The contemporary socio-constructivist view of mathematics, mathematics teaching and learning was more prevalent among teachers and principals than among consultants.

While teachers' beliefs are difficult to change, making teachers aware of the impact of those beliefs is a first step in assisting them to transform those counter-productive beliefs into a positive force to enhance mathematics teaching and learning.

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