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Teachers' Beliefs in a Constructivist Approach

To

Teaching Mathematical Problem Solving

In

Singapore Primary School

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Teachers' Beliefs in a Constructivist Approach To Teaching Mathematics in Singapore Primary School

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This paper reports on a study to examine in-service and pre-service teachers' pedagogical beliefs about teaching children mathematical problem solving in Singapore primary schools. A Likert scale questionnaire consisting of three subscales, for measuring teachers' pedagogical content beliefs was used. A high score on a scale indicated teachers' beliefs as towards a constructivist perspective, while a low score indicated a more traditional view. The subjects consisted of 55 in-service primary school teachers and 66 pre-service primary teachers. The findings suggested that there was variation in the in-service and pre-service teachers' beliefs toward a constructivist approach in teaching children mathematical problem solving. Both groups tended towards a traditional didactic perspective on Scale I where they believed that children might be able to construct their own knowledge but in classroom learning teachers had to instruct for pupils to receive knowledge. However, both groups believed in the role of teachers as facilitators in pupils' mathematical problem solving on Scale II, but they were undecided about children's ability to solve simple arithmetic word problems on their own before the mastery of number facts.

Introduction

There has been much development all over the world about the need for mathematics educators and teachers to think of mathematics as not just explaining its content, but also engaging students in the process of doing mathematics. To reflect this trend in mathematics education for Singapore schools in the 1990s', a revised curriculum has been conceptualised based on a framework that puts more emphasis on development of students' ability in mathematical problem solving from the primary to the secondary level (MOE, 1990). The theme "Problem Solving in School Mathematics" has been adopted in many countries since the 1980's (Schoenfeld, 1992). The reason for this focus in school mathematics curriculum arose from concerns that many school leavers were unable to use their acquired mathematics knowledge to solve everyday problems that required them to think and reason mathematically.

Traditional teaching emphasises the mastery of symbols and procedures, largely ignoring the processes of mathematics. It is often in problem situations where students have to reason and

think creatively that the mathematics knowledge is acquired. Teachers everywhere and in Singapore, in particular, are aware of the need to reform their teaching approaches in order to implement the new curriculum. To bring about changes in what goes on in mathematics classrooms depends on individual teachers. Any attempt by teachers to change must begin with an examination of their beliefs in the context of what is now known about teaching and learning in mathematics. This study attempts to examine in-service and pre-service teachers' pedagogical beliefs about teaching children mathematical problem solving in primary schools as a first step towards establishing relevant training courses to prepare teachers for the new curriculum.

Teachers' Pedagogical Beliefs - A Constructivist Perspective

For most teachers, conceptions of teaching and learning tend to be a mixed collections of beliefs and views that appear to be more the result of their years of experience in the classroom than of any type of formal or informal study. For those of us who studied both our mathematics and our pedagogy some time ago, probably were not taught a constructivist manner, and therefore, have not taught from this perspective. In the last few years a cognitive science perspective called constructivism, has emerged and provided new insights into the processes by which students learn mathematics (Burton,1993). Cognitive science research has shown that children develop informal system of mathematics outside of the classroom, and they do not simply absorb what they are taught. Children structure and interpret their own knowledge of mathematics over a period of time in their own unique ways building on their pre-existing knowledge.

Constructivist like von Glaserfeld (1987) believes that students construct their own meanings of mathematical concepts and procedures when they are given the opportunity to become actively involved in learning. Teachers facilitate students' active construction or problem solving rather than dispense rules and algorithms. Whilst in the traditional didactic fashion teachers tend to be very explicit in their instruction to get pupils to behave in a particular way. As a result it often leads to emphasis on manipulative skills and pupils become very mechanical in their behaviour without any reference to understanding or appreciation of the underlying mathematical ideas and processes. Thus the constructivist view to teaching mathematics and problem solving will require new teaching methods in the classroom. It is often true that in any call for adoption of a new curricula, what seems ideally desirable is often difficult to achieve in practice and the teachers have to struggle with the implementation.

Many studies on teachers' beliefs and concerns have worked on the premise that to understand teaching from teachers' perspectives we have to understand the beliefs with which they define their work. According to Ernest (1989), research literature on mathematics teachers' beliefs indicates that the teachers' approaches to mathematics teaching depend fundamentally on their systems of beliefs, in particular on their conceptions of the nature and meaning of mathematics, and on their mental

models of teaching and learning mathematics. These in turn affect how teachers perceive and think about teaching a new curricula and the extent to which they implement the curricula as intended by the developers.

