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ABSTRACT

The results of the International Assessment of Educational Progress released in February 1992 indicate that in mathematics and science the United States ranks near the bottom, while South Korea and Taiwan rank at the top. This paper compares the nature of mathematical problem-solving instruction in Korean elementary schools to that in American elementary schools. Questionnaires that attempt to determine teachers' use of instructional strategies to promote problem solving, teachers' perceptions of the usefulness of specific problem-solving strategies, teachers' confidence in using those strategies, and beliefs concerning specific recommendations for problem-solving instruction were given to 164 Korean teachers from 7 urban public elementary schools (grade levels 1-6) in Seoul and 195 American teachers of grade levels 1-6 from 10 elementary schools from school districts in Phoenix, Arizona. Korean and American teachers reported similar amounts of time spent each week on mathematics instruction and problem solving; however the Korean school year is 44 days longer than the American school year. Korean teachers perceived textbooks as being more useful for problem-solving instruction, used less student grouping as an instructional technique, and used manipulatives less frequently. (MKR)

Elementary School Teachers' Instructional Behavior in Mathematics Problem Solving: A Comparative Study

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The results of the International Assessment of Educational Progress (IAEP) released in February 1992 indicated that in mathematics and science the United States ranked near the bottom, while South Korea and Taiwan ranked at the top (Educational Testing Service (ETS), 1992). The gap between the American and Asian students was especially wide in mathematics. For example, nine year old American students scored an average of 58% correct while the top scorers, the Koreans, scored an average of 75% correct. Korean students' superiority in mathematics in general was mirrored by their achievement in specific aspects of mathematics including problem solving. Korean students averaged about 70% correct and American students averaged about 57% correct on items categorized as problem solving. This superiority in mathematical problem solving has been confirmed by other studies. Stevenson (1987) found that Asian students scored higher than American students on tests involving mathematical word problems.

Attempts have been made to explain why American students are not doing well in the international mathematics competition. It is clear that Asian students are not more intelligent than American students as measured by intelligence tests (Stevenson, 1987). The ETS study offered several environmental-cultural factors that may contribute to Korean children's relative success in mathematics. For example, it has been suggested the differences in amount of time spent at school, teaching methods, homework behavior, and/or time spent watching television might account for American students' lower performance in mathematics compared to Korean students.

American students attend school on an average 44 less days than students in Korea (ETS, 1992). American students might also attend fewer instructional hours per school day compared to their Asian counterparts (Kim, 1993). Textbooks within the two cultures are also different. American schools districts have a choice among textbooks that are produced by all the major publishers and as a result selections vary between school districts. Aligned to the national curriculum, textbooks used in Korea are uniform. The textbooks used in Korea contain many less review lessons than American textbooks (Kim, 1993). Increased instructional time and textbooks which uniformly devote less time to review could both be factors contributing to the relative success of Korean students.

In addition, researchers have reported that Asian classrooms differ considerably from American classrooms in the types of lessons that are conducted (Stigler, 1988). American teachers tend to focus first on the development of mathematical skills. Secondly they address the application of skills to the solution of problems. In contrast, Asian teachers tend to use what could be called a problem centered approach to teaching mathematics. In a problem centered approach mathematical skills are developed within the primary focus of problem solving. In the context of the problem centered approach, Asians students are engaged in activities that could accentuate their problem solving performance. These activities include generating multiple approaches to reach a problem solution and presenting the rationale for answers. Use of a problem centered approach to mathematics instruction could have a positive effect on the problem solving performance of students.

Purpose

This article compares the nature of mathematical problem solving instruction in Korean elementary schools to that in American elementary schools. Data were collected about elementary school teachers' instructional behavior in mathematics problem solving from their self-assessment of factors/strategies involved in mathematical problem solving instruction through the use of a questionnaire. The aspects of problem solving investigated included; time spent on problem solving instruction, teachers' use of instructional strategies to promote problem solving, teachers' perceptions of the usefulness of specific problem solving strategies, teachers' confidence in using those strategies, sources of problems, and beliefs about problem solving instruction.

