Secondary mathematics teachers' beliefs about mathematics assessment and components that influence these beliefs

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The espoused beliefs of 465 secondary mathematics teachers regarding mathematics assessment are the focus of this study. The data for this investigation were collected using a 19 items questionnaire. There is evidence from this study that there are teachers who espouse a 'socio-constructivist' orientation to mathematics assessment, teachers who espouse a 'problem solving' orientation to mathematics assessment and teachers who espouse an 'accountability' orientation to mathematics assessment.

Since the beginning of the twentieth century considerable research interest has been invested in studying the nature of beliefs and their influence on people's actions among social psychologists, according to Thompson (1992). Following a recession period during the 1920s, research interest was renewed in the 1930s and the 1960s but it was not until the 1970s and the emergence of cognitive science, that "a place for the study of belief systems in relation to other aspects of human cognition and human affect" (Abelson, 1979, p. 355; cited in Thompson, 1992) was created.

Interest in beliefs and belief systems resurfaced in the 1980s. As far as mathematics education is concerned over the past two decades numerous empirical and qualitative studies (Berger, 2000; Leder, Pehkonen and Törner, 2002; Barkatsas and Malone, 2005) have shown the impact mathematical beliefs have, on mathematics teaching and learning processes. A shift in the direction of research in the study of teachers' beliefs was prompted by a shift in paradigms for research on teaching, according

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to Thompson (1992). This shift of focus was grounded on the need for an understanding of belief systems and conceptions based on the seminal work of Green (1971) and Rokeach (1960), the need to situate the role of beliefs in the practice of teaching (Nespor, 1987), a focus on teachers' thinking and decision-making processes (Shulman, 1986; Bromme, 1994) and the need for a re-examination of the philosophy and the didactics of mathematics (Ernest, 1994). Pajares (1992) argued that although research on teacher thinking has been thriving, critics have questioned the utility of its findings on teacher education:

> They suggest that another perspective is required from which to better understand teacher behaviors, a perspective focusing on the things and ways that teachers believe. This view is based on the assumption that beliefs are the best indicators of the decisions individuals make throughout their lives. (p. 307)

He also argued that knowledge and beliefs are inextricably intertwined and that beliefs individuals hold, strongly affect their behaviour. In addition, 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.

The main aim of the present study was to investigate Greek secondary teachers' beliefs regarding mathematics assessment and components influencing these beliefs. In the next two sections some previous research on teachers' beliefs in general and on teachers' beliefs about mathematics assessment is presented.

Previous research on teachers' beliefs

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 the proponents of reforms in mathematics education to understand the impact teachers' beliefs have on their everyday cognitions and classroom practices. *Beliefs* has been a particularly slippery term in the educational and psychological literature and a number of researchers have offered definitions. The definition McLeod (1992), put forward has been considered sufficient for this survey:

> 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, as when the frustration of trying to solve a hard problem

> is followed by the joy of finding a solution. 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).

Pajares (1992) claimed that the confusion arising from the many terms that have been used to describe the same phenomena and the consequent attempts of the researchers to provide definitions for the terms they had introduced, could be generally attributed to the distinction between beliefs and knowledge. In all cases, according to Pajares (1992):

> It was difficult to pinpoint where knowledge ended and belief begun, and the authors suggested that most of the constructs were simply different words meaning the same thing (p. 309).

The complexity of defining *educational beliefs* can also be highlighted by the fact that the concept of beliefs has been presented in the research literature as a very broad and difficult to operationalise term. Pajares (1992) cited a number of aliases which can be considered as subsets of the broadly defined 'educational beliefs' term, the most commonly used being: teacher efficacy, epistemological beliefs, attributions, anxiety, self-concept and self-esteem, self-efficacy and specific subject matter beliefs, are just in the long list. Green (1971) proposed a multidimensional perspective on the structure of beliefs incorporating three dimensions of belief structures: the quasi-logical relation between beliefs, the central-peripheral dimension introduced by Rokeach (1960), and the premise that beliefs are held in clusters. Pajares (1992) further argued that beliefs are prioritised according to their connections to other cognitive and affective structures.

Berger (1999), drawing from Rokeach (1960), conceptualised these structures as 'dimensions' and proposed a synoptic model of teacher 'dimensions'. In this model the conscious domain is paralleled by a subconscious one in an attempt to account for the diverse views different stakeholders (students, teachers, researchers) may hold on teacher 'dimensions'. Berger (1999) proposed that the four visible dimensions (surface beliefs, explicit knowledge, reflection and normal action) of the conscious domain could be conceived of as mirror images of the four hidden dimensions (entrenched beliefs, tacit knowledge, emotion and ritual) of the subconscious domain.

Hofer and Pintrich (1997) arrived at the conclusion that there is very little agreement:

> On the construct under study, the dimensions it encompasses, whether epistemological beliefs are domain specific or how such beliefs might connect to disciplinary beliefs (p. 89).

They also concluded that it is not clear if beliefs about learning, intelligence, and teaching should be considered as central components of the construct of epistemological beliefs, for research purposes. As far as the definition of the content of epistemological beliefs is concerned, Hofer and Pintrich (1997) argued that it should be "limited to individuals' beliefs about the nature of knowledge and the process of knowing" (p. 117). They went on to propose that the development of a widely acceptable definition of the construct of epistemological beliefs constitutes one of the most important issues to be resolved by future research efforts.