Researchers on teachers' beliefs have focused on teachers' general conceptions of their roles and their general beliefs about curriculum. These studies are limited because they report findings on teachers' beliefs across a wide range of curriculum areas and grade levels. For example, the latest review of literature by Thompson (1992) examined several studies on teachers' beliefs about mathematics curriculum and instruction in general. There are however, a few studies, Peterson, Fennema and Carpenter (1987) and Thompson (1988) which analysed teachers' beliefs within a specific topic area such as learning of addition and substraction in first grade and problem solving. These studies are more pertinent to teachers' thoughts and behaviours in the classroom which might lead to better prediction and understanding of their students' learning and achievement within a specific content domain.

The Research Questions

The present study focused on primary school teachers' pedagogical beliefs with respect to teaching and learning of pupils' problem solving in arithmetic word problems. The process of representing a real-world or verbally posed problem is a fundamental problem solving skill. The development of this skill is a major objective of the primary school mathematics curriculum. This study attempts to examine in-service and pre-service teachers' pedagogical beliefs in teaching mathematical problem solving in the primary schools in Singapore. The research questions are:

1. Do in-service and pre-service primary teachers' believe in a constructivist perspective of teaching and learning mathematical problem solving in primary school?

2. Is there any difference in the pedagogical beliefs between in-service and pre-service teachers in the teaching of mathematical problem solving in primary school ?

Beliefs Questionnaire

A Likert scale questionnaire for measuring teachers' pedagogical content beliefs developed by Peterson, Fennema and Carpenter (1987) was adapted for the purpose of this study. The 30 items questionnaire constituted three scales, each of which is a statement of propositional knowledge based on findings from cognitive science research. Each scale consisted of 10 items to which the teacher responded on a five-point Likert scale by indicating "strongly agree", "agree", "undecided", "disagree", or "strongly disagree". For each scale, the proposition of

teachers' beliefs was represented as a continuum from a constructivist position at one end to a traditional didactic position at the other. Half of the items on each scale were worded so that agreement with the statement indicated agreement with the constructivist perspective, while the other half of the items were worded so that agreement with that item indicated agreement with a non-constructivist or traditional didactic perspective. A high score on each scale indicated teachers' beliefs as towards a constructivist perspective, while a low score indicated a more traditional view. The following is a discussion of the three scales:

Scale I :Children Construct Their Own Knowledge in Problem Solving

The constructivist perspective of classroom learning posits that new knowledge cannot be transmitted directly, but must be constructed by the pupil from elements of prior knowledge, and from acting on the world. The pupil acts on curriculum materials instead of just "receiving" them. In contrast to this view is the traditional didactic view of the pupil as the receiver of knowledge transmitted from the teacher and the text. The following ten items in the scale's continuum goes from the belief that children construct their own knowledge to the belief that children receive knowledge. Examples of items in this scale include:

+.Children can figure out ways to solve many math problems without formal instruction.

+.It is important for a child to discover how to solve simple word problems for himself/herself.

+.Children usually can figure out for themselves how to solve simple word problems.

-.Most young children have to be shown how to solve simple word problems.

-.It is important for a child to know how to follow directions to be a good problem solver.

-.Children learn mathematics best from the teachers' demonstrations and explanations.

Scale II : Teachers Facilitate Children's Problem Solving

This scale is concerned with how mathematical problem solving should be taught. The constructivist perspective is that pupils should engage in purposeful activities that grows out of problem situations requiring reasoning and creative thinking. The role of the teacher as a facilitator is to encourage pupils to solve problems, to inculcate independent thinking and to ask for

a wide variety of approaches. On the other hand the traditional perspective of "exposition and imitation" is where teacher presents procedures in a clear way for pupils to follow and practice with lots of exercises on similar type of problems. The scale's continuum goes from the belief that instruction should facilitate children's construction of knowledge to the belief that problem solving instruction should facilitate teacher's presentation of knowledge. Examples of items on this scale include:

+.Teachers should allow children to figure out their own ways to solve problems.

+.Problem solving abilities of children are enhanced by encouraging variety in the ways that problems are solved.

+.Problem solving abilities of children are enhanced by having them create problems of their own.

-.Problem solving abilities of children are enhanced by emphasising word cues as clues to solving problems.

-.Children should be told to solve problems the way the teacher has taught them.