The instructional factors/strategies investigated were selected after an analysis of problem solving and instructional strategies suggested by different scholars (e.g., Kloosterman, 1992; Duren & Cherrington, 1992; Proudfit, 1992; Carey, 1991), as well as those appearing in teacher publications (e.g., Silverman, Winogard, and Strohauer, 1992; Kroll, Masingila & Mau, 1992; Maher & Martino, 1992). In addition, the items used in the questionnaire were intended to reflect the recommendations for instruction of the National Council of Teachers of Mathematics (NCTM). The NCTM *Curriculum and Evaluation Standards for School Mathematics* (1989) have been a major influence on mathematics instruction in America. The *Standards* have become the criteria by which curricula and textbooks are evaluated.

American students are not doing well in international competition in the field of mathematics. Although cross-cultural comparisons are confounded by the large numbers of variables, it is logical to examine the populations that are excelling in mathematics to gain insights that may shed light on the insufficiencies in our own educational system. Investigating the teachers beliefs and practices in problem solving instruction provides information that is important to the discussion about how teachers are taught as well as about how teachers teach.

Methods

Questionnaire development began with a review of the literature identifying recommendations about instructional strategies for developing student problem solving ability and specific problem solving strategies for solving problems. These recommendations were used as the basis for writing 83, five point, Likert-type items which attempted to determine teachers' use of instructional strategies to promote problem solving, teachers' perceptions of the usefulness of specific problem solving strategies, teachers' confidence in using those strategies, and beliefs concerning specific recommendations for problem solving instruction. Additional questions addressed sources of problems, the amount of time spent weekly on problem solving instruction, demographic data about the teachers, teachers' self-assessment of their problem solving ability, and teachers' self-assessment of their students' problem solving ability. The questionnaire was piloted with a small group (n=17) of American elementary school teachers to evaluate its clarity and freedom from ambiguity. The questionnaire was revised based on the pilot administration. A copy of the questionnaire is contained in the Appendix to this paper.

After revisions the questionnaire was translated into Korean for the Korean subjects. Two bilinguals (English/Korean) translated the original questionnaire into Korean. The translation was then validated by one of the authors of this paper.

The questionnaires were distributed to the participating teacher during the 1992-1993 school year. The investigators collected the completed forms. Although gender, degree, and grade level of teaching assignment were included in the questionnaire, the name of the participants was not asked to retain anonymity.

Subjects

The Korean portion of the sample consisted of 164 teachers (119 females and 44 males) of all grade levels (1-6) from seven urban public elementary schools in Seoul, Korea. They had been teaching on an average of 15.5 years. Eleven percent of the teachers reported attending inservice training on mathematics instruction.

The American portion of the sample consisted of 195 (171 females and 22 males, 2 not reporting) teachers of all grade levels (1-6) from 10 elementary schools from school districts in Phoenix, Arizona. They had been teaching on an average of 13.0 years. Forty-eight percent of the teachers reported attending inservice training on mathematics instruction.

Results

For each subset of items on the questionnaire (e.g., items concerning the usefulness of specific problem solving strategies), multivariate analyses of variance were employed to establish cross-cultural differences, those yielding significant results were followed by univariate ANOVAs.

Korean and American teachers reported similar amounts of time spent each week on mathematics instruction with means of 4.5 hours and 4.7 hours, respectively and on problem solving with means of 2.2 and 1.7, respectively.

There were no significant differences in either the perceived usefulness of, or confidence in, using 20 specific problem solving strategies, for example, drawing diagrams and estimating. Ratings for the usefulness of these strategies were high in both countries with the majority of means at 4+ (5 being highest). The teachers' reported confidence in using the strategies was similarly high for both groups.

Teachers' responses to other items did produce differences all of which were significant at the .005 level. The results of the significant univariate tests with Bonferroni corrections follow.

Teachers were asked to rate sources of problems to use in problem solving instruction (5=very useful, 1= not at all useful). Korean teachers ranked textbooks significantly higher than their American counterparts with means of 4.3 and 3.5, respectively. Korean teachers also agreed mor strongly that textbooks supplied all they needed to know about problem solving (3.02 compared to 1.82). Korean teachers also felt more positive about the use of step by step problem solving plans than the American teachers (4.14 compared to 3.28).

