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INVESTIGATING THE INFLUENCE OF TEACHERS' PEDAGOGICAL BELIEFS AND REPORTED PRACTICES ON STUDENT ACHIEVEMENT IN BASIC MATHEMATICS

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This study investigated the pedagogical beliefs of the elementary and high school mathematics teachers. It sought to find out whether their pedagogical beliefs are consistent with the School Mathematics Tradition (SMT) and Inquiry Mathematics Tradition (IMT). It determined if there are differences in the pedagogical beliefs of math teachers in high, average and low performing schools (HPS, APS, LPS) at the elementary and secondary levels. It also determined how the pedagogical beliefs of teachers are related to their reported teaching practices. Results show that there is no difference in reported teaching practices in HPS, APS and LPS. Teachers' pedagogical beliefs but not practices might be related to the performance of their students. There was a clearer link between the performance level of the schools and the teachers' pedagogical beliefs. The qualitative data suggest that many teachers hold the naive view that how students learn mathematics is determined by how they teach mathematics.

Key words: basic mathematics, pedagogical beliefs, school mathematics tradition, inquiry mathematics tradition

INTRODUCTION

Researchers have endeavored to identify the range of factors that contribute to the level of achievement of Filipino students in mathematics. One of the most important factors that have been identified is the competency of mathematics teachers at different levels. Competency has typically been associated with mastery of the subject matter of mathematics. Hence, government programs designed to address problems on mathematics achievement of Filipino students have been directed at upgrading mathematics content knowledge competencies of teachers at different levels.

However, research in education has shown that although the teacher's mastery of the subject matter is a good predictor of student achievement, there are a range of factors (teacher-related and otherwise) that also predict student achievement. One such factor is the range of knowledge, attitudes, beliefs that teachers hold about the instructional situation and the subject matter among others. These factors, which may or may not form a coherent system of ideas and may or may not be explicit in the minds of the teacher can be referred to as the teacher's pedagogical beliefs about learning and teaching.

These beliefs, knowledge and attitude are said to be important predictors of student achievement because they actually shape the teachers' practices. That is the ways by which teachers design and conduct their classes, evaluate their students' leaning among others, are shaped by the teachers implicit or explicit beliefs about the frequency with which the teacher asks higher order questions but the ability to ask the right question of the right student at the right time." Within this conceptualization, educational researchers began analyzing teachers' cognitions in relation to how they mediate classroom practices, teacher development, and other aspects of the educational process.

THE STUDY

Research literature show how mathematics teachers come to hold contradictory beliefs about teaching and learning mathematics as their more deeply entrenched traditional beliefs come to be challenged by more progressive belief systems.

In this regard, we can consider the features of these divergent pedagogical belief systems about mathematics education. Many scholars (see e.g., Cobb, Wood, Yackel, & McNeal, 1992; Gregg; 1995) have described the different features of the school mathematics tradition. This tradition involves classroom routines and patterns of discourses that are usually rigidly controlled by the teacher and follow an "initiation-reply-evaluation pattern" (see Richards, 1991). The school mathematics tradition also emphasizes the formalized presentation of mathematics as a collection of facts and procedures. Brown, Cooney, & Jones (1990) noted that in such classes that follow school mathematics tradition, mathematics is often viewed as a set of propositions and doing mathematics involves simply repeating procedures specified in the textbook and by the teacher in class. In this tradition, the teacher and the textbook are the clear authorities of mathematical knowledge, and the activities in the classroom mainly involve the transfer or transmission of knowledge from these authoritative sources to the students. Students are presumed to have learned mathematics when they can follow the procedures they were instructed to use to obtain correct answers. This school mathematics tradition is consistent with the "broadcast models" on "transmission models" of classroom learning that characterize most traditional classrooms across the different subject areas.

There are many alternatives that have been proposed to this traditional model of school mathematics. Most of these alternatives can be described as following a "learning-support model" that also emphasizes more active learning on the part of the students, particularly by way of exploration, conjecturing, argumentation, proving, problem posing, problem solving, and collaboration (see e.g., Cobb, et al, 1992; De Corte, 1995; Fennema, Carpenter, & Peterson, 1989; Lampert, 1990; Mathematical Sciences Education Board, 1990, 1991, 1993). It is assumed that students learn mathematics "by resolving problematic situations that challenge their current conceptual understanding" (Gregg, 1995, p. 444) and thus there is an emphasis on discussion and negotiation of understanding among students and between students and teacher. The teacher's role is redefined as a facilitator of the students' learning processes and activities, rather than transmitters or authorities of mathematical knowledge. Textbooks are also conceived as resources or stimuli to engage students in the process of inquiry and problem solving. Moreover, students are assumed to learn mathematics when they can explain and justify their actions on mathematical objects. The differences between the school mathematics tradition and the inquiry mathematics tradition are summarized in Table 1.

A number of studies have documented the difficulty that teachers have in shifting from a school mathematics tradition to an inquiry mathematics tradition. For example, in their quantitative study, Sosniak, et al (1991) found that Grade 8 math teachers in the United States did not hold curricular beliefs that were consistently convergent with either tradition.

Table 1: Contrast between school mathematics and inquiry mathematics traditions

Dimension	School Mathematics Tradition	Inquiry Mathematics Tradition
Mathematics Knowledge	Formalized mathematics as collection of facts and procedures	Mathematics as a mode of inquiry & problem solving
Mathematical learning activities	Mastering and replicating mathematical procedures & operations	Exploration, discovery, conjecturing, argumentation, proving, problem posing, problem solving, & collaboration.
Classroom interactions/ discourse	Teacher controlled, initiation-reply-evaluation pattern	Discussion & negotiations among students & between students & teacher
Role of learner	Passive recipient of information (mathematical facts & procedures) who should master the execution & use of the same	Active constructor of mathematical meanings & processes (i.e., inquirers & problem solvers)
Role of teachers	Authority and transmitter of mathematical knowledge	Facilitator of students' inquiry and learning
Role of textbook	Authority of mathematical knowledge	Resource and stimulus for students' inquiry and problem solving
Indicator of Student learning	Ability to follow procedural instructions to obtain correct answers	Ability to explain and justify actions on mathematical objects

Note: This table is adopted from Bernardo (2002).