-.The best way to teach problem solving is to show children how to solve one kind of problem at a time.

Scale III: Problem Solving Facilitates Understanding

Traditional practice in the classroom has been based on the assumption that computational skills must be learned before children are taught to solve simple word problems which appear only at the end of a unit, emphasising computational skills taught in the unit. Whatever value such exercises may have for practising the computational skill, they do very little to teach problem solving. Research on constructivism have shown that young children can solve a wide variety of addition or substraction problems by modelling the problem with manipulatives or their own counting strategies, even before they receive formal instruction in the basic operations. Hence this scale is developed to measure a continuum that goes from the beliefs that instruction for computational skills should be in relationship to problem solving to the beliefs that skills should be taught in isolation from understanding and problem solving. Examples of items on this subscale include:

+.Children should understand computational procedures before they spend much time practising them.

+.Children should have many informal experiences solving simple word problems before they are expected to memorise basic number facts.

+.Children should solve word problems before they master computational procedures.

-.Time should be spent practising computational procedures before children are expected to understand the procedures.

-.Recall of basic numbers facts should precede the development of an understanding of the four basic operations.

-.Children will not be able to solve simple word problems until they have mastered some basic number facts.

Method

Subjects

The subjects for the study consisted of 55 in-service primary school teachers and 66 pre-service trainee teachers. The in-service teachers were from two groups who were participating in a 30-hour course on Teaching of Mathematical Skills and Concepts through Problem Solving at the National Institute of Education. The mean number of years of teaching in primary school for these in-service teachers was 21.04, ranging from a shortest length of service of 4 years to the longest of 30 years. Forty-one of the teachers had participated in in-service courses in the last three years and most of them had previously attended a course on Teaching of Problem Sums. For this study they were given the belief questionnaires to complete at the beginning of the course. The pre-service teachers were enrolled at the Institute for a one year Postgraduate Diploma in Education course. All of them had no formal teaching experience in primary school. The same belief questionnaire were administered to them at the beginning of their course. The composition of the subjects is given in Table 1.

TABLE 1

COMPOSITION OF SUBJECTS

Sex	In-Service Teachers	Pre-Service Teachers
Female	47	64
Male	8	2
Total	55	66

RESULTS

Table 2 shows the mean and standard deviations of teachers' scores on the three scales as measured by the beliefs questionnaire. A higher score on the scale indicates greater agreement with a constructivist perspective while a lower score

on the scale indicates greater agreement with the traditional didactic perspective. The mean score for each scale was computed as a simple mean of the items in the scale. Table 3 shows the percentage frequency distribution of total scores for each of the three scales for the in-service and pre-Service teachers.

TABLE 2

MEANS AND STANDARD DEVIATIONS OF TEACHERS' SCORE ON THE THREE SCALES AS MEASURED BY THE BELIEFS QUESTIONNAIRE

Belief Scale		In-service Teachers (N=55)	Pre-Service Teachers (N=66)	Signif. Value
I. Children Construct Knowledge	Mean	3.06	3.04	n.s
	SD	(0.47)	(0.45)	
II. Teachers Facilitate Problem Solving	Mean	3.67	3.52	*
	SD	(0.33)	(0.30)	
III. Problem Solving Facilitates Understanding	Mean	3.26	3.28	n.s
	SD	(0.35)	(0.41)	

* significant at $p < 0.05$. n.s - not significant

TABLE 3

FREQUENCY DISTRIBUTION OF TOTAL SCORES FOR EACH OF THE THREE SCALES FOR THE IN-SERVICE AND PRE-SERVICE TEACHERS

Score Intervals	In-Service Teachers' Scale: I	II	III	Pre-Service Teachers' I	II	III
0 -10	0.00	0.00	0.00	0.00	0.00	0.00
11-20	0.00	0.00	0.00	0.00	0.00	0.00
21-30	50.91	1.82	27.27	57.58	6.06	30.30
31-40	47.27	85.45	70.91	40.90	90.91	63.64
41-50	1.82	12.73	1.82	1.52	3.03	6.06

Both groups of in-service and pre-service teachers had the highest mean scores (3.67 and 3.52 respectively) on Scale II which indicated that they had greater agreement with the constructivist perspective in respect to their beliefs that teachers's instruction should facilitate children's construction of knowledge during problem solving tasks. This was also evident in Table 3, which shows that 98.18% of the in-service teachers and 96.97% of the pre-service teachers rated high scores for this Scale. The in-service teachers had a higher mean than the pre-service teachers on this Scale and the difference is significant.

