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ABSTRACT

This paper reports on a project that involved 16 middle school teachers incorporating fraction calculators into the mathematics curriculum. Teachers completed questionnaires prior to the beginning of the project and again two years later. Findings indicate that two years after the end of the project, teachers held positive attitudes or dispositions toward calculators and mathematics and showed no significant change in their beliefs about calculators and mathematics. Data suggest that mathematics teacher educators and the research community need to consider the benefits of short professional development programs in the reform movement, and learn how to reach into the school culture to support teachers' continued development of constructivist beliefs. The questionnaires and items analysis for each response set are included. Contains 21 references. (DDR)

The Effects of a 6 Month Professional Development Project on 5th and 6th Grade Teachers' Beliefs & Attitudes about Calculators 2 Years After the Project

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Abstract

Sixteen middle grade teachers who participated in a 6 month project focused on incorporating fraction calculators into the mathematics curriculum completed a questionnaire to assess their beliefs about calculators before the project began and 2 years later. Two years after the project ended the teachers 1) expressed positive attitudes or dispositions toward calculators and mathematics but 2) showed no significant change in their beliefs about calculators and mathematics. Mathematics teacher educators and the research community need to consider: 1) the benefits of short professional development programs in the reform movement, and 2) how to reach into the school culture to support teachers' continued development of constructivist beliefs.

One goal of mathematics education professional development projects is to introduce inservice teachers to innovations in teaching and learning but often after project support ends the innovation is not sustained in their teaching practice. Many factors contribute to this problem including the teachers' beliefs and knowledge about mathematics, their beliefs about the innovation, and their level of professional development. Researchers must continue to study the effects of projects for several years to learn which innovations are long-lasting and can withstand the pressures of the classroom and the school climates (Brown & Borko, 1992).

This study reports the effects of a project focused on calculator use in middle grade mathematics. It compares teachers' beliefs about calculator use before the project to their beliefs 2 years later, after participating in a project designed to teach them how to: 1) connect calculators to the middle grade mathematics curriculum, and 2) continue their professional development in mathematics after the project support ended. It was anticipated that after teachers participated in a project which exposed them to NCTM's constructivist philosophy of teaching, learning, and assessment (National Council of Teachers of Mathematics, 1989; National Council of Teachers of Mathematics, 1991; National Council of Teachers of Mathematics, 1995) through integrating calculators into the mathematics content they teach, and after teaching with calculators for 2 years in the classroom, that there would be significant changes in their beliefs about calculators.

A questionnaire was used to assess teachers' beliefs. Their responses to the questionnaire's Likert-scale items and open-ended items were compared to determine if significant changes in beliefs occurred.

Thompson (1992) synthesized the research about teachers' beliefs and conceptions. She reported that the nature of teachers' beliefs about the subject matter and about teaching and learning, as well as the influence of those beliefs on teachers' instructional practice are relatively new topics of study constituting largely uncharted areas of research. Studies in mathematics education (Dougherty, 1990; Grant, 1984; McGalliard, 1983; Thompson, 1984; among others), have indicated that teachers' beliefs about mathematics and its teaching, play a significant role in shaping their patterns of instructional behavior. Some Likert-scale items on the questionnaire addressed teachers' beliefs about teaching and learning mathematics.

Ernest (1989) reported that the three most notable elements influencing the practice of mathematics teaching are: 1) the teachers' mathematics knowledge, particularly their system of beliefs concerning mathematics and its teaching and learning; 2) the social context of the teaching situation, particularly the constraints and opportunities it provides; and, 3) the teachers' level of thought process and reflection. According to Ernest the research literature on mathematics teachers' beliefs, though scant, indicates that teachers' approaches to mathematics teaching depend fundamentally on their beliefs, in particular on their conceptions of the nature and meaning of mathematics, and on their mental models of teaching and learning. Some Likert-scale items and open-ended items on the questionnaire address these key elements noted by Ernest.