The teachers studied agreed with propositions that reflect entirely different conceptions of mathematics, mathematics teaching and learning. In another study. Gregg (1995) conducted an ethnography on beginning high school mathematics teachers. He found, among other things, that most of the teachers hold beliefs consistent with the school mathematics tradition but come to realize the contradictions within this tradition as practiced. The study also showed that the way the teachers tried to justify these contradictions tended to sustain beliefs consistent with the school mathematics tradition.

In the Philippines Bernardo (1998) began exploring the beliefs of mathematics teachers at the tertiary level. He found a number of interesting observations regarding the beliefs of the teachers surveyed. In particular (a) there was very little consensus among the teachers surveyed about what the nature of mathematical knowledge and skill involved, (b) the teachers endorsed statements expressing constructivist ideas, (c) the teachers endorsed statements stating the importance of the affective component of learning, (d) the teachers held some apparently contradictory beliefs about mathematics teaching and learning, and (e) the teachers beliefs varied somewhat based on the educational preparation of the teacher.

Bernardo, Clemeña, and Prudente (2000) found that mathematics (and science) teachers in elementary schools in three different regions also held inconsistent beliefs about the nature of their subject matter, teaching, and student learning in their subject. The authors argued that these inconsistent beliefs come about as teachers, who were trained in the school mathematics tradition in poorly designed and implemented in service teacher education programs.

Similar inconsistencies in pedagogical beliefs were found in a more recent study by Bernardo (2000) that looked into the structure of pedagogical beliefs of mathematics teachers in tertiary education. Using careful quantitative analysis the study revealed that the teachers' beliefs about mathematics teaching and learning could not be described neatly in terms of a distinction between traditional and contemporary belief systems as defined in the Western literature as will be defined in the next section.

The present study focuses on the pedagogical beliefs of mathematics teachers at the elementary and high school levels in the National Capital Region and surrounding provinces. The broad research problem that was studied was: "What are the pedagogical beliefs of elementary and high school mathematics teachers in the Philippines?" More specific research questions were also addressed. These were:

"Are the pedagogical beliefs of the elementary and high school mathematics teachers more consistent with the school mathematics tradition or the inquiry mathematics tradition?

"Are there differences in the pedagogical beliefs of mathematics teachers in high, average and low performing elementary and high schools?"

"How are the pedagogical beliefs of the elementary and high school mathematics teachers related to their teaching practices?"

The research problems posed in this study go beyond a mere description of the pedagogical beliefs of teachers. The research problems begin inquiring into the relationships between the pedagogical beliefs and aspects of the teachers' actual classroom practices, and also between pedagogical beliefs, practices, and the achievement performance of students.

METHODOLOGY

The research question were addressed using two methodological approaches. The first approach involved the use of likert-type items to inquire about the teachers' pedagogical beliefs and practices. This methodological approach allowed for detailed quantitative analysis of specific aspects of the phenomenon under investigation. The second approach involves the use of interviews which gave more in-depth information about the teachers' pedagogical beliefs and practices, and were analyzed using more qualitative means. Thus we could say that two sub-studies were conducted.

Selection of Schools

Data on the performance of the schools in National Elementary Achievement Test (NEAT) and the National Secondary Achievement Test (NSAT) were obtained from the National Educational Testing and Research Center (NETRC). Based on the distribution of scores, criteria were set for the classification of schools in the high, average and low-performance brackets. The selection criteria referred only to the NEAT and NSAT sub-test scores for Mathematics. These criteria are summarized in Table 2.

Table 2: Criteria for classifying schools according to the math achievement/performance

NEAT/NSAT Math Score	Elementary Schools	High Schools
High Performing	75 & above	80 & above
Average Performing	45-55	55-65
Low Performing	30 & below	40 & below

Using the above criteria, different schools were identified for possible inclusion in the study. The schools with at least 200 test-takers were prioritized in the list, as schools with large numbers of students would most likely have more teachers in their faculty, thus facilitating the data-gathering process. An explicit attempt was made to include schools from urban and semi-urban schools.

Participants

The participants in the study were 511 mathematics teachers from 29 elementary schools and 39 schools in Metro Manila, Bulacan, and Laguna, who were requested and consented to complete the data-gathering questionnaire. However out of 511, 37 participants did not complete the entire questionnaire and thus their data were not included in the actual analysis. Thus, data from only 474 teachers were analyzed.

Of the 474 teachers, 262 were elementary school teachers and 212 were high school teachers. Of the 262 elementary school teachers, 29 were teaching in high-performing schools, 123 in average-performing schools, and 110 in low-performing schools. Of the 212 high school teachers, 51 were teaching in high-performing schools, 76 in average-performing schools, and 85 in low-performing schools. The profile of teacher participants in summarized in Table 3 below.

Materials and Procedure

A questionnaire was prepared to determine mathematics teachers' beliefs about specific aspects of the processes of learning and teaching mathematics, and about their teaching practices. The questionnaire comprised of four parts. Part 1 referred to the teachers' beliefs about what the goal of mathematics education should be.