Teachers were asked to respond on a five point Likert type scale (5=most of the time, 1 = not at all) concerning their frequency of using specific instructional strategies. Significant differences occurred in the frequency of grouping, (Korean mean = 3.7, American mean = 4.3) and in the frequency of using manipulatives (3.8 and 4.3).

Korean teachers rated themselves significantly higher than the Americans concerning their own problem solving ability (4.4 compared to 4.1) and their skill in teaching problem solving (4.5 compared to 3.9). Korean teachers also felt more strongly than American teachers that to teach problem solving a teacher has to be a good problem solver (4.37 compared to 3.03).

The Korean teachers also rated their students higher than the American teachers in terms of student problem solving ability (4.4 compared to 3.3), student interest in problem solving (4.5 compared to 3.4), student effort in problem solving (4.6 compared to 3.4), and student ability to discuss problem solving (4.2 compared to 3.2). Likewise, Korean teachers reported that their students could solve the textbook problems more easily than the American teachers did (3.57 compared to 2.60). However, Korean teachers agreed more strongly that their students did not like to solve word problems because they were more involved (3.68 compared to 3.05).

Discussion

There are major similarities between Korean and American teacher practices in and beliefs about problem solving instruction. Both groups allot about the same amount of time per week to mathematics and problem solving. However, the Korean school year is about 44 days longer than the school year in American (Kim, 1993). As a result Korean students receive more instruction in mathematics and in mathematical problem solving than their American counterparts.

Both groups of teachers also rated specific strategies as very useful for solving problems. Apparently, the strategies approach to problem solving that is pervasive in American textbooks and curricula is also the accepted approach in Korea.

However, differences were apparent in the use of other instructional methods. Korean teachers perceived textbooks as being more useful for problem solving instruction and appear somewhat more reliant on them as sources of problem solving activities. Only one textbook series is approved for national use in Korea. The idea of textbooks linked to a national curriculum may in some way account for the higher perceived usefulness of textbooks in Korea.

American teachers reported the use of grouping students as an instructional technique significantly more than Korean teachers. This is consistent with the findings of Stevenson (1987) that Korean teachers tended to conduct whole class instruction without grouping more often than American teachers. The Koreans tendency to work in the whole class format exists in spite of the fact that class size in Korea is at times double class size in American schools (ETS, 1992). Although whole class activities might be more easily managed than small group work, the use of small groups is recommended by many educators to increase student learning achievement through a cooperative approach.

Larger class size may also contribute to the less frequent use of manipulatives by Korean teachers than American teachers. Classroom management factors would make it more difficult to include manipulative use in classrooms with higher student counts. Mathematics educators tend to recommend that mathematics instruction incorporate using of manipulatives as models for the abstract processes of mathematics. Manipulatives also allow young students to explore problem solutions at a level of abstraction congruent to their level of development.

Korean teachers rated themselves higher in problem solving ability than American teachers and felt more strongly that it was important to be a good problem solver to teach problem solving effectively. Korean teachers also rated their students more highly as problem solvers that American teachers. The ETS study indicated that Korean students are better problem solvers than American students and responses to this item indicate that teachers are well aware of their students problem solving ability. Korean teachers also ranked themselves higher as problem solvers than American teachers, but the differences were small.

Interestingly, Korean teachers agreed more strongly that their students did not like to solve word problems even though they ranked their students' interest in and effort in solving word problems higher than American teachers.

How these apparent differences in instructional factors affect student achievement is not clear. In some ways mathematics instruction in Korean schools is conducted in a manner that is contrary to the recommendations of mathematics educators. For example, the lower frequencies of using groups and manipulatives for problem solving instruction could be a potential negative influence on mathematics achievement. Nevertheless, Korean students are leading in international assessments of mathematics. Other factors, whether in or out of the classroom, not surveyed by this study must be responsible for the success of the Korean students. The results of this study could be used as a guide to identifying other aspects of instruction that require additional investigation.