Previous research on teachers' beliefs about assessment

There has been a growing interest in mathematical assessment during the last two decades and a wealth of research reports has led to the development of authentic assessment strategies and tasks (NCTM, 1989, 2000; Clarke, 1996; Clarke and Stephens, 1996). Clarke (1996) proposed that assessment should be assigned a proactive role in the process of determining what kind of learning and instruction will be planned. He also proposed that assessment should be 'constructive' in the sense that its' principal aim is to inform 'a constructive consequent action' (Clarke, 1996, p. 336). A number of assessment strategies could be used to exemplify the new (constructivist) approach, such as student portfolios, group work, open-ended tasks, student self-assessment, extended investigations and projects.

Clarke and Stephens (1996) conducted a study in the State of Victoria, Australia, regarding the instructional impact of the systemic introduction of performance assessment in mathematics. They introduced the term 'ripple effect' in an attempt to encapsulate their thesis.

> The introduction of new assessment practices into existing high stakes assessment creates a climate of change, which has immediate and direct consequences for policy and instruction at the level of school and classroom. This change climate functions to stimulate and support the introduction of specific practices. The emergent hypothesis is that unless a term or practice receives the explicit sanction of inclusion in high stakes assessment it is unlikely to influence school policy or classroom practice. (p. 70)

Clarke and Stephens (1996) reported that: "consistently high levels of approval (50 %) were given to those aspects which were strongly endorsed

by Victorian Certificate of Education curriculum advice and assessment practice" (p. 83).

Nisbett and Warren (2000) noted that despite the fact that much has been written about the purposes of assessment "there is a paucity of research" (p. 36) on how mathematics teachers use assessment information and on what they actually believe about assessment. The same can be said about research efforts regarding the relationship between espoused beliefs about assessment and the actual teaching practice. Assessment approaches may be considered as extensions of mathematics teachers' beliefs about mathematics, and mathematics teaching and learning. Cooney (1999) cited a study by Senk, Beckmann and Thompson (1997), in which they found that:

> About 68 % of teachers' tests focus on lower level outcomes and that only about 5 % of the items require any depth of thinking. Further, they found that virtually no teachers used open-ended items on tests. (p. 167)

Cooney (1999) remarked that according to his studies: "teachers felt uncomfortable in answering and unlikely to use open-ended items with their students" (p. 167).

With regard to the introduction of contemporary assessment practices into mathematics classrooms, the role of teachers is considered pivotal. Shepard (2000) noticed that mathematics teachers' prevailing ideas about assessment could be far from what new trends on assessment aim to tackle. In that respect if mathematics educators aim to bring about change in outdated assessment practices in mathematics classrooms, then "teachers' knowledge and beliefs should be a primary site for research" (Shepard, 2000, p. 71).

In this investigation, we have endeavoured to explore Greek secondary mathematics teachers' beliefs regarding mathematics assessment. In the following sections the research questions and the statistical methods used to analyse them will be presented.

Research questions

The focal research questions were as follows:

1 What are the beliefs of Greek secondary mathematics teachers with regard to mathematics assessment? Specifically, does there exist a typology of mathematics teachers' beliefs that correspond to that postulated in the research literature concerning Western teachers?

2 In what ways do Greek secondary mathematics teachers' bio-data, such as gender, professional development background, postgraduate studies background, experience and position held, influence their espoused beliefs? In other words, what differences in beliefs exist across professional development undertaken, years of experience, position held, the range of qualifications, and between female and male teachers?

Instrument

The data for this investigation were collected using a 19 items researcher-designed questionnaire. In developing the items, we drew on previous research findings about teacher beliefs issues in mathematics education (Clarke and Stephens, 1996). This investigation of the espoused beliefs of secondary mathematics teachers, working during 1999-2000 in State High schools in Greece, covers the following areas: subject demographics such as gender, age, length of teaching experience, professional development undertaken, position held, postgraduate studies, and beliefs about mathematics assessment. Teachers were asked to indicate the degree of importance they attached to each of the aspects described on each item of the questionnaire. A four-point scale was used [highly important (HI), of some importance (SI), beneficial but not essential (BNE), of little importance (LI)]. A score of 1 was assigned to the (HI) response and a score of 4 to (LI). A space was also provided for teachers to comment on any aspect of the instrument and its items.

A limitation of this study is that all results must be considered in the context that responses to the questionnaire items depend on the interpretations assigned to them by each respondent.

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 no gender specified) mathematics teachers – including principals and regional mathematics consultants – in 39 Greek State High Schools. The returned surveys reflected a reasonably well-balanced distribution of grade level experience (table 1).

Data analysis

Data from the questionnaire responses regarding beliefs about mathematics assessment were analysed using $SPSS_{win}$. Inferential statistical techniques (MANCOVA, t-tests, Cluster Analysis, Trend Analysis) as well as Principal Component Analysis (PCA) was used in order to interrogate the 24 questionnaire items for a typology of teachers' espoused beliefs, using an Analysis of Variance (ANOVA) and the scree plot technique. The significance level was set at .05.