Table 3: Profile of the teacher participants

	Elementary	**High School**	**High Performing**	**Average Performing**	**Low Performing**
Total Number	262	212	80	199	195
Type of School					
• Public	159	116	50	51	174
• Private	87	85	24	145	3
• No answer	16	11	6	3	18
Gender					
• Male	14	51	17	35	13
• Female	229	145	56	156	163
• No answer	19	15	7	8	19
Age Range	22 – 64 yrs	20 – 65 yrs	21 – 62 yrs	20 – 64 yrs	22 – 65 yrs
Total years of teaching (range)	0.5 - 39.5 yrs	1 – 39 yrs	1 – 39 yrs	0.7 – 38 yrs	0.5 - 39.5 yrs
Total years of teaching math (range)	0.3 - 39.5 yrs	1 – 39 yrs	1 – 39 yrs	0.7 – 37 yrs	0.3 - 39.5 yrs
Total years teaching in current school (range)	0.5 - 39.5 yrs	0.25 – 37 yrs	1 – 37 yrs	0.25 – 37 yrs	0.5 - 39.5 yrs
% with graduate degree*	12.08%	19.49%	21.88%	15.22%	16.56%
% with education degree*	90.20%	87.69%	71.88%	90.76%	93.42%
% with math education degree *	19.18%	76.41%	46.88%	48.91%	45.03%
% with math education graduate degree *	2.45%	10.77%	9.38%	5.43%	19.61%

*% was computed by using the total number of respondents who answered the pertinent item in the questionnaire.

Part 2 referred to the teachers' beliefs about the characteristics of effective teaching practices. Part 3 referred to beliefs about the features of effective learning activities for mathematics classes. Part 4, inquired about the teachers' actual classroom teaching practices. Parts 1 to 3 consisted of several statements which stated a belief (e.g., "Effective mathematics teacher immediately correct false statements made by students.") The respondents were asked to read each statement carefully and to decide whether they agreed with the statement. They were asked to indicate their response using a 5-point scale (ranging from 1 = strongly disagree to 5= strongly agree). Part 4 consisted of statements that stated teaching practices (e.g., "In my math classes, I present the content in a highly structured fashion"). The respondents were asked to read each statement carefully and to decide how often they do what was described in the item. They were asked to indicate their response using a 5-point scale (ranging from 1 = never to 5 = always).

For Part 1, there were 14 items and all the items completed the sentence stem, "At the end of a mathematics class, students should be able to…" For part 2, there were also 14 items and the sentence stem was, "Effective mathematics teachers…" For Part 3, there were 8 items that completed the sentence stem, "Effective mathematics classes involve…" Finally, for Part 4, there were 14 items that completed the sentence stem, "In my math classes, I…"

For each part half of the items referred to beliefs of practices that are associated with the school-math tradition. The selection and grouping of the item were based on the prescriptions in the research literature (e.g., Bernardo, 2002; Gregg, 1995; Sosniak, et al., 1991). There were eight subscales in the questionnaire.

- Beliefs about the goals of math education associated with the school-math tradition (GOAL-SMT)
- Beliefs about the goals of math education associated with the inquiry-math tradition (GOAL-IMT)
- Beliefs about the nature of effective math teaching associated with the school-math tradition (TEACH-SMT)
- Beliefs about the nature of effective math teaching associated with the inquiry math tradition (TEACH-IMT)
- Beliefs about the nature of effective math learning activities associated with the school-math tradition (LEARN-SMT)
- Beliefs about the nature of effective math learning activities associated with the inquiry-math tradition (LEARN-IMT)
- Report of implementation of various teaching practices associated with the school-math tradition (PRAC-SMT)
- Report of implementation of various teaching practices associated with the inquiry-math tradition (PRAC-IMT)

Reliability analyses were conducted for each of the scales, and the pertinent reliability statistics are summarized in Tables 4 & 5. As the tables show, all the scales show high levels of internal consistency (Cronbach alpha) both for the elementary and high school samples.

From the list of schools in the three performance groups, teachers were invited to participate in one-in-one interviews. The responses of a total of 18 teachers were analyzed. Among 18 teachers, 9 were elementary and 9 high school teachers each group having 3 teachers from high-, average-, and low performing schools. The interview protocol was designed to elicit the teachers' beliefs on the goals of mathematics education, on the characteristics of effective mathematics teaching and characteristics of effective mathematics learning.

Table 4: Reliability statistics for the various subscales of questionnaire with grade school sample

Subscale	Mean	Minimum	Maximum	Variance	Standardized Cronbach α
GOAL-SMT	4.102	3.947	4.285	.018	.927
GOAL-IMT	4.043	3.601	4.379	.062	.926
TEACH-SMT	4.277	3.840	4.537	.049	.857
TEACH-IMT	4.325	4.117	4.495	.022	.899
LEARN-SMT	4.366	4.298	4.412	.003	.819
LEARN-IMT	4.162	4.027	4.252	.010	.793
PRAC-SMT	4.339	3.599	4.557	.118	.675
PRAC-IMT	4.322	4.057	4.546	.033	.740

Table 5: Reliability statistics for the various subscales of questionnaire with high school sample

Subscale	Mean	Minimum	Maximum	Variance	Standardized Cronbach α
GOAL-SMT	4.129	4.055	4.439	.019	.864
GOAL-IMT	4.287	4.104	4.538	.019	.880
TEACH-SMT	4.307	3.976	4.495	.029	.808
TEACH-IMT	4.406	4.076	4.626	.037	.830
LEARN-SMT	4.284	4.131	4.491	.029	.703
LEARN-IMT	4.330	4.165	4.462	.015	.599
PRAC-SMT	4.265	3.769	4.458	.064	.767
PRAC-IMT	4.246	3.925	4.505	.038	.740

RESULT

Overall Profile of Pedagogical Beliefs and Practices

We first describe the general pattern of results relating to the pedagogical beliefs and teaching practices of the entire sample, the elementary school sample, and the high school sample. Table 6 summarized these results.

