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ABSTRACT

This study investigated 407 in-service elementary teachers' level of mathematical content knowledge, attitude toward mathematics, beliefs about effective instruction, use of reform-orientated instruction and modeled the relationship among these variables. Upper elementary teachers (grades 3-5) were found to have greater content knowledge and more positive attitudes toward mathematics than primary teachers (grades K-2). There was no difference in teachers' beliefs about effective instruction, but primary level teachers were found to use reform- oriented instruction more frequently than upper elementary teachers. Overall, it was found that teachers with higher content knowledge were less likely to believe in the effectiveness of reform-oriented instruction and less likely to use such instruction in their classrooms. However, teachers with more positive attitudes towards mathematics were more likely to believe in the effectiveness of reform-oriented instruction and use it in their classroom. Findings from this study have implications for the goals and objectives of elementary mathematics methods courses. (Author)

THE IMPACT OF TEACHERS' CONTENT KNOWLEDGE AND ATTITUDES ON INSTRUCTIONAL BELIEFS AND PRACTICES

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This study investigated 407 in-service elementary teachers' level of mathematical content knowledge, attitude toward mathematics, beliefs about effective instruction, use of reform-orientated instruction and modeled the relationship among these variables. Upper elementary teachers (grades 3-5) were found to have greater content knowledge and more positive attitudes toward mathematics than primary teachers (grades K-2). There was no difference in teachers' beliefs about effective instruction, but primary level teachers were found to use reform-oriented instruction more frequently than upper elementary teachers. Overall, it was found that teachers with higher content knowledge were less likely to believe in the effectiveness of reform-oriented instruction and less likely to use such instruction in their classrooms. However, teachers with more positive attitudes towards mathematics were more likely to believe in the effectiveness of reform-oriented instruction and use it in their classroom. Findings from this study have implications for the goals and objectives of elementary mathematics methods courses.

Mathematical content knowledge (Ball, 1990a, 1990b, 1991) and positive attitudes toward mathematics (Quinn, 1997; Richardson, 1996) are both important components of being an effective teacher. Also important are teachers' beliefs about mathematics and mathematics instruction (Grossman, Wilson, & Shulman, 1989) which often impact instructional practices (e.g., Pajares, 1992; Richardson, 1996; Thompson, 1984). In order to better prepare teachers to use instructional practices that follow from the ideals of reform-oriented mathematics teaching and learning (National Council of Teachers of Mathematics [NCTM], 1989, 2000; Simon, 1995) it is important to understand how teachers' content knowledge and attitudes impact their beliefs, and ultimately impact their instructional practices. Thus, the purpose of this study is to: (1) investigate elementary teachers' level of mathematical content knowledge, attitude toward mathematics, beliefs about effective instruction, and use of reform-orientated instruction, and (2) model the relationship among these variables.

In particular, this study investigates the following questions: (1) Does the level of teachers' mathematical content knowledge and attitude toward mathematics differ for primary (K-2) versus upper elementary (3-5) teachers? (2) Do beliefs about effective teaching strategies differ for primary and upper elementary teachers? (3) Does the frequency of usage of reform-oriented instruction differ for primary and upper elementary teachers? (4) Are teacher beliefs about effective teaching strategies related to use of reform-oriented instruction in the classroom? (5) How does the level of teachers'

content knowledge and attitude toward mathematics impact their beliefs about effective instruction and their use of reform-oriented instruction? Information gained from investigating these questions can provide useful information for teacher educators to better develop methods courses that address the many different components of effective teaching.

Methods

Sample

This study involved 407 K-5 in-service teachers from two school districts. These teachers were part of a professional development project focusing on the implementation of NCTM-based mathematics curricula.