Thompson (1992) reported that there is a scarcity of reasoned discourse on beliefs. Researchers have noted that teachers frequently treat their beliefs as knowledge. However, it is "not useful for researchers to search for distinctions between teachers' knowledge and beliefs but, rather, to search for whether and how, if at all, teachers' beliefs--or whatever they might take to be knowledge--affect their experience." What teachers take as factual knowledge is dependent on their theory or theories of teaching and learning, and their conceptualization of the nature of mathematics. This can change over time as their theories change, thus allowing contradictions to coexist. Moreover, it is important that researchers make explicit, to themselves and others, the theory or theories of teaching and learning and the conceptualizations of the nature of mathematics with which they are approaching the study of teachers beliefs (Thompson, 1992). The teachers in this study were explicitly exposed to and reflected on theories about teaching and learning consistent with constructivist philosophy. However, their exposure within the context of this study was limited to the 6 month length of the project, and they were at varying points in their development, most having little prior exposure to constructivist philosophy except a few who were involved in whole language teaching and learning programs in their classrooms.

Green (1971) reported three dimensions to belief systems that are relevant to the results of this study. They are: 1.) a belief is never held in total independence from all other beliefs and some beliefs are related to others in the way that reasons are related to conclusions; 2.) there are two degrees of conviction, i.e. psychological strength--central beliefs, the most strongly held beliefs; and peripheral beliefs, most susceptible to change or examination; 3.) beliefs are held in clusters and protected from any relationship with other sets of beliefs. If beliefs about an innovation, such as calculator use, are peripheral to a person's central beliefs about mathematics, then the change in beliefs about calculators, over time, should reflect their beliefs about mathematics rather than about the innovation, calculators. Likewise, it seems that sustaining innovations in teaching and learning would be limited by the degree to which a project influenced teachers' beliefs and knowledge about mathematics, and enabled them to continue their development after the project support ended.

Brown and Borko (1992) summarized the research findings concerning teacher development. They noted patterns and implications for teacher development that inform us about teacher change. The studies reviewed found that: 1.) differences in teachers in terms of their developmental stage are not necessarily based on age or amount of experience; 2.) teachers' progression through developmental stages is not linear, but differs depending on what aspect of teaching is probed; 3.) teachers could be dealing with competing concerns related to self, task, and impact on students; and, 4.) teachers at low levels with respect to Perry's or Loevinger's developmental theories appear to have difficulty accepting varieties of approaches to teaching or viewpoints that deviate from the traditional, implying that teachers will tend to reject innovation and hold to traditional modes of mathematics teaching. These patterns suggest that a lack of change may be due in part to the fact that research has not been longitudinal, and that longer interventions or more experiences in the classroom may lead to greater developmental changes than have been noted to date. Brown and Borko (1992) in a study that looked at change over time after project support ended, also noted that there is little evidence to indicate whether the changes reported in studies are long-lasting or temporary.

There are a few studies that look at teachers' beliefs about calculators (Yvon & Downing, 1978; Bitter, 1980; Terranova, 1989; Schmidt & Callahan, 1992; Schmidt, 1993; Graber, 1993; Simon, 1990) while none that study changes in beliefs about calculators over time have been identified in the literature review. The purpose of this study was to determine if there were changes in teachers' beliefs and attitudes about calculators over time. The null hypothesis of this study is that there is no difference in teachers' beliefs and attitudes about calculators between pre and post questionnaire responses. Significant change in the pre and post mean responses to the Likert-scale questionnaire items and the open-ended statement responses would indicate that significant changes in teachers' beliefs about calculators, a subset of their beliefs about mathematics, took place and continued, over time. An analysis of their responses to the Likert-scale items and the open-ended statement responses concerning the project goals, would indicate their attitude or disposition, two years after the project.

The teachers in this study participated in a project that was aligned with constructivist philosophy and practices. They were exposed to and reflected on constructivist philosophy through discussion, readings, and action research, providing the opportunity for reflection during their professional development program and teaching experiences. The project focused on teaching and learning 5th and 6th grade mathematics with calculators, and on learning how to continue professional development in mathematics. "Inservice" and "availability of calculators" were identified by teachers in previous studies as the items most helpful to them in facilitating the integration of calculators into mathematics programs (Schmidt & Callahan, 1992) and the project satisfied those needs. Moreover, in the project calculators were used to promote concept development, reasoning, and problem solving within the 5th & 6th grade curriculum rather than to do computation which was reported by teachers in another study as the main use of calculators (Terranova 1989). This study is significant because it provides insights into teacher change, and whether or not change is sustained after project support ends.