Table 6: Mean belief and practice scores

Scale	Overall		Elementary		High School	
	Mean	SD	Mean	SD	Mean	SD
GOAL-SMT	4.154	.701	4.102	.804	4.219	.542
GOAL-IMT	4.152	.694	4.043	.776	4.287	.548
TEACH-SMT	4.290	.586	4.277	.649	4.307	.500
TEACH-IMT	4.361	.576	4.324	.636	4.406	.488
LEARN-SMT	4.329	.566	4.366	.607	4.284	.509
LEARN-IMT	4.237	.585	4.162	.656	4.330	.470
PRAC-SMT	4.306	.451	4.339	.443	4.265	.459
PRAC-IMT	4.288	.453	4.322	.455	4.246	.448

The first research problem inquires into whether the teachers' pedagogical beliefs are more consistent with the school mathematics tradition (SMT) or the inquiry mathematics (IMT). The data summarized in the Table 6 are equivocal on this matter. An eyeballing of the data indicates that as regards the teachers' beliefs about the goal of mathematics education, there seems no clear preference for either the goals defined in the SMT or the IMT (GOAL-SMT vs. GOAL-IMT). However, the teachers seem to more strongly endorse statements consistent with the IMT when it comes to beliefs about the nature of effective teaching (TEACH-IMT) vs. TEACH-SMT). Interestingly, there seems to be a reverse preference when it comes to beliefs about the nature of effective learning activities (LEARN-IMT vs. LEARN-SMT). On the other hand, the teachers' present teaching practices do not seem to indicate a clear movement towards either tradition (PRAC-SMT vs. PRAC-IMT). As these are simply eyeballing observations, these trends will be verified with the appropriate statistical analysis presented later in this paper.

Is there a relationship between the pedagogical beliefs and practices of teachers on the one hand, and the performance of their students on the other? The second research problem addresses this matter by inquiring whether there are differences in the pedagogical beliefs and practices of teachers of high performing, average performing, and low performing schools.
Figure 1 shows that teachers in high-performing schools seem to view the goals of mathematics education in ways more closely aligned to the IMT, whereas those in average- and low-performance schools do not do so. All scores are analyzed using the 2 x 3 Analysis of Variance.

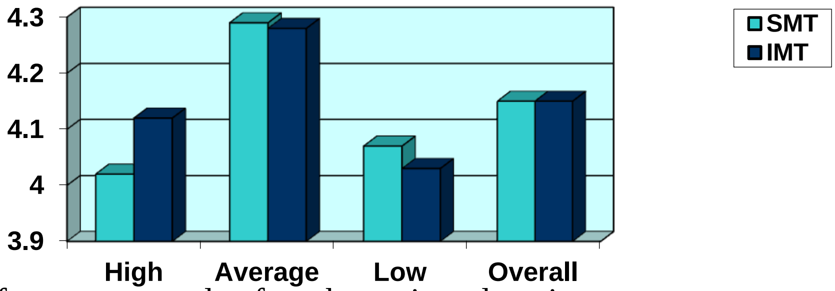

Figure 1. Mean belief scores on goals of mathematics education across performance-level groups

Figure 2 describes the mean belief scores regarding the characteristics of effective mathematics teaching for each of the three performance-level groups.

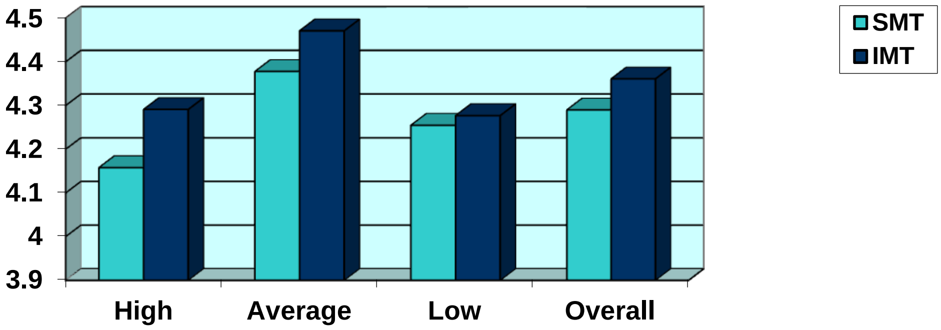

Figure 2. Mean belief scores on characteristics of effective mathematics teaching across performance-level groups.

The results suggest that teachers in high and average-performing schools are more likely to endorse beliefs about the characteristics of effective teaching that are consistent with the inquiry mathematics tradition, but those from the low-performance schools were equivocal about the two traditions in their beliefs related to effective teaching.

Figure 3 describes the mean belief scores regarding the nature of effective mathematics classroom learning activities for each of the three performance-level groups.

In high-performance group, the teachers favored IMT characteristics over SMT characteristics. This is not the case in the other groups.

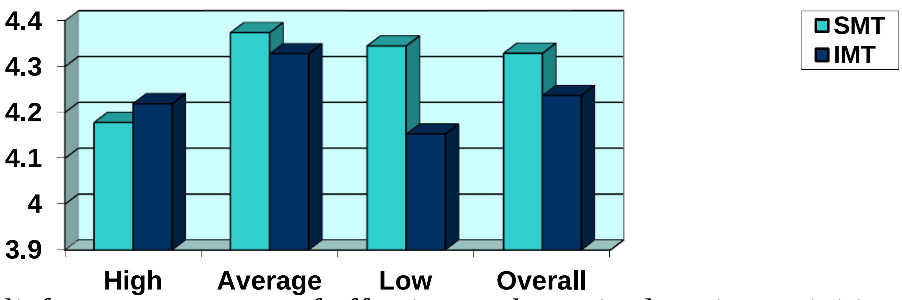

Figure 3. Mean belief scores on nature of effective mathematics learning activities across performance-level groups.

Figure 4 presents the results related to teachers' reported practices. The results were analyzed using the same 2x3 Analysis of Variance used previously.