Measures

At the beginning of the professional development project teachers' content knowledge, attitudes, beliefs, instructional practices, and other background characteristics were surveyed. Teachers' mathematical content knowledge was measured using a 44-item mathematics test (reliability of test: KR-20 = .88). Items were related to content that would most likely be found in grades K-8. The test was made up of 32 multiple-choice items and 4 open-ended items (multiple-part questions constituting the remaining 12 items). Teachers' attitude toward mathematics was measured using 14 items rated on a 6-point Likert scale (1=*strongly disagree* to 6=*strongly agree*; reliability of the scale based on Cronbach's a = .88). Teacher's were also asked to rate on a 4-point Likert scale (1=*not important* to 4=*very important*) their beliefs about the importance of 14 activity/techniques/strategies for effective mathematics instruction in the grades they teach. Through exploratory factor analysis, a subset of 10 of these items was determined to represent a single factor. Further inspection of the items found them to be consistent with the reform efforts outlined by the NCTM (1989; 2000). These items were used to create a measure of teachers' beliefs about effective instruction (Cronbach's a = .80). Teachers were also asked to rate the frequency of occurrence of 29 instructional activities in their mathematics lessons on a 5-point Likert scale (1=*never*, 2=*rarely*, 3=*sometimes*, 4=*often*, 5=*all or almost all mathematics lessons*). Again, through exploratory factor analysis, seventeen of these items were determined to form a single factor. Inspection of the items found that they aligned with instructional activities advocated by the NCTM (1989; 2000). These items were used to create a measure of teachers' use of reform-oriented instruction (Cronbach's a = .87). Measures of background characteristics of teachers were also included such as years of teaching experience (categorized into 7 ranges: 0-2 years; 3-5 years; 6-10 years; 11-15 years; 16-20 years; 21-25 years; 26 or more years), number of mathematics courses taken, and highest degree attained (Bachelor's vs. Graduate).

Procedures

Teachers were categorized as either primary (grades K-2) or upper elementary (grades 3-5) and compared using descriptive statistics related to their level of content knowledge, attitude toward mathematics, beliefs about effective instruction, and use of reform instruction. Based on the full sample of teachers, a series of path models was used to investigate and compare the relationship between teachers' level of mathematics content knowledge and attitudes toward mathematics and their belief about effective instruction and use of reform-oriented instruction while controlling for number of mathematics courses taken, years experience, and degree level.

Results

Means and standard deviations of all variables are reported in Table 1 for all 407 teachers as well as by grade level. An investigation of means found that upper elementary teachers have significantly higher levels of mathematical content knowledge and a more positive attitude toward mathematics than primary teachers. There was no difference between primary and upper elementary teachers beliefs' about effective instruction, but primary teachers reported more frequent use of reform-oriented instructional activities than upper elementary teachers. Considering teacher background character-

Table 1. Means and Standard Deviations for Variables

	All Teachers (N=407)	K-2 (N=259)	3-5 (N=148)
Content Knowledge (KR-20 = .88)	27.02 (8.18)	25.68 (7.89)***	29.37 (8.18)
Attitude (α=.88)	4.67 (0.77)	4.57 (0.75)**	4.83 (0.80)
Effective Instruction (α=.80)	3.32 (0.42)	3.34 (0.41)	3.30 (0.44)
Reform Instruction (α=.87)	3.17 (0.53)	3.27 (0.52)***	2.98 (0.51)
Years Experience	3.70 (1.96)	3.64 (1.97)	3.79 (1.96)
Math Courses	3.43 (1.45)	3.35 (1.39)	3.57 (1.54)
Highest Degree	0.39 (0.49)	0.35 (0.48)*	0.46 (0.50)

Note: *p<.05; ** p <.01; *** p <.001; Asterisks in the K-2 column represent significant differences between K-2 and 3-5 teachers.

istics, a higher percentage of upper elementary teachers reported having a graduate degree than primary teachers. There was no difference in years teaching experience or mathematics courses taken across the two groups.

Intercorrelations between variables are reported in Table 2 for all teachers. Overall, teachers' beliefs in effective instruction was found to have a moderate positive relationship with teachers' reported use of reform-oriented methods (r = .42). That is, teachers who believe that reform-oriented instruction is effective tend to use more reform-oriented instructional techniques. However, the magnitude of this relationship suggests that beliefs and actions do not always match.

In order to investigate the relationship between teachers' content knowledge, attitude, instructional beliefs, and instructional practices a series of path models was estimated. Initially, a saturated model, including all possible paths between the variables was estimated. Subsequent inspection of the path coefficients revealed that some effects were negligible suggesting that a more parsimonious model existed. After deleting these paths a final model was estimated. This model, with significant standardized path coefficients, is presented in Figure 1. The chi-square value for the model was not significant suggesting a good fit with the data, $c^2(9, N = 407) = 6.43$, p = .696. Other fit indices further support a good fit of the model with the data. The goodness-of-fit index (GFI) was .996; adjusted goodness-of-fit index (AGFI) = .986; comparative fit index (CFI) = 1.00. These indices can take on a value from 0 to 1 with values closer to 1 showing a better fit and values greater than .90 usually indicating a relatively good fit (Hoyle, 1995). The standardized root mean square residual (SRMR) was .02. This index represents the average residual between the observed and hypothesized correlation matrix. The root mean square error of approximation (RMSEA) was .00. This index takes into account the complexity of the model, that is, the number of

