

Secondary Mathematics Teachers' Beliefs About Assessment and Factors That Influence These Beliefs

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The espoused beliefs of 465 secondary mathematics teachers regarding mathematics assessment were the focus of this study. The data for this investigation were collected using a 24 items questionnaire. There is evidence from this study that teachers with experience at Junior High schools placed more emphasis on a problem solving orientation to mathematics assessment than did teachers with experience at other levels. The problem solving view of assessment in mathematics was more prevalent among experienced teachers and veteran teachers than among the inexperienced teachers and the socio-constructivist view of mathematics assessment was more prevalent among teachers than among consultants and principals.

The term “*beliefs*” has been particularly slippery 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 paper:

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)

The complexity of defining *educational beliefs* can 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.

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 (p. 309).

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 & 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 their 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 that:

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. (Clarke and Stephens 1996, 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).

Nisbet 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 secondary mathematics teachers' beliefs regarding mathematics assessment.

The main aim of the present study was to investigate Greek secondary teachers' beliefs regarding mathematics assessment and factors influencing these beliefs.

The Study

This study examined secondary teachers' beliefs on assessing mathematics. The focal research questions were as follows:

What are the beliefs of Greek secondary mathematics teachers with regard to mathematics assessment?

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 24 items questionnaire. In developing the items, we drew on previous research findings about teacher beliefs issues in mathematics education (Clarke & Stephens, 1996). This investigation of the 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).

Participants

Six hundred survey forms were sent to a random selection of grade 7-12 mathematics teachers in Greece. The resulting sample comprised 465 (276 males, 145 females, 44 no gender specified) 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 assessment were analysed using SPSS_{win}. Inferential statistical techniques (MANCOVA, t-tests, Cluster Analysis, Multiple Discriminant Analysis (MDA) and Trend Analysis) were used. The significance level was set at .05.

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 Factor Analysis (Barkatsas, 2001) 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 provides information about the homogeneity of the clusters being combined at each stage. 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 enabled 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 solution. The

independent variables used for the MDA were the three factors obtained from the factor analysis (Barkatsas, 2001).

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, which represents mathematics teachers who espouse *a socio-constructivist orientation to mathematics assessment*, was 91.7%. There was 9.2% (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 factors 1 and 2 represent contemporary assessment approaches. The prediction for group 2, which represents mathematics teachers who espouse *a problem solving orientation to mathematics assessment*, was 91.9%. There was 7.9% (5.2%+2.7%) misclassification for group 2 cases. The 5.2% drift in predictions towards socio-constructivist methods of assessment was to be expected also, since both factors 1 and 2 represent contemporary assessment approaches. The prediction for group 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.

Average Mean Responses

To gain some insight into how the sample responded overall to each of the factors, the average mean responses were calculated for the items comprising each factor. Table 1 summarizes the average mean frequency for each factor together with the range of mean frequencies for the items in each factor.

Table 1
Average Mean Frequencies of Responses to Each Factor

Factor	Average Mean response	Range of item Mean frequencies
1. Socio-constructivist	2.24	1.59 – 2.83
2. Problem solving	1.99	1.63 – 2.20
3. Accountability	2.06	1.93 – 2.11

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

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

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 factors relating to mathematics assessment, varied according to these five characteristics.

It was found that Professional Development, gender and experience at senior high school level, suggesting that teachers' beliefs about mathematics assessment were not significantly influenced by the in-service they had undertaken, by their gender or by their experience at senior high schools.

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 factors –Factor 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 1) 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 1) 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).

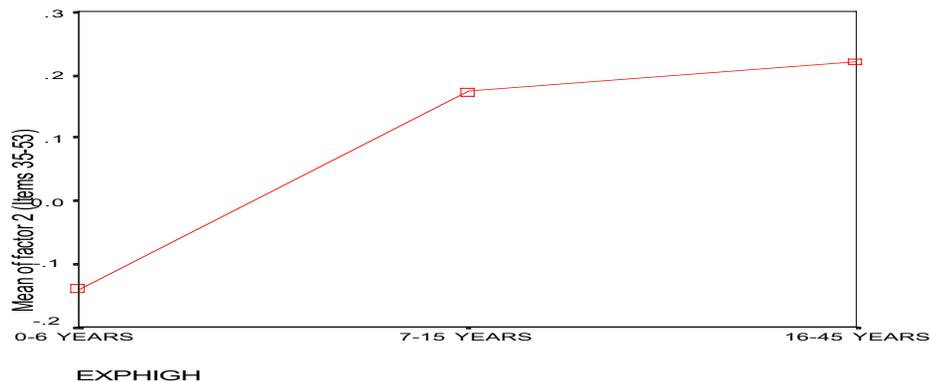


Figure 1. Means plot (Experience at junior high school).

Position held. The ANOVA showed that *Position* was significant for one of the three factors – Factor 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 2), 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 2). From Figure 2 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.

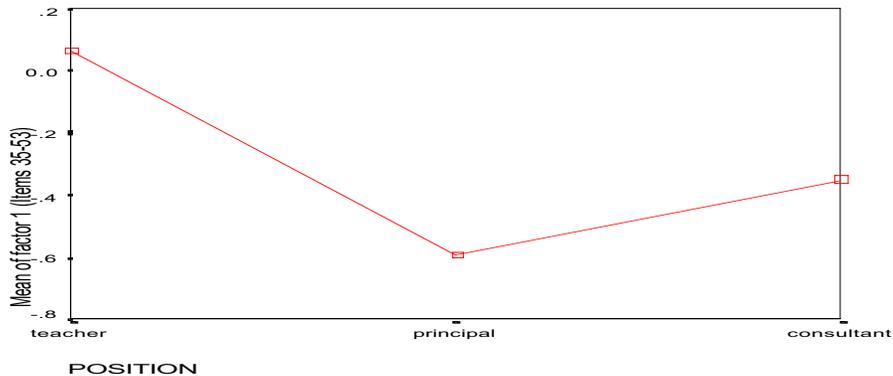


Figure 2. Means plot (Position held).

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 three factors – Factor 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 3) across teachers' postgraduate qualifications. Of interest is the finding that teachers with Ph.D. degrees have the lowest means for Factor 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.

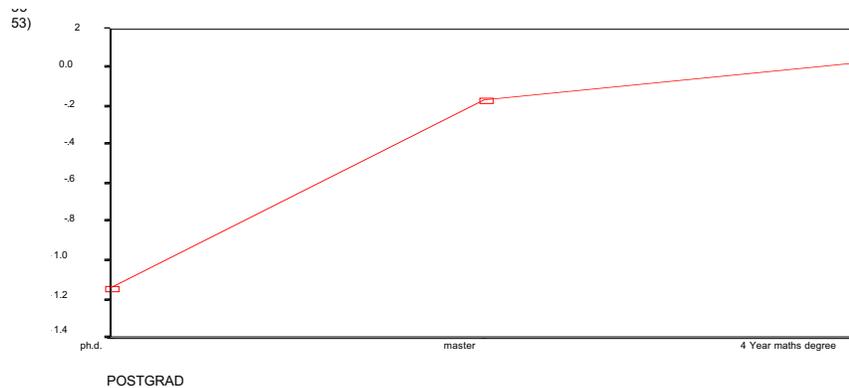


Figure 3. Means plot (Postgraduate studies).

From the means plot (Figure 3) 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.

Conclusion

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.

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.

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.

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. 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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