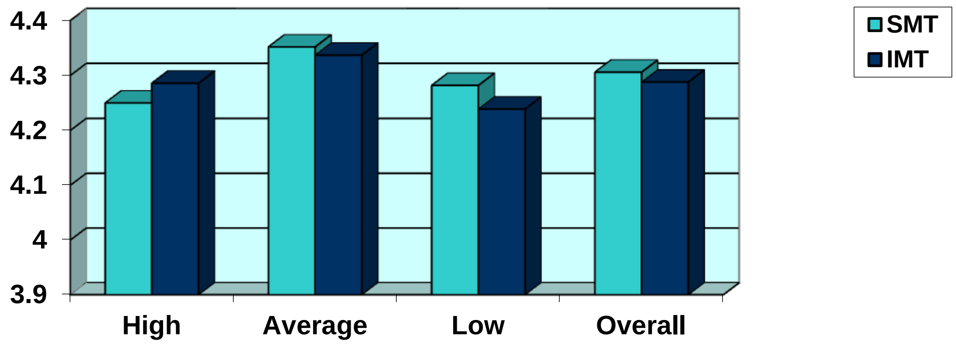

Figure 4. Mean scores on reported teaching practices across performance-level groups

Although there were significant effects of tradition and performance with the belief scores, the results of the ANOVA indicated that there were no significant differences in the actual teaching practices of the teachers.

Although the data seems to indicate that teachers in high-performance schools report more IMT practices, and the low-performance schools report more SMT practices, these differences were not found to be statistically significant. The data from the two levels of schooling will be analyzed separately in the next section. The purpose of doing this is to see whether there are particularly data patterns that are peculiar to teachers in each level of schooling.

Grade School Teachers' Beliefs and Practices across Performance Levels

Figure 5 describes the mean belief scores regarding the goals of mathematics education for elementary teachers for each of the three performance-level groups.

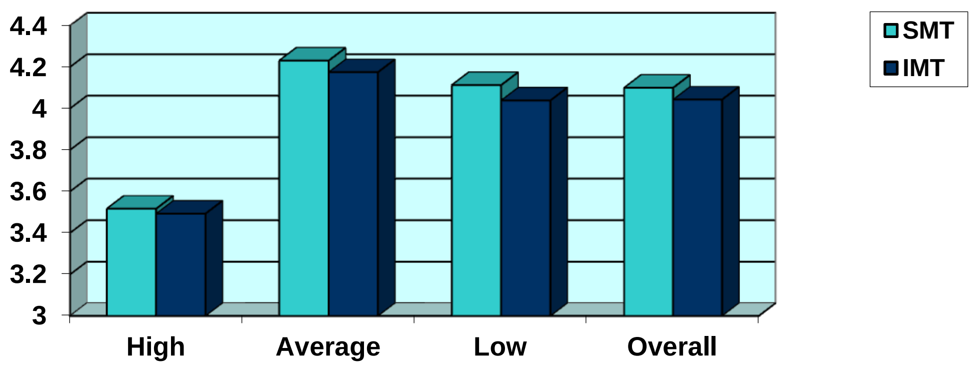

Figure 5. Mean belief scores of grade school teachers on goals of mathematics education across performance-level groups.

As Figure 5 shows, it seems that across all performance-groups, grade school teachers tended to more strongly endorse statements about SMT goals, although the differences are not that sizeable.

Figure 6 describes the mean belief scores of grade school teachers regarding the characteristics of effective mathematics teaching for each of the three performance-level groups. These scores were analyzed using the same 2 x 3 Analysis of Variance used in the previous section.

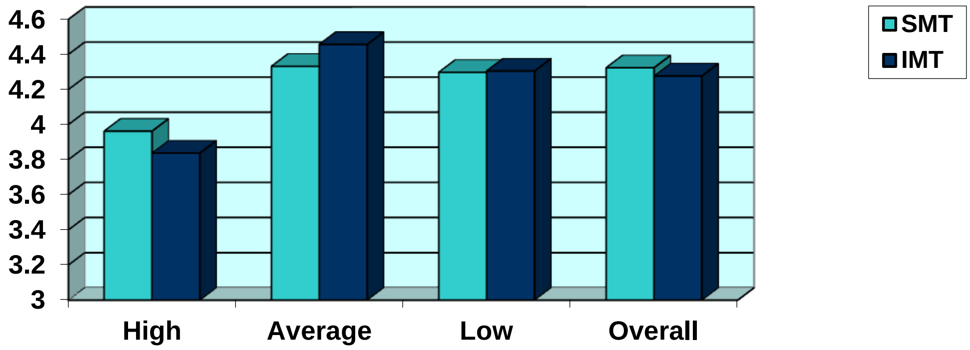

Figure 6. Mean belief scores of grade school teachers on characteristics of effective mathematics teaching across performance-level groups.

The results of the ANOVA indicated that there was not significant effect of tradition. The teachers equally endorsed statements about IMT characteristics of effective mathematics teaching (M = 4.277) and SMT characteristics (M = 4.324; see rightmost bars in Figure 6).

Figure 7 describes the mean belief scores of grade school teachers regarding the nature of effective mathematics classroom learning activities for each of the three performance-level groups. These scores were analyzed using the same 2 x 3 Analysis of Variance used previously. The teachers more strongly endorsed SMT learning activities (M = 4.366) compared to IMT activities (M = 4.162; see the rightmost bars in Figure 7).

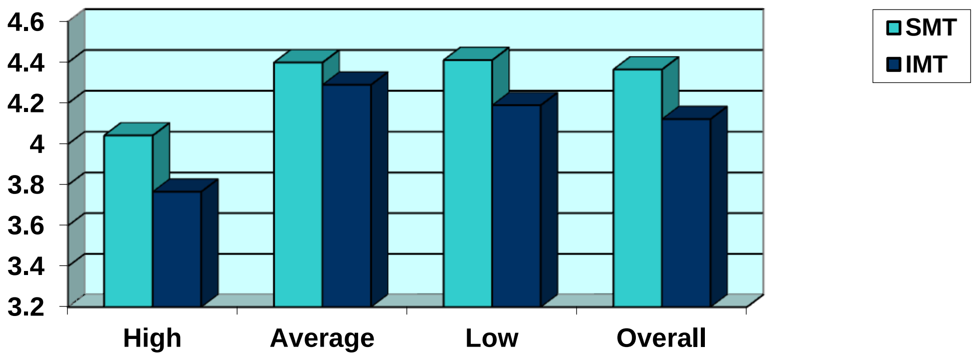

Figure 7. Mean belief scores of grade school teachers on nature of effective math learning activities across performance-level groups.