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APPENDIX

English Version of the Questionnaire Used in This Study

TEACHER SURVEY ON PROBLEM SOLVING INSTRUCTION

GENERAL INFORMATION

Instructions. (Circle your choice.)

1. CURRENT GRADE LEVEL   1   2   3   4   5   6

2. PREVIOUS GRADE LEVEL   1   2   3   4   5   6

3. HIGHEST DEGREE EARNED.   BA/BS   MA/MS   Ed. Spec   Ph.D.

4. GENDER   Female   Male

5. TYPE OF CLASSROOM   CLOSED   DEPARMENTALIZED   SPECIAL EDUCATION CLOSED   SPECIAL EDUCATION RESOURCE ROOM

Instructions. (Fill in the blanks with numbers.)

6. About how many inservice days a year do you devote to math? _______

7. Years at current grade level _______

8. Total years of teaching experience _______

9. Total hours of instructional time per week teaching mathematics _______

10. Total hours of instructional time per week teaching mathematical problem solving ______

INSTRUCTIONAL STRATEGIES

Instructions. (For each strategy, circle the response that best describes the frequency of use in your classroom.)

		most of the time	often	sometimes	not very often	not at all
11.	Students work in small groups or with a friend.	4	3	2	1	0
12.	Students model the problem with manipulatives.	4	3	2	1	0
13.	Students explain how they had solved a problem.	4	3	2	1	0
14.	Teacher asks for different ways to solve the same problem.	4	3	2	1	0
15.	Students are asked to defend their reasoning and answer.	4	3	2	1	0
16.	Students make up their own word problems to share.	4	3	2	1	0

SOURCES OF WORD PROBLEMS

Instructions. (Circle the number representing the usefulness of each of the following sources of mathematics word problems.)

5=very useful   4=useful   3=about average   2=not very useful   1=not at all useful

17. Textbooks   5 4 3 2 1
18. Teacher written   5 4 3 2 1
19. Supplemental Materials   5 4 3 2 1
20. Other ______________   5 4 3 2 1

TEACHER ASSESSMENT OF SELECTED FACTORS

Instructions. (Circle the letter grade you would assign to each of the following.)

21.	Your own problem solving ability.	A	B	C	D	F
22.	Your skill in teaching problem solving.	A	B	C	D	F
23.	Your motivation to teach problem solving.	A	B	C	D	F
24.	Your students' problem solving ability.	A	B	C	D	F
25.	Your students' interest in problem solving.	A	B	C	D	F
26.	Your students' effort in problem solving.	A	B	C	D	F
27.	Your students' ability to discuss their problem solving work.	A	B	C	D	F

USEFULNESS OF SELECTED PROBLEM SOLVING STRATEGIES

Instructions. (For each strategy, rate its usefulness in classroom instruction.)

		Very useful	Useful	Uncertain	Not very useful	Not at all useful
28.	Act it out.	5	4	3	2	1
29.	Check reasonableness of answer.	5	4	3	2	1
30.	Choose an operation.	5	4	3	2	1
31.	Draw a diagram.	5	4	3	2	1
32.	Draw a picture.	5	4	3	2	1
33.	Estimate.	5	4	3	2	1
34.	Find the facts.	5	4	3	2	1
35.	Find the question.	5	4	3	2	1
36.	Guess check revise.	5	4	3	2	1
37.	Listen carefully.	5	4	3	2	1
38.	Look for a pattern.	5	4	3	2	1
39.	Make a graph.	5	4	3	2	1
40.	Make a physical model.	5	4	3	2	1
41.	Make a table or a chart.	5	4	3	2	1
42.	Solve a simpler problem.	5	4	3	2	1
43.	Sort and classify.	5	4	3	2	1
44.	Use a model.	5	4	3	2	1
45.	Use manipulative.	5	4	3	2	1
46.	Work backwards.	5	4	3	2	1
47.	Write a number sentence.	5	4	3	2	1
48.	Other ____________	5	4	3	2	1

CONFIDENCE IN USING SELECTED PROBLEM SOLVING STRATEGIES

Instructions. (For each strategy, rate your confidence level in using that strategy.)