Table 1. *Percentage distribution of teachers by experience*

	Years of experience		
	0 - 5	6 - 15	16 +
Experience at Junior High School (years 7-9)	53.7	25.8	20.5
Experience at Senior High School (years 10-12)	46.2	30.4	23.4

Principal Component Analysis

A Principal Component Analysis (PCA) was used in order to interrogate the 19 questionnaire items for a typology of teachers' espoused beliefs, using an Analysis of Variance (ANOVA) and the scree plot technique. The significance level was set at .05. If the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy is greater than .6 and the Bartlett's Test of Sphericity (BTS) is significant then factorability of the correlation matrix is assumed. The Kaiser-Meyer-Olkin Measure (KMO) of Sampling Adequacy is greater than .6 (KMO=.774) and the Bartlett's Test of Sphericity (BTS) was significant (<.001); therefore factorability of the correlation matrix was assumed.

The analysis yielded 5 components with eigenvalues greater than 1. Given the exploratory nature of the study and guided by the interpretability of the components, as well as the scree plot, a three-component orthogonal solution was accepted after the extraction of principal components and a Varimax rotation. The solution accounted for 37.5 % of the variance, and 16 of the 19 items were used to delineate the components.

A final confirmatory component analysis (table 2) was carried out following the elimination of psychometrically "poor" items (double loadings and reliability and normality tests), using Principal Component Analysis as the extraction method and Varimax with Kaiser Normalization as the rotation method. The rotation converged in 5 iterations.

Table 2. *Components related to views about assessment*

Item	Item description	Loading
	Component 1: *A socio-constructivist orientation to mathematics assessment*	
5	TOOMAI*: Students undertaking an extended mathematical activity	.643
7	TOOMAI: Students posing their own problems	.642
8	TOOMAI: Students undertaking open-ended mathematical activities	.607
10	TOOMAI: Developing students' report writing skills	.592
12	TOOMAI: The encouragement of student participation via properly designed activities	.560
14	TOOMAI: Presenting problems spanning a range of content areas in mathematics	.391
4	TOOMAI: The regular completion of student mathematical journals	.334
	Component 2: *A problem solving orientation to mathematics assessment*	
16	TOOMAI: The use of different mathematical skills in combination	.725
3	TOOMAI: Teaching problem solving skills	.661
13	TOOMAI: Students developing investigating skills	.645
11	TOOMAI: Presenting problems, which require a range	.597
19	TOOMAI: The application of mathematics to real world contexts	.457
	Component 3: *An accountability orientation to mathematics assessment*	
18	TOOMAI: To succeed in university entrance exams	.753
17	TOOMAI: To assess students' work and to verify if they should be promoted to the next grade	.653
1	TOOMAI: To provide students and parents with feedback on progress being made	.535
2	TOOMAI: To provide students and parents with feedback on progress being made	.448

Note: * TOOMAI means: The Objective of Mathematics Assessment Is

The three components represent three apparently differing beliefs about mathematics assessment. The three components loaded on each of the following items respectively:

Item 5: The objective of mathematics assessment is: Students undertaking an extended mathematical activity

Item 16: The objective of mathematics assessment is: The use of different mathematical skills in combination

Item 18: The objective of mathematics assessment is: To succeed in university entrance exams

Seven items loaded on Component 1, five items on Component 2 and four items on Component 3. Teachers whose beliefs are those expressed by Component 1 (49.1 % of total sample) may be assumed to espouse a *socio-constructivist orientation* to mathematics assessment. They may be considered to 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 knowledge is the result of the learner interpreting and organising the information gained from experiences and that mathematics learning is enhanced by challenging activities within a supportive environment.

Teachers whose beliefs are those expressed by Component 2 (17.6 % of total sample) may be assumed to espouse a *problem solving orientation* to mathematics assessment. Teachers in this category may be considered to believe that the objective of mathematics education is that: students should develop investigating skills, teachers should be presenting problems which require a range of problem solving techniques, and that mathematics should be applied to real world contexts.

Teachers whose beliefs are those expressed by Component 3 (33.3 % of total sample) may be assumed to espouse an *accountability orientation* to mathematics assessment. Teachers in this category may be considered to subscribe to the view that assessment in mathematics is used for accountability purposes. The inclusion of 'TOOMAI: To succeed in University entrance exams' in this component may imply that if teachers are assessing for an 'outside audience' (Nisbet and Warren, 2000) it is easier for them to justify the purposes of the assessment used.

Table 3. *Average mean frequencies of responses to each component*

Component	Average Mean response	Range of item mean frequencies
1. Contemporary–social constructivist	2.24	1.59 - 2.83
2. Dynamic problem solving	1.99	1.63 - 2.22
3. Traditional–Accountability	2.06	1.93 - 2.11

Note: Responses are based on a 4-point scale: 1: Highly Important and 4: Of Little Importance.

Average mean responses

To gain some insight into how the sample responded overall to each of the components, the average mean responses were calculated for the items comprising each component. Table 3 summarizes the average mean frequency for each component together with the range of mean frequencies for the items in each component.

The results indicate that overall, teachers in the sample emphasised the use of contemporary methods of assessment. They also used assessment for accountability purposes and lastly they use problem solving methods of assessment. The wide range of responses to the contemporary orientation indicates that it represents a wide spectrum of approaches not sufficiently coherent.

Cluster Analysis and Multiple Discriminant Analysis

Cluster analysis was used to determine homogeneous and clearly discriminated classes of teachers. The results of cluster analysis were used in this study to confirm the results of the PCA and Component Analysis and to enhance the depth of the analysis by developing more interpretable classes of the participating teachers. The selection of a cluster solution was facilitated by the interpretation of the agglomeration schedule, which provided information about the homogeneity of the clusters being combined at each stage (Coakes and Steed, 1999).