Figure 8 describes the mean scores for the grade school teachers' reported teaching practices for each of the three performance-level groups.

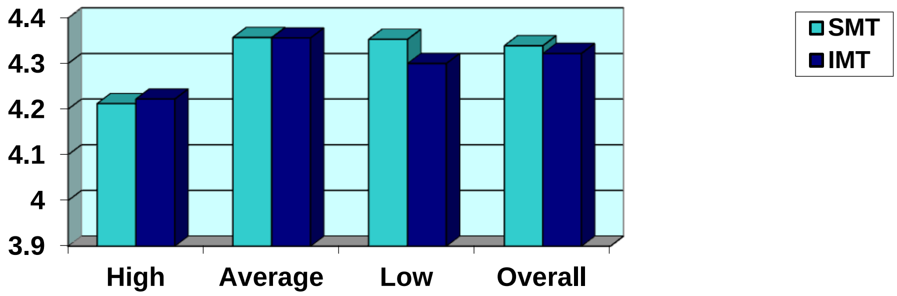

Figure 8. Mean scores on reported teaching practices of grade school teachers across performance-level groups.

As it was with the complete data set, the results of the ANOVA indicated that there were no significant differences in the actual teaching practices of the grade school teachers.
The results involving the comparison of the three performance-groups of grade school teachers revealed distinct patterns compared to the overall dataset. In particular, there was a stronger endorsement of SMT principles across most of the groups. The grade school teachers all seemed to endorse SMT definitions of the goals of math education and of effective learning activities, compared to the IMT counterparts. Among teachers in the high-performance group, their idea of an effective teacher was more consistent with SMT characteristics.

High School Teachers' Beliefs and Practices across Performance Levels

In this section, we present the data from the high school teachers.

Figure 9 describes the mean belief scores regarding the goals of mathematics education for high school teachers for each of the three performance-level groups. The high school teachers tended to more strongly endorse statements about IMT goals (*M* = 4.287) of mathematics education (for SMT, *M* = 4.219, see the rightmost bars in Figure 9).

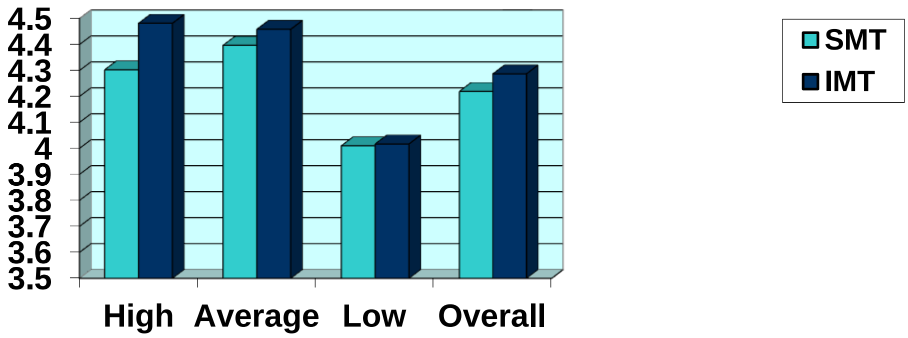

Figure 9. Mean belief scores of high school teachers on goals of mathematics education across performance-level groups

Figure 10 describes the mean belief scores of high school teachers regarding the characteristics of effective mathematics teaching of each of the three performance-level groups.

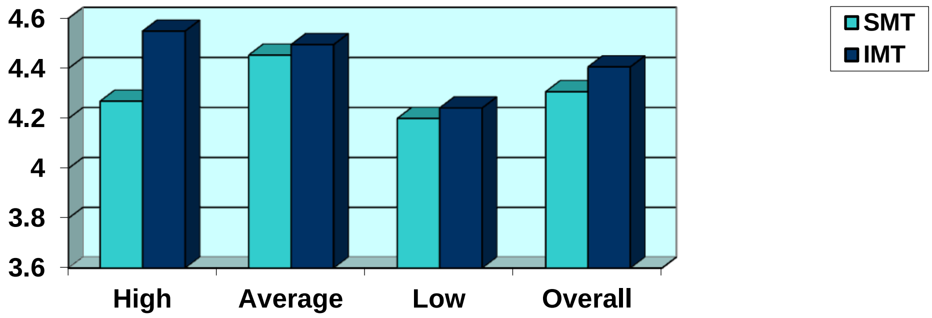

Figure 10. Mean belief scores of high school teachers on characteristics of effective mathematics teaching across performance-level groups.

The teachers more strongly endorsed statements about IMT characteristics of effective mathematics teaching (M = 4.406) and SMT characteristics (M = 4.307 see rightmost bars in Figure 10).

Figure 11 describes the mean belief scores of high school teachers regarding the nature of effective mathematics classroom learning activities for each of the three performance-level groups. The teachers more strongly endorsed IMT learning activities (*M* = 4.330 compared to SMT activities (*M* = 4.284; see rightmost bars in Figure 11.)

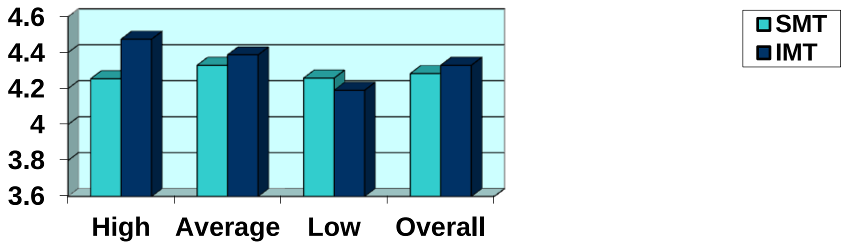

Figure 11. Mean belief scores of high school teachers on nature of effective math learning activities across performance-level groups.