		Very Confident	Confident	Uncertain	Not very confident	Not at all confident
49.	Act it out.	5	4	3	2	1
50.	Check reasonableness of answer.	5	4	3	2	1
51.	Choose an operation.	5	4	3	2	1
52.	Draw a diagram.	5	4	3	2	1
53.	Draw a picture.	5	4	3	2	1
54.	Estimate.	5	4	3	2	1
55.	Find the facts.	5	4	3	2	1
56.	Find the question.	5	4	3	2	1
57.	Guess check revise.	5	4	3	2	1
58.	Listen carefully.	5	4	3	2	1
59.	Look for a pattern.	5	4	3	2	1
60.	Make a graph.	5	4	3	2	1
61.	Make a physical model.	5	4	3	2	1
62.	Make a table or a chart.	5	4	3	2	1
63.	Solve a simpler problem.	5	4	3	2	1
64.	Sort and classify.	5	4	3	2	1
65.	Use a model.	5	4	3	2	1
66.	Use manipulative.	5	4	3	2	1
67.	Work backwards.	5	4	3	2	1
68.	Write a number sentence.	5	4	3	2	1
69.	Other ______________	5	4	3	2	1

QUESTIONS ABOUT PROBLEM SOLVING

Instructions. (Circle the response that reflects your agreement with the following statements.)

		Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
70.	It is better to tell or show students how to solve problems than to let them discover how on their own.	SA	A	U	D	SD
71.	Teachers must be very good at problem solving before they can help their students become efficient problem solvers.	SA	A	U	D	SD
72.	I feel a sense of insecurity when attempting to conduct problem solving instruction.	SA	A	U	D	SD
73.	The best way to become a good problem solver is to solve a lot of problems.	SA	A	U	D	SD
74.	Teachers should tell students the best way to solve each type of problem.	SA	A	U	D	SD
75.	Problem solving should be the major emphasis of mathematics instruction.	SA	A	U	D	SD
76.	Getting the correct answer should be the main focus of problem solving in elementary school.	SA	A	U	D	SD
77.	I feel very confident when I am discussing word problem in my class.	SA	A	U	D	SD
78.	Students need to be given the right answer to all of the problems they work.	SA	A	U	D	SD
79.	Hearing different ways to solve the same problem confuses children.	SA	A	U	D	SD
80.	Students need to know the "key word" approach to problem solving.	SA	A	U	D	SD

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
81. I enjoy teaching most other subjects more than mathematics.	SA	A	U	D	SD
82. I would like to try new ideas but I am not confident that they will work.	SA	A	U	D	SD
83. The textbook I use in my classroom supplies all that I need to know about teaching problem solving.	SA	A	U	D	SD
84. Students need a step by step plan to follow in order to solve problems.	SA	A	U	D	SD
85. Students don't like to solve word problems because they are too much work or too difficult.	SA	A	U	D	SD
86. Most of my students easily solve the word problems supplied by the textbook.	SA	A	U	D	SD
87. Children can develop their word problem solving skills by working together in small groups.	SA	A	U	D	SD
88. Calculators are useful in solving word problems.	SA	A	U	D	SD
89. I always allow my students to use calculators when they are solving word problems.	SA	A	U	D	SD
90. I believe that this survey is collecting valuable information about practices in problem solving instruction	SA	A	U	D	SD
91. It is more important for children to compute efficiently, than to solve word problems.	SA	A	U	D	SD
92. My students solve word problems every day.	SA	A	U	D	SD
93. I need advice about how to teach problem solving in my classroom.	SA	A	U	D	SD

PROBLEM SOLVING INSTRUCTIONAL METHODS

Briefly describe the way in which problem solving instruction is typically conducted in your classroom. What do you do first? Second? Etc.?

Do you believe that you adequately include problem solving in your instruction?

If not, what are the obstacles that prevent you from including sufficient problem solving instruction?