Multiple Discriminant Analysis (MDA) has been used to determine how reliable cluster membership is and to enable the researchers both to describe the nature of the differences between clusters and test these differences for significance. MDA allowed the researchers to predict which variables discriminate between the groups entered in the analysis. The grouping variable for this analysis was the cluster membership variable from the three cluster solutions. The independent variables used for the MDA were the three components obtained from the principal component analysis.

The following statistical analyses were also carried out in order to rule out any violations of assumptions regarding linearity, univariate and multivariate normality, homogeneity of variance-covariance matrices and

Table 4. *Pooled within-groups correlation matrices*

	Component 1	Component 2	Component 3
Component 1	1.000		
Component 2	-.048	1.000	
Component 3	.075	-.074	1.000

Table 5. *Tests of equality of group means*

	Wilks' lambda	F	df1	df2	Sig.
Component 1	.447	257.737	2	417	.000
Component 2	.497	211.343	2	417	.000
Component 3	.990	2.155	2	417	.117

multicollinearity, in accordance with current statistical practices (Coakes and Steed, 1999; Tabachnick and Fidell, 1996).

To test for multicollinearity, the within-groups correlation matrices (table 4) were examined. The matrices indicate that the correlations between the variables were low ranging from -.074 between components 2 and 3, and .075 between components 1 and 3. Low correlations indicate that multicollinearity is not problematical.

The one-way comparisons are reported in table 5. Wilks' Lambda statistic was used here. Significant differences exist for all the predictor variables. It was concluded that the five groups differ significantly on all the predictor variables ($p<.0001$).

An examination of the canonical discriminant functions output (table 6) indicates that four discriminant functions have been extracted. The eigenvalues, percentage of variance explained and significance of these discriminant functions are also reported. The first row of the table indicates the significance of all functions (with zero functions removed). The chi-squared value of 635.601 is highly significant ($p<.0001$), indicating that the two functions together discriminate between the sectors very well. The second row indicates the significance after the first function has been removed. This measures the significance of function two. All functions are significant at an alpha .0001 ($p<.0001$).

Table 6. *Wilkes' lambda*

Test of function(s)	Wilkes' lambda	Chi-square	df	Sig.
1 through 1	.217	635.601	6	.000
2	.497	291.016	2	.000

In table 7 it can be seen that the first function has an eigenvalue of 1.289, which accounts for 56.0% of the total explained variance. The second function is smaller with an eigenvalue of 1.013 and accounts for 44.0% of the variance. The canonical correlation is the ratio of the between-groups variation and varies, like normal correlation, from 0.00 to 1.00. Function 1 has a high canonical correlation ($r=.750$) and explains more than half of the variation.

Table 7. *Canonical correlation*

Function	Eigenvalue	% of variance	Cumulative %	Canonical correlation
1	1.289	56.0	56.0	.750
2	1.013	44.0	100.0	.709

Note. First 2 canonical functions were used in the analysis

Table 8. *Canonical discriminant function coefficients*

	Function	
	1	2
Component 1	.960	-.288
Component 2	.333	.944
Component 3	-.084	.183

A further part of the Multiple Discriminant Analysis (MDA) relates to the standardized canonical discriminant function coefficients. This matrix (table 8) was used to calculate predicted group membership using the products of raw scores and the function coefficients, in a manner similar to the Beta (β) weights in multiple regression (Coakes and Steed, 1999).

The structure matrix (table 9) shows the correlation of each variable with each function. These are similar to component loadings in component analysis and are ordered in descending magnitude for function 1 then function 2 and so on. These sets of variables are seen to be the variables that maximally predict differences between the three components.

Table 10 represents the Canonical discriminant functions evaluated at group means (group centroids). These means are joint means based on the linear combinations of predictor variables and they are standardized. They were used to interpret the differences between the groups. It can be seen for example (table 10) that component 2 has a high score on function 2 and a low score on function 1.

Table 9. *Structure matrix*

	Function	
	1	2
Component 1	.937	-.320
Component 2	.293	.944
Component 3	-.037	.092

Table 10. *Functions at group centroids*

	Function	
3 clusters	1	2
1	-1.075	-.370
2	.246	2.157
3	1.452	-.596

Note. Unstandardized canonical discriminant functions evaluated at group means

Figure 1 is a diagram of the canonical discriminant functions, which provides a graphical representation of the group centroids and the participants' scores. An examination of the group centroids (table 10) and the graph (figure 1) provides an indication of the differences between the 3 groups (components) and the corresponding mathematics teachers' beliefs categories. It can be seen (figure 1) that group 1 differs from group 3 on the first function, and that groups 1 and 3 differ from group 2 on the second function.