Figure 12 describes the mean scores for the high school teachers' reported teaching practices for each of the three performance-level groups. The results were analyzed using the same 2 x 3 Analysis of Variance used previously. As it was with the grade school group, the results of the ANOVA indicated that there were no significant differences in the actual teaching practices of the high school teachers.

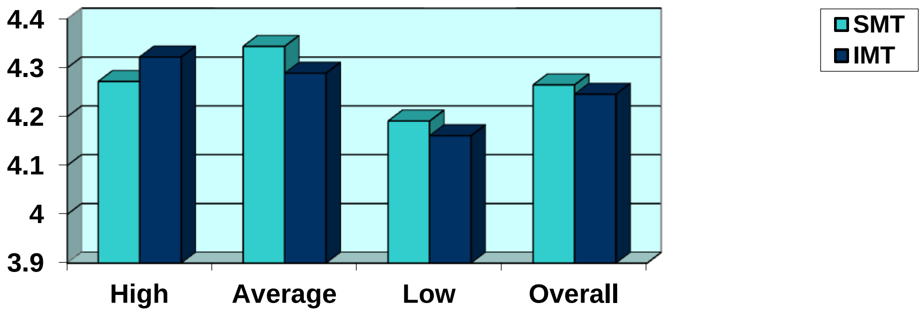

Figure 12. Mean scores on reported teaching practices of high school teachers across performance-level groups.

The results involving the comparison of the three performance-groups of high school teachers also revealed distinct patterns compared to the overall and grade school datasets. In particular, in contrast with the grade school teachers, there was a stronger endorsement of IMT principles across most of the high school teachers. For example, the high school teachers all seemed to endorse IMT definitions of the goals of mathematics education, and of effective teaching and learning activities, compared to the SMT counterparts. There was also a clearer link between the performance-level of the schools and the teachers' pedagogical beliefs. In particular, the high school teachers from the high performance schools all seemed to endorse IMT pedagogical beliefs compared to the SMT principles.

Predicting School Performance with Pedagogical Beliefs

In order to more directly assess the hypothesis that teachers' pedagogical beliefs are related to students' academic achievement, a multiple regression procedure was undertaken. The dependent variable being predicted was the performance level of the teacher's school. A dummy variable was created with the performance level where those teaching in high-performance schools were assigned to a value of +1, those in average-performance schools were assigned a value of 0, and those in low-performance schools were assigned -1. The independent variables were the various pedagogical beliefs in the SMT and IMT systems (i.e., GOAL-SMT, GOAL-IMT, TEACH-SMT, TEACH-IMT, LEARN-SMT & LEARN-IMT). Since the preceding analyses indicated that teaching practices did not differ across the performance levels, this variable was not included as an independent variable. The independent variables were entered into the regression using a stepwise procedure. An exploratory path analysis was done using a series of multiple regression procedures.

The results of the preceding multiple regression analyses can be represented in a path model for schools' performance level, with the pedagogical beliefs as the direct predictors and the educational and professional background variables as indirect predictors in the model. The path model is described in Figure 13; the model only includes the significant paths and the beta-weights are indicated in the significant paths.

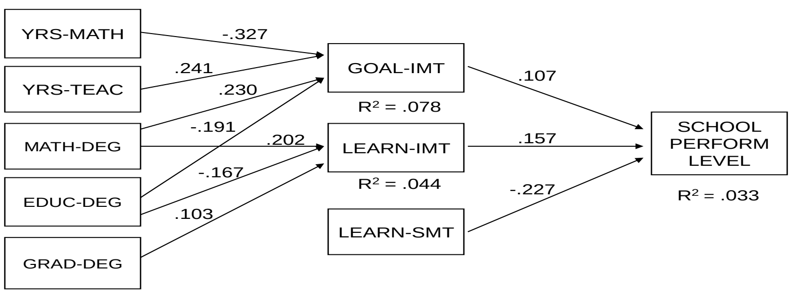

Figure 13. Path model of predictors of schools' performance level.

Figure 13 shows that IMT beliefs contribute positively towards the schools' performance level, whereas SMT beliefs contribute negatively . Having a degree in math/math education or having a graduate degree in any field indirectly contributes to higher achievement of the teachers' students. Besides, a degree in education is negatively associated with higher student achievement. Years of teaching is positively associated with the teachers' beliefs related to IMT goals of math education, but total years of teaching math was negatively associated with the same.

Predicting Teaching Practices

Although the results so far do not seem to show any systematic relationship between actual teaching practices and student performance, it would be interesting to determine whether the teachers' pedagogical beliefs are related in any way to their reported teaching practices.

In this section, we explore the relationships among the reported practices of the teachers, their pedagogical beliefs and the teachers' educational and professional background using multiple regression procedures. The results of the multiple regression analyses can be represented in a path model for the two types of teaching practices, with the pedagogical beliefs as the direct predictors and the educational and professional background variables as indirect predictors in the model. The integrated path model is described in Figure 14; the model only includes the significant paths and the beta-weights are indicated in the significant paths.

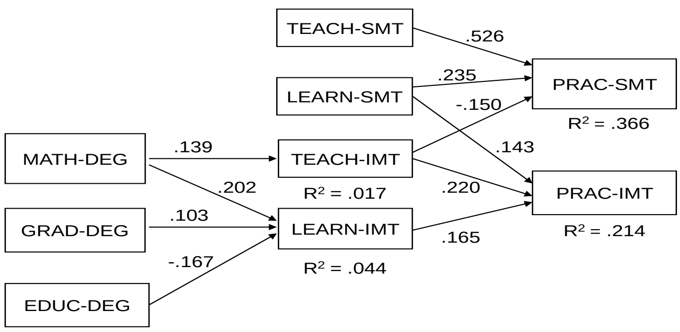

Figure 14. Path model of predictors of reported teaching practices.