Project summary

The professional development project was designed by members of the regional consortium of schools and university in the midwest to meet the needs of fifth and sixth grade teachers who were implementing new mathematics courses-of-study that compared favorably with the state curriculum and the National Council of Teachers of Mathematics *Curriculum and Evaluation Standards for School Mathematics.* The project goals were to improve teachers' understanding of mathematics content, their facility in use of fraction calculators, and their methods of using calculators as an instructional tool, while preparing a cadre of teachers who: 1) understood the mathematics content of the new curriculum, and 2) learned how to continue their professional development in mathematics.

The project was held over a 6 month period; during a one week summer workshop/course the teachers were exposed to mathematics content, and used calculators to explore 5th and 6th grade concepts and applications. While learning about calculators and content, they experienced pedagogy and assessment appropriate to transfer to classroom practice, however, methodology was not the emphasis of the project. Working in teams, teachers designed action research projects to take back to the classroom at the beginning of the school year. Throughout the one week session teachers: kept reflective journals; reviewed and evaluated teaching materials; read and reacted to journal articles they selected from topics such as constructivism, research about calculators, action research, research about rational number, procedural and conceptual knowledge, activities with calculators, etc.; and, participated in and led small group and large group discussions. The following autumn quarter teachers continued their professional development. The results of their action research projects were shared with colleagues at after school meetings. Teachers also attended the state mathematics conference, and co-hosted a conference for teachers and principals where they presented sessions on using calculators in mathematics.

Method

Participants

Teachers in this study are a subset of the original group of 34 project teachers. Teachers' questionnaires from the follow-up session were matched with their pre-project questionnaires. All but 1 of the teachers were white females who taught in 13 different elementary schools (12 public, 1 private) in urban, small cities and towns, and rural districts near a midwestern university regional center. The schools served populations of minority students and economically disadvantaged students. All teachers taught 4th, 5th, and/or 6th grade level students.

Teachers applied to participate in the project through the mathematics and science consortium (Schmidt, 1994) that served their schools. A grant from Eisenhower funds for mathematics and science, which typically support projects up to 1 year in length, funded this project. Support was provided for 50, 5th and 6th grade teachers, about half of the 5th and 6th grade mathematics teachers in regional schools served by the consortium. However, there were only 38 applications for the project, and 5 applications were from 4th grade or 4th/5th grade teachers who were accepted into the project because of the available space. Four male teachers left the project after the first half day session reasoning that sports programs prohibited them from ongoing participation in the project. Therefore, 34 teachers participated in the first part of the project; 32 of them completed the pre-project questionnaires. [Thirty-three teachers completed the second part of the project.]

The teachers were given materials for participating in the project. They received: 15 fraction calculators, 1 overhead fraction calculator, $100 to spend on teaching materials for the classroom, assorted materials such as NCTM Addenda books, journal articles, and stipends for substitute teachers so that they could attend the state mathematics conference. The teachers' building principals signed an agreement promising to support the teachers throughout the project.

In spring, of the second school year after the project, teachers were contacted by mail and asked to attend a 2 hour follow-up session at the university. (Another follow-up questionnaire was sent to teachers after the first year of the project, however, only 6 teachers replied to all 3 questionnaires, and that data is not reported in this study.) An agenda was sent to them along with the promise to distribute 200 calculators to those who attended the session. Twenty teachers responded to the letter; calls were not made to non-respondent teachers, and post questionnaires were not sent to them by mail. No doubt the promise of more calculators motivated some teachers to attend the session, and others who wanted to attend where not able to come on the day the meeting was scheduled.