Table 2. Intercorrelations Between Variables for All Teachers (N = 407)

	1	2	3	4	5	6	7
1. Content Knowledge	--						
2. Attitude	.32	--					
3. Effective Instruction	-.11	.13	--				
4. Reform Instruction	-.18	.10	.42	--			
5. Years Experience	-.21	.05	.03	.03	--		
6. Math Courses	.05	.16	.02	.07	.13	--	
7. Highest Degree	.24	.06	-.06	-.07	.11	.02	--

parameters being estimated. These two indices can range from 0 to 1 with values less than .05 representing good fit (see Byrne, 2001). Theoretically, it is possible for the direction of the path between content knowledge and attitude to be in either direction (see Figure 1). However, based on an inspection of the residual covariance matrix, representing the difference between the estimated and observed covariances, it was decided that the model presented in Figure 1, with knowledge predicting attitude, better fit the data.

Results from the path analysis found a significant negative direct effect of teachers' content knowledge on their beliefs about effective instruction (b = -.17, $p < .001$). However, teachers' attitude toward mathematics was found to have a significant positive direct effect on beliefs about effective instruction (b = .19, $p < .001$). Similar results were found for the occurrence of reform-oriented instruction in the classroom. Teachers' content knowledge was found to have a significant negative direct effect on instructional practices in the classroom (b = -.18, $p < .001$) and teachers' attitude toward mathematics was found to have a positive direct effect on teachers' instructional practices in the classroom (b = .10, $p < .05$). Teachers' content knowledge was found to have a positive direct effect on teachers' attitude toward mathematics (b = .34, $p < .001$). Teachers' beliefs about effective instruction was also found to have a significant positive direct effect on instructional practices (b = .39, $p < .001$).

Indirect effects show a relationship between two variables that is mediated by one or more other variables. For example, there was a significant positive indirect effect of content knowledge on teachers' beliefs that was mediated by teacher attitude (b =

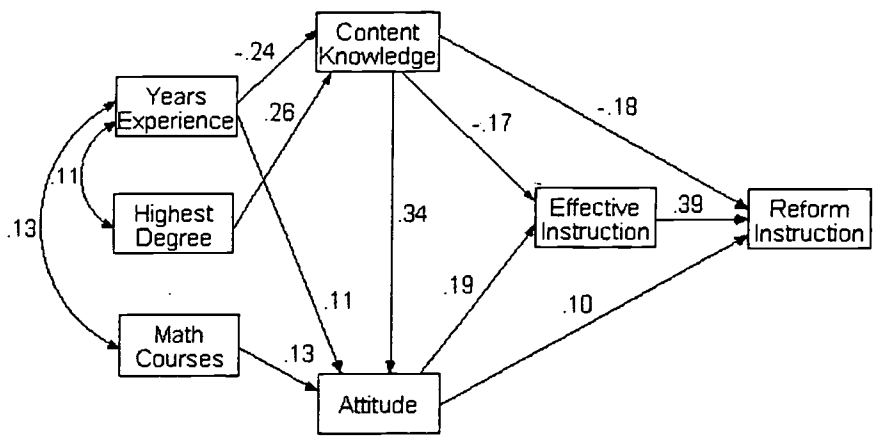

Figure 1. Final path model. All path coefficients are standardized and statistically significant at $p < .05$. Fit indices for the model: $\chi^2(9, N = 407) = 6.43$, $p = .696$, GFI=.996, AGFI=.986, CFI=1.00, RMSEA=.00, SRMR=.02.

.06, $p < .05$, calculated by multiplying intermediary effects, i.e., .34 x .19 = .06). This indirect effect is represented by the path that leads from content knowledge through attitude to effective instruction (see Figure 1). However, the total effect of content knowledge on beliefs, found by summing the direct effects and indirect effects, was still negative (b = -.11, $p < .05$). There was also a significant indirect effect of attitude on instruction which was mediated by beliefs (b = .07, $p< .01$) resulting in an overall greater total effect (b = .18, $p < .01$).