As mentioned previously, cluster analysis produces typologies of items or groups by using the similarities or proximities between participants as the basis for producing clusters. One measure of the outcome of the

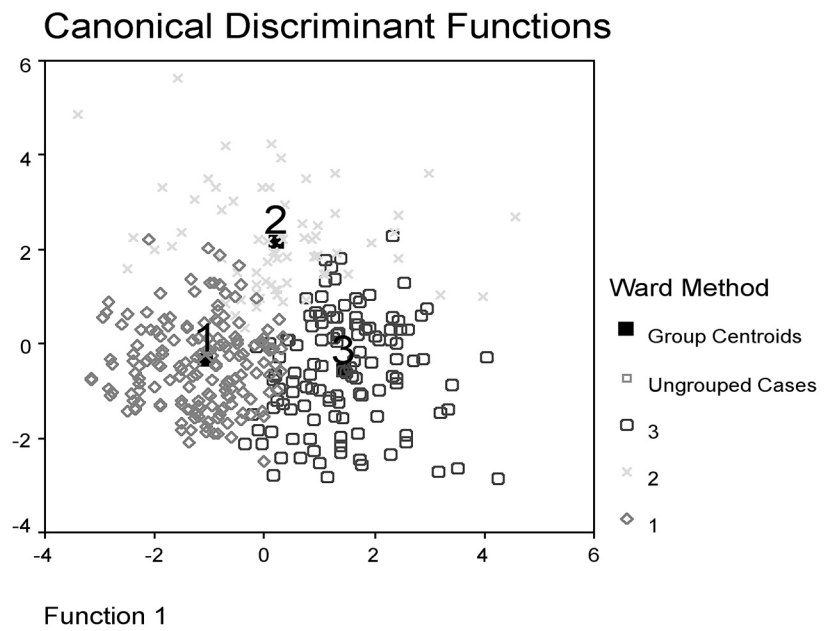

Figure 1. *Canonical discriminant functions of the participants' scores.*

analysis is the extent to which it is able to correctly assign predicted group membership. Table 11 represents a classification of the group membership, indicating that 91.2 % of original grouped cases were correctly classified. The percentage of cases correctly classified in each predicted group is given along the diagonal of the table. Chance prediction would be approximately 33.3 % per group since there are three groups, but this would vary slightly since there are unequal cell sizes across groups. According to the values in table 11, it can be claimed that the functions do discriminate among the groups better than by chance (>33.3 %).

Table 11. *Classification results*

		Predicted group membership			Total
		1	2	3	
Original count	1	189	13	4	206
	2	4	68	2	74
	3	6	8	126	140
Percent	1	**91.7**	6.3	1.9	100.0
	2	5.4	**91.9**	2.7	100.0
	3	4.3	5.7	**90.0**	100.0

Note. 91.2 % of original grouped cases correctly classified.

The prediction for all groups (91.7 %, 91.9 % and 90.0 %) was satisfactory meaning that the extent to which MDA was able to correctly assign predicted membership was quite high.

The prediction for group 1 (component 1), which represents mathematics teachers who espouse a *socio-constructivist orientation to mathematics assessment*, was 91.7 %. There was 8.2 % (6.3 %+1.9 %) misclassification for group 1 cases. The 6.3 % drift in predictions towards problem solving assessment methods was to be expected, since both components 1 and 2 represent contemporary assessment approaches.

The prediction for group 2 (component 2), which represents mathematics teachers who espouse a *problem solving orientation to mathematics assessment*, was 91.9 %. There was 8.1 % (5.4 %+2.7 %) misclassification for group 2 cases. The 5.4 % drift in predictions towards socio-constructivist methods of assessment was to be expected also, since both components 1 and 2 represent contemporary assessment approaches.

The prediction for group 3 (component 3), which represents mathematics teachers who espouse an *accountability orientation to mathematics assessment*, was 90.0 %. There was 10.0 % (5.7 %+4.3 %) misclassification for group 3 cases. There was a 10.0 % drift in predictions towards

problem solving assessment and socio-constructivist assessment approaches. This percentage could represent some uncertainty or apprehension on the part of the teachers to fully adopt a traditional orientation towards mathematics assessment.

Teacher characteristics and their influence on teachers' beliefs

Data were collected on five teacher characteristics, namely, gender, professional development, years of teaching experience at Lower High school level, years of teaching experience at Senior High school level, position held and postgraduate qualifications possessed. One-way analyses of variance, linear contrasts and Scheffe pair-wise comparisons were performed in order to test if the three beliefs components (table 2) relating to mathematics assessment varied according to these five characteristics.

Professional Development

Professional Development was not a significant variable for any of the components, suggesting that the in-service training they had undertaken did not significantly influence secondary mathematics teachers' beliefs about mathematics assessment.

Gender

Gender was not a significant variable for any of the components, suggesting that teachers' beliefs about mathematics assessment were not significantly influenced by their gender.

Years of experience at Junior High school

The ANOVA showed that that *Years of experience at Junior High school* was significant for one of the three components – Component 2: *A problem solving orientation to mathematics assessment* ($F_{(2,321)}=4.064$, $p=.018$). It could be argued that teachers with experience at Junior High school (years 7-9) placed more emphasis on a problem solving orientation to mathematics assessment than did teachers with experience at other levels. By examining the linear term, which was also significant across the years of experience at junior high school, it could be concluded that the problem solving orientation to mathematics assessment increases consistently (figure 2) across all teachers' experience categories. To further examine these differences across the three levels of experience (0-6 years, 7-15 years and 16+ years) Scheffe pair-wise comparisons were

performed. The results of this analysis showed no clear trend and no discernible pattern.

From the means plot (figure 2) it can be seen that the problem solving view of assessment in mathematics was more prevalent among experienced teachers (7-15 years experience) and veteran teachers (16+ years of experience) than among the inexperienced teachers (0-6 years of experience).