On the other hand, in Scale I both groups had the lowest means (3.06 and 3.04 respectively) which were just above the neutral mark. This could be interpreted that both in-service and pre-service teachers were neutral in their beliefs that children can construct their own knowledge without formal instruction. The frequency distribution of their scores in Table 3 shows that 50.91% and 57.58% of the in-service and pre-service teachers respectively were neutral or not in agreement towards the constructivist view of children constructing their own knowledge.

For Scale III, 72.73% of the in-service teachers and 69.7% of the pre-service teachers had high scores as shown in Table 3. The moderately high means of 3.26 and 3.28 (Table 2) for two groups respectively, indicated that the teachers were in agreement although not strongly towards a constructivist perspective in their beliefs that teaching computational skills should be integrated with problem solving for understanding by children.

DISCUSSION AND IMPLICATIONS

In-service and pre-service teachers' scores on the three beliefs Scales I, II and III showed significant variation with neither a "ceiling effect" nor a "floor effect". Teachers differed in the degree to which their beliefs corresponded to a constructivist perspective on the three scales. In view of such variation, teachers' implicit beliefs about teaching mathematical problem solving in the primary school might be considered as three related constructs on which teachers could be ranked instead of considering just the total scores of the three scales as a whole in the beliefs questionnaire. Teachers could then be ranked in such a way that those who are high on the three Scales correspond to a constructivist perspective and those who are low on the Scales do not correspond to a constructivist perspective. Such a ranking of individual teachers on the three scales enable identification of teachers whose beliefs correspond to a constructivist perspective and those who correspond to a traditional didactic perspective.

Inspite of the great difference in years of teaching experience between in-service teachers (mean = 21 years) and pre-service teachers who had no formal teaching experience, there was no significant difference in their beliefs with respect to Scale I and Scale III. Both groups tended towards a traditional didactic perspective on Scale I where they believed that children might be able to construct their own knowledge but in classroom learning teachers had to instruct for pupils to receive

knowledge. Although there was moderate agreement by both groups towards a constructivist perspective in the meaningful teaching and learning of computational skills for primary children, there were indications in the items scores of Scale III that both groups of teachers tended to be undecided about children's ability to solve word problems before mastery of number facts.

This concurrence in beliefs by both groups has support for the common notion that teachers are shaped by the way they were taught and they tend to teach the way they were taught.
The relatively high scores by both groups in Scale II, augur positively for the new school mathematics curriculum which emphasises problem solving. Both in-service and pre-service teachers believed in the role of teachers as facilitators in pupils' mathematical problem solving rather than the traditional perspective of "exposition and imitation" method for helping pupils to solve problems. There was a significant difference between the in-service and pre-service teachers in that the former held stronger beliefs in the constructivist perspective than the latter. It could be due to the fact that 41 out of 55 of these in-service teachers had been exposed to a constructivist perspective in their previous attendance of in-service courses on problem solving and hence were influenced in their beliefs.

CONCLUSION

This is a preliminary study on teachers' beliefs in specific aspects of teaching mathematical problem solving in primary school. The findings suggested that there was variation in the in-service and pre-service teachers' beliefs toward a constructivist perspective with respect to children's construction of mathematical knowledge, instruction that facilitates problem solving and understanding in the acquisition of computational skills by children. Both in-service teachers and pre-service concurred in their beliefs. Further study from here would be to examine the extent to which these teachers' beliefs actually correspond to a constructivist perspective in their teaching pupils in the classroom. It will be reflected in the quality of the mathematics contents and strategies that they use.

Teachers whether in service for long or just beginning rely on their knowledge and beliefs in order to survive daily events in the classroom and adapt to new changes in the school curriculum. Studies (Thompson, 1992) have suggested that teachers' conceptions and beliefs are not easily altered, that one should not expect noteworthy changes to come about over a period of training course. This has implication for teacher education where there should be follow-up studies on teachers participating in pre-service or in-service programmes on how many would make an effort to implement or try out new ideas. Insightful analyses and detailed accounts of how teachers internalize new ideas and develop new instructional practices can further contribute to our understanding of the cognitive processes involved in teachers changing their beliefs and practices. From a practical viewpoint, such studies should prove particularly valuable at this time of rapid change in mathematics education.

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