Considering teacher background characteristics, there was a significant negative direct effect of years experience on content knowledge (b = -.24, $p < .001$) and years experience was found to have a positive direct effect on attitude toward mathematics (b = .11, $p < .05$). There was a positive direct effect of degree earned on content knowledge (b = .26, $p < .001$). The number of mathematics courses taken was found to have a positive direct effect on attitude toward mathematics (b = .13, $p < .01$). Teachers' background characteristics were not found to have any direct effects on either beliefs about effective instruction or instructional practices. However, the impact of these variables was mediated indirectly by both teachers' content knowledge and attitude. For example, mathematics courses taken was found to have a positive indirect effect on both instructional beliefs (b = .02, $p < .01$) and practices (b = .02, $p < .01$). Years of teaching experience was also found to have a positive indirect effect on both instructional beliefs (b = .05, $p < .01$) and practices (b = .06, $p < .01$). However, the indirect effect of degree earned was negative for both instructional beliefs (b = -.03, $p < .05$) and practices (b = -.05, $p < .01$). Because there were no direct effects for these variables the indirect effects represent the total effects.

Conclusions

Results from this study suggest that primary teachers (K-2) and upper elementary (3-5) teachers differ in their level of mathematical content knowledge and attitude toward mathematics. Upper elementary teachers were found to have higher levels of content knowledge and a more positive attitude toward mathematics than primary-level teachers. However, primary teachers reported using reform-oriented methods of instruction more frequently than upper elementary teachers. Beliefs in the use of effective instruction were not found to differ for primary and upper elementary teachers. Overall, teachers' beliefs in what constitutes effective mathematics instruction was found to be positively related to more frequent use of reform-oriented instruction. However, further investigation of this relationship suggests that teachers' actions do not always align with their beliefs as many teachers who professed the importance of reform-oriented instruction did not report frequent use of such instruction in their classroom (cf. Cooney, 1985).

After controlling for teachers' years experience, mathematics courses taken, and highest degree earned, teachers' content knowledge was found to have a negative relationship with teachers' beliefs and use of reform-oriented instruction. Teachers'

attitude toward mathematics was found to have a positive relationship with teachers' beliefs about effective instruction and ultimate use of reform-oriented instruction. Perhaps teachers who have higher content knowledge feel that since they were successful as a result of traditional instruction that such methods are adequate for their students. In other words, they tend to teach as they were taught. Although teachers' content knowledge is important in helping students to learn and understand mathematics, findings from this study suggest that higher levels of content knowledge alone may not transfer into instructional practices that help promote students' mathematical power beyond basic content knowledge. Teachers who have a more positive attitude toward mathematics may be more able to transfer positive beliefs about mathematics by incorporating what Bishop (1991, 2000) referred to as a mathematically enculturating curriculum that not only promotes students' content knowledge but also instills in them the ideas of mathematics as inquiry-based, as a way of thinking, and as an important part of everyday life. Thus, the importance of teacher education programs goes beyond the development of content knowledge and pedagogical content knowledge to also help teachers develop a positive attitude toward mathematics (e.g., Quinn, 1997) which based on this study may be more likely to transfer into positive instructional beliefs and practices.

The design of this study and the variables used limit the causal links that can be made between the predictor variables and teachers' instructional beliefs and practices. It is quite possible that there are other confounding variables that were not included in this study that may further explain the relationships that were found. For example, perhaps teachers are influenced by the beliefs and policies of their school or school principal. In other words, teachers who are in schools in which reform-oriented instruction is not supported may be less likely to use it even if they believe that it is more effective. Also, consistent with the findings of this study, past research suggests that upper elementary teachers are less willing to use reform-oriented strategies with their students than teachers of students in younger grades (e.g., see Hatfield, 1994 and Gilbert and Bush, 1988, for research on teachers' use of manipulatives). However, this may be due more to the fact that they teach the upper grades than that they have a higher level of content knowledge. In order to take this possibility into account it would be necessary to investigate the relationship between content knowledge and instructional practices across different grades levels. Future models of the relationship between teachers' content knowledge, attitudes toward mathematics and their instructional beliefs and practices would be strengthened by including variables to control for school administrative climate and grade level of teachers. However, even with these limitations, the findings from this study offer interesting insights into the relationship between these variables and provides teacher educators with additional evidence of the importance of enhancing teachers' attitudes toward mathematics as a possible way of encouraging the use of more reform-oriented instruction in the classroom.

Note

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