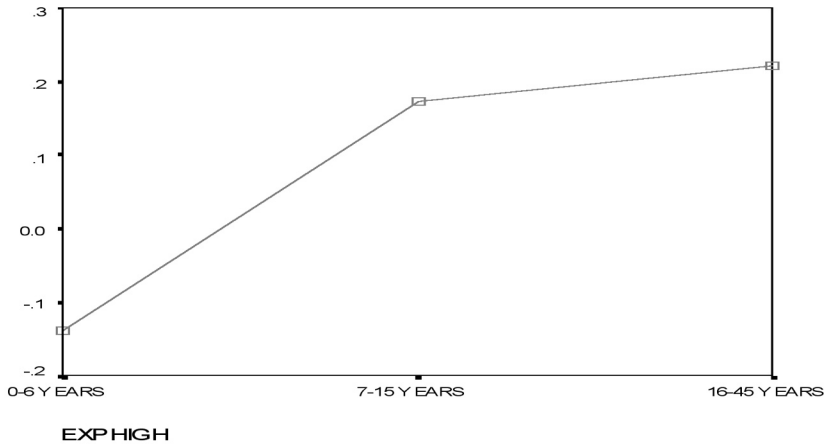

Figure 2. *Means Plot (Experience at Junior High school)*

Years of experience at Senior High school

Years of experience at Senior High school was not a significant variable for any of the components, suggesting that teachers' beliefs about mathematics assessment were not significantly influenced by their experience at Senior High school (years 10-12).

Position held

The ANOVA showed that *Position* was significant for one of the three components – Component 1: *A socio-constructivist orientation to mathematics assessment* ($F_{(2, 367)}$=5.042, p=.007). The three position categories in the survey were: (a) teacher (244 males, 143 females, 44 no gender specified), (b) principal (22 males, 2 females) and (c) regional mathematics consultant (10 males). It could be argued that position held (teacher, principal, consultant) influenced teachers who espoused a socio-constructivist view to mathematics assessment. By examining the

linear term which is also significant across position categories, and taking under consideration the means plot (figure 3), it can be concluded that the socio-constructivist orientation to mathematics assessment decreases between the teacher and principal categories and increases between the principal and consultant categories (figure 3). From figure 3 it can also be seen that the socio-constructivist view of mathematics assessment was more prevalent among teachers than among consultants, principals and vice-principals.

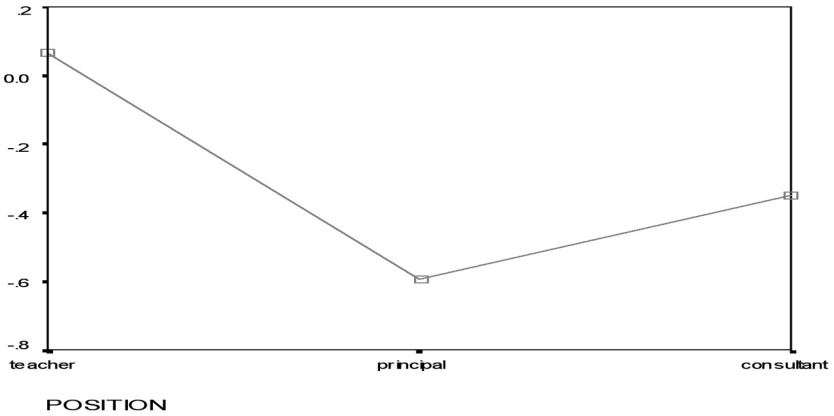

Figure 3. *Means Plot (Position held)*

To examine the differences across the three teachers' positions in this study (teacher, principal and mathematics consultant) Scheffe pair-wise comparisons were performed. The results of this analysis showed that teachers' and principals' views differ significantly with regard to a socio-constructivist orientation to mathematics assessment.

Postgraduate studies

The ANOVA showed that the variable *Postgraduate studies* was significant for one of the five components – Component 1: *A socio-constructivist orientation to mathematics assessment* ($F_{(2, 414)}$=3.164 p=.043). By examining the Linear term which is also significant across the years of experience at Junior High school, it can be concluded that the socio-constructivist orientation to mathematics assessment increases consistently (figure 4) across teachers' postgraduate qualifications. Of interest is the finding that teachers with Ph.D. degrees have the lowest means for Component 1 as compared to teachers holding a Masters degree and a first degree in mathematics. To examine the differences across the three

levels of qualifications (Ph.D., Masters and 4 year mathematics degree) further, Scheffe pair-wise comparisons were performed. The results of this analysis showed no clear trend and no discernible pattern.

From the means plot (figure 4) it can be seen that the socio-constructivist view of mathematics assessment was more prevalent among teachers with Masters and 4 year mathematics degrees than among teachers with Ph.D. degrees in mathematics education.

A tenable explanation for this finding is that a number of the Ph.D. degrees had been of a theoretical nature in pure mathematics, the history of mathematics or other topics, which bear no direct relevance to mathematics education.