SMT beliefs about teaching and learning seem to be maintained regardless of the educational or professional experiences of the teachers. On the other hand, the teachers' education background seems to be related to the development of IMT beliefs about teaching and learning. Most interestingly, the results indicate that a degree in education is negatively associated with these more contemporary and more progressive beliefs on teaching in learning. In other words, teacher whose highest degree is in the field of education are less likely to develop beliefs and practices associated with the inquiry tradition, or to put it more positively, those whose highest degree is not in the field of education are more likely to do so.

Key Results of Qualitative Sub-Study

This section shows the result of the interview on selected teachers to find out whether there are differences in the pedagogical beliefs and practices of high performing, average performing, and low performing schools. The responses of a total of 18 teachers on the goals of mathematics education, on the characteristics of effective mathematics teaching and characteristics of effective mathematics learning were analyzed. Among 18 teachers, 9 were elementary and 9 high school teachers each group having 3 teachers from high-, average-, and low performing schools.

Pedagogical Beliefs of Teachers

Almost all the teachers interviewed at the elementary and high school levels cited their school curriculum when asked how they would design the mathematics curriculum of their students. They rarely depart from the required standards of learning. Consequently, they focus their curriculum on skill building, the way it was prescribed by their school. Since all teachers cited their school's curriculum in elementary mathematics, they expect their students to meet the goals set by the curriculum. There were those who say though, that the most important thing for students is to learn how to apply the mathematical facts to real life situations.

All teachers are aware of the fact that effective mathematics teaching should be student centered. The difference lies in the kind of inquiry that they make. Most of them look at how well the students learn the algorithms and procedures.

At the elementary level, while they use real objects and situations in teaching, these are used to enhance computational skills.

While all of them recognize the importance of problem solving, none of them explicitly expressed its use to build concepts. Activities follow the explanation and demonstration. These consist of application problems. Sometimes, they use the terms problem solving interchangeably with drills and practices.

All high school teachers agree that students should be given a lot of activities on class making teaching student centered. A close analysis of their responses indicates though that these activities are mostly drills. They still adhere to the lecture – demonstration – drills (LDP) type of instruction. They believe that the skills should be developed through plenty of drills.
To most teachers both elementary and high school, mathematics is skill building. They believe that students have to build their skills progressively from elementary to high school. Mathematics consists of practice and drills. There are variation only in the manner they conduct the drills.

Apparently the teacher knows that elementary students have to develop both procedural and conceptual understanding of the operations. Yet, it is not clear to them exactly how learning takes place. Consequently they resort to feeding them with procedures which help students build their computational skills. Skills are tangible evidence of learning thus they find it more comfortable to base learning on algorithmic skills.

All teachers believe that mathematical skills should be built in succession from the elementary levels to the high school levels. This consists of algorithmic and procedural skills in the elementary level and algebraic skills at the high school level. Only two teachers consistently emphasized the development of problem solving skills as an essential tool to ensure conceptual understanding. One of them is an elementary teacher in high performing school and the other is a high school teacher from a high performing school.

While there are teachers who seem to adhere to the IMT approach, a close look at the kind of inquiry that they make reveals that the questions are not geared towards building concepts. Inquisitions are focused on the application of concepts that have been presented and demonstrated. Thus, while it is true that teachers probe into the students' thinking the probing is done to check how well they can replicate instruction.

Teachers express their beliefs on how students learn by the way they teach the subject matter. There seems to be no documentation on how students build concepts in arithmetic at the elementary level and how high school students come to understand algebraic concepts.

All teachers cite social factors aside from the other metacognitive factors like interest and self-regulation as cause for how low or high performance in school. To them, the family is a vital key to the success of a child in school. While there are genetic factors that affect learning, most of them still believe that the social factors especially the parents and family support are important motivations for student performance.

IMPLICATIONS

This study shows that generally, mathematics teachers hold rather traditional beliefs about mathematics teaching and learning, but they seem to show some openness and some understanding of principles associated with the more progressive inquiry mathematics tradition. Teachers' endorsement of the more progressive ideas and beliefs seem to be associated with their students' higher levels of achievement, although these ideas and beliefs still do not seem to be fully realized in the actual practices of the teachers. There are also somewhat clear indicators of how these more progressive beliefs and ideas come from; they seem to emerge from a more intensive mathematics education, but not from the present forms of formal studies in education. Moreover, the longer the teachers teach mathematics, the more resilient their tradition beliefs become. Those who are newer in the mathematics education enterprise seem more open to the more progressive pedagogical beliefs. Teachers also seem not to have personal views about the goals of mathematics education, suggesting that teachers view themselves as passive implementers of the mathematics curriculum. Teachers also lack basic knowledge about how students come learn and understand mathematics knowledge and skills. We could surmise that this passive perspective of their notes in mathematics education and the deficient knowledge about learners and learning are rooted in features of the teacher's formal studies in education.

The results of the study clearly point to problems in formal teacher education programs. It seems rather unfortunately that a degree in education seems negatively dispose (or predispose) teachers to more progressive ideas and beliefs about mathematics education. One would expect that studies in the educational field would serve as the means by which teachers can come to develop more positive ideas and beliefs that would contribute to improving teaching practice and student learning. However, the experiences of teachers as indicated by the data seem to indicate otherwise.

Fortunately, a deeper exposure to mathematics as a discipline seems to open up the teachers to these more positive ideas and beliefs. It is possible that their more intimate encounter with the subject matter of mathematics and their more extensive experiences with various mathematical tasks, problems, and activities lead them to be more receptive to pedagogical beliefs related to the inquiry dimension of mathematics.

We could also speculate that the in – service teacher education programs contribute to the rather confused linked between teacher beliefs and practices. Many teacher seem to have some understanding of the more contemporary concepts of the inquiry mathematics tradition, but their understanding is often superficial, vague, incomplete, and thus the impact on changing actual practice is feeble. It seems that teachers think they are doing something progressive when they are actually simply doing the same old stuff with some new trimmings. All this may be unintended product of sporadic, intermittent, and rudimentary in-service education programs (see Bernardo, et al, 2000 for analysis of in-service training programs that suggest this outcome).

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