<u>Data collection</u>

The questionnaire was an adaptation of an instrument designed to assess teachers' (and principals') beliefs about calculators (Terranova, 1989; Schmidt & Callahan, 1992). The development of the instrument was presented in Terranova (1989), and a summary follows.

> A two part questionnaire was developed as an assessment instrument; a review of the literature did not find one suitable to assess teachers' (and principals') beliefs about calculators. In the first part of the questionnaire, respondents were asked personal and professional descriptors: educational position, gender, location of district, length of experience in education, length of teaching experience, grade level teaching experience, calculator inservice/workshop experience, college course experience with calculators, and calculator availability. The first part included open-ended questions concerning what has hindered calculator use, what would help facilitate the integration of calculators, and how calculators were made available and used in schools.
>
> In the second part of the questionnaire, practitioners were asked to respond to 31 statements from the point of view of the educational position they held during the school year. A six point Likert-type scale (1--strongly agree, 2--agree, 3--

slightly agree, 4--slightly disagree, 5--disagree, and 6--strongly disagree) was used to encourage thoughtful responses to statements, rather than an "undecided" response.

Several steps were taken to insure statement and questionnaire quality. The statements were based on information from research, a preliminary survey, and discussions with educators. They were reviewed twice: first, by four doctoral students to determine ambiguous statements, and again, after revision, by seven experts in mathematics education to determine the statement's importance. The final selection of statements centered on the recommendations made by the experts, thus providing face validity of the instrument.

The final form of the questionnaire gave attention to techniques that strengthened its design such as randomly arranging statements, choosing an 'easy to respond to' first statement, embedding a lie factor statement, and asking open-ended questions.

For this study, minor changes were made on the questionnaire to better align the statements with the point of view of the respondents, and to clarify the wording of statements. For example, statements using the words "elementary" school were changed to "middle" school.

The questionnaires were distributed during the first session of the summer program before instructional activities began and at the end of the follow-up session (the follow-up session will be referred to as 'post' session in the remainder of the article). On both the pre and post questionnaires, teachers completed the same questions on Part A and Part B. However, Part C was added to the post session questionnaire that asked teachers use the Likert-scale to responded to 5 statements about the project's goals and to support /explain their response.

Demographic data and teacher's notes on the post questionnaire were used to match pre and post questionnaires. Teachers anonymously completed the questionnaires and voluntarily gave information at the post session that would allow their questionnaire to be matched with their pre-session questionnaire. For example, one teacher noted that she had changed grade level in the last year.

Data analysis techniques

Statview was used to analyze data. Descriptive statistics and frequency distributions were calculated for the Likert-scale items. An alpha level of .05 was used for all statistical tests. Open-ended questions were transcribed verbatim, and responses were classified into categories, beginning with categories identified in earlier studies, and adding new categories as they emerged. The data was summarized on tables. Patterns were noted throughout the analysis.

The following section will present the results of the study.

Results

Statement responses

The correlation between pre and post test item responses was high (r = .963). The differences between the pre and post item mean responses were not significant [df: 28; paired t: 1.889; p: .069]. To query teachers' orientation towards a Standard-like constructivist perspective, it was hypothesized that there was no difference between their responses and those most representative of a constructivist oriented response. When their mean scores were oriented toward a constructivist response (1) on the pre and post questionnaire, there were significant differences on the pre and post questionnaire responses: pre questionnaire responses [df: 15; t: 12.123; p: .0001]; post questionnaire responses [df: 15; t: 16.141; p: .0001]. However, there was no significant difference between their pre and post mean responses [df: 15; t: 1.879; p: .080].

The 29 statements were categorized into 2 subsets (17 associated with teaching and learning in the classroom micro culture and 12 associated with other influences in the school macro culture on calculator use) for reporting and discussion purposes. The lie-factor statement and a statement which was relative to school district's policy were removed from the data. Tables 1 and 3 present the mean and standard deviation for the statements within the 2 subgroups on the pre and post questionnaire. A mean written in boldface and italic print indicates strong agreement (mean range is ≥1, and < 2) and a mean written in boldface print indicates strong disagreement (mean range is > 5, and ≤ 6).

Responses are summarized on Table 2 and