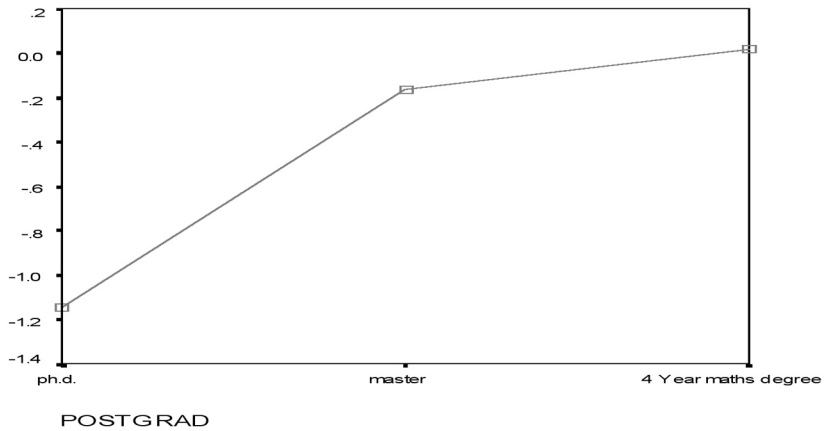

Figure 4. *Means Plot (Postgraduate studies)*

Discussion

Clarke and Stephens (1996) used 15 items in the questionnaire part of their study and the participants were asked to indicate the degree of importance they attached to the aspect described by each item. The 15 items were designed to reflect different ways in which problem solving and investigations could be valued and used by teachers. One of the aims of the study was to compare the assessment views of teachers teaching VCE mathematics at the time, with those of teachers from Greece with no VCE (or equivalent) mathematics teaching experience.

In the present study, the 15 items used by Clarke and Stephens (1996) formed part of a larger questionnaire on secondary teachers' beliefs about assessment. Two of the items used by Clarke and Stephens have been slightly reworded for the purposes of this study. The percentage responses

of Greek secondary mathematics teachers who indicated that a particular aspect of problem solving or investigation was *highly important*, on the 15 items common to both studies, is shown in figure 5 (The numbers in brackets correspond to the items of the study questionnaire).

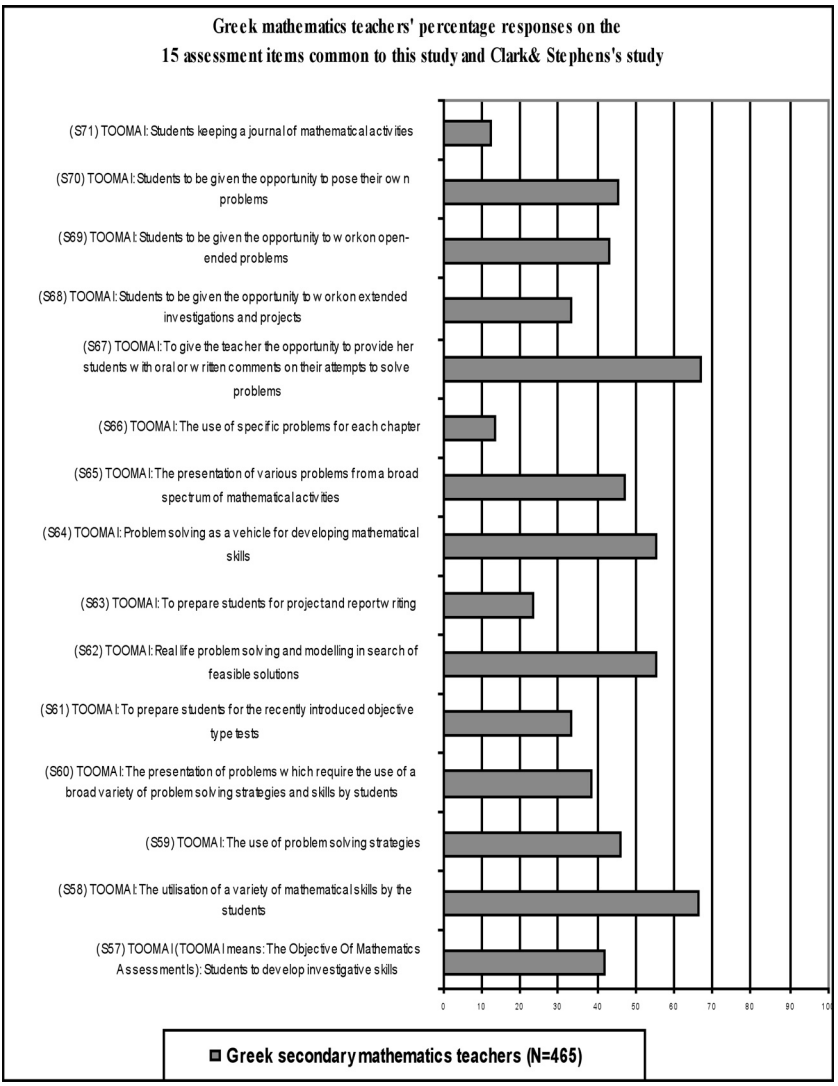

Figure 5. *Greek secondary mathematics teachers' views on the 15 assessment items common to this study and Clarke and Stephens's study.*

Clarke and Stephens (1996, p. 83) reported that "consistently high levels of approval (50%) were given to those aspects which were strongly endorsed by VCE curriculum advice and assessment practice" (items 57 to 64 from the Victorian sample satisfy this condition). It can be seen from figure 5 that four items from the Greek sample (58, 62, 64 and 67) satisfy the condition as well. If we reduce the (arbitrary) value of 50% to 40%, for the category of high levels of approval, then five more items from the Greek sample satisfy the condition (40% for high levels of approval or moderate approval). These items are 57, 59, 65, 69 and 70. This finding indicates Greek secondary mathematics teachers value problem solving and posing, modelling and investigations highly. In regard to Clarke and Stephens' (1996) statement that:

> The emergent hypothesis is that unless a term or practice receives the explicit sanction of inclusion in high stakes assessment it is unlikely to influence school policy or classroom practice. (p. 70)

It appears that this hypothesis can only partially be substantiated, since it is evident that Greek secondary mathematics teachers value problem solving and investigations highly, in a system where *there is no* 'explicit sanction of inclusion in high stakes assessment'.

Teachers hold beliefs towards the nature as well as the purposes and uses of assessment in mathematics. It can be conjectured that teachers' beliefs about assessment influence their teaching in many ways. There is evidence from this study that there are teachers who espouse a 'socio-constructivist' orientation to mathematics assessment, teachers who espouse a 'problem solving' orientation to mathematics assessment and teachers who espouse an 'accountability' orientation to mathematics assessment. It was also found that secondary mathematics teachers in the sample:

- Emphasised the use of assessment for accountability purposes.
- Used assessment for problem solving purposes.
- Used contemporary methods of assessment.

The wide range of responses to the contemporary orientation indicates that it represents a wide spectrum of approaches not coherent enough.

The investigation of the existence of a typology of beliefs categories that could be used to characterise secondary mathematics teachers' beliefs relating to mathematics assessment, resulted in the following conclusions:

- A *socio-constructivist orientation to mathematics assessment* indicated a preference towards problem solving assessment methods.
- A *problem solving orientation to mathematics assessment* indicated a preference towards socio-constructivist assessment methods.
- An *accountability orientation to mathematics assessment* indicated a preference towards problem solving assessment and socio-constructivist assessment approaches. This finding could represent some uncertainty or apprehension on the part of the teachers to fully adopt a traditional orientation towards mathematics assessment.

From the analysis of the data collected on teacher characteristics, it was found that:

- Teachers' beliefs about mathematics assessment were not significantly influenced by their gender.
- Teachers with experience at Junior High school level placed more emphasis on a problem solving orientation to mathematics assessment than did teachers with experience at other levels.
- The problem solving orientation to mathematics assessment increased consistently across all teachers' experience categories.
- The problem solving view of assessment in mathematics was more prevalent among experienced teachers and veteran teachers than among the inexperienced teachers.
- The socio-constructivist view of mathematics assessment was more prevalent among teachers than among consultants, principals and vice-principals.
- The socio-constructivist view of mathematics assessment was more prevalent among teachers with Masters and first degrees in mathematics than among teachers with Ph.D. degrees. A tenable explanation for this finding is that a number of the Ph.D. degrees had been of a theoretical nature in pure mathematics, the history of mathematics or other topics, which bear no direct relevance to mathematics education.

Conclusions

Teachers hold beliefs towards the nature as well as the learning and teaching of mathematics. It can be conjectured that teachers' beliefs influence their teaching in many ways. There is evidence from this study that

there are teachers who espouse sets of beliefs that might be described as 'transmission' beliefs, teachers who espouse sets of beliefs that could be described as 'socio-constructivist' and teachers who espouse a generally non-traditional (alternative) orientation to teaching and learning mathematics. As well as seeking data from interviews with teachers, there is support for the view that teachers' reflection on their classroom experiences can shape and influence their beliefs. Particular emphasis needs to be placed on investigating the effect of classroom experiences on the evaluation and reorganisation of teacher beliefs and the effect of this reorganisation on what occurs in the mathematics classroom.

It is our contention that in attempting to transform current transmission-orientated teaching practices, an understanding of the complex topology of the region where teachers' espoused and enacted sets of beliefs intersect, is of paramount importance. Taking under consideration the recent interest being expressed by the mathematics education community on the importance of values in teaching and on their interrelationship to belief systems, we could conjecture that such an understanding will constitute the 'fulcrum' of both future reforms and the delivery of in-service and pre-service programs.

It could be argued that the data reported in this study illustrate that teachers seem sensitive to, and aware of, socio-constructivist theories about the learning and teaching of mathematics, and adjust their beliefs about mathematics and themselves as teachers of mathematics to reflect prevailing societal norms. The findings on teachers' beliefs and expectations reported in this study invite further investigation as to whether the transition from traditional to contemporary views about mathematics and mathematics teaching and learning constitutes a smooth continuous process or there exists a deep chasm between the dominant paradigms.

The findings reported in this paper indicate that there may be an apparent impact of the broad social and cultural climate on teachers' espoused beliefs about mathematics and mathematics learning and teaching, and invites further investigation. It would appear that the cultural climate in which the mathematics teaching-learning process takes place influences teachers' beliefs about mathematics assessment and it reflects prevailing societal norms.

We argued that 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 the proponents of reforms in mathematics education to understand the impact teachers' beliefs have on their everyday cognitions and classroom practices.

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Sammanfattning

Fokus för denna studie utgör de uttalade uppfattningar (beliefs) om utvärdering i matematik som innehas av 465 grekiska matematiklärare på de stadier som motsvarar grundskolans högre årskurser och gymnasiet. Data insamlades med en enkät som omfattade 19 frågor. Studien ger belägg för att det finns lärare som ger uttryck för en socio-konstruktivistisk orientering, lärare som ger uttryck för en problemlösnings-orientering och lärare som ger uttryck för en orientering som betonar ansvarighet i fråga om utvärdering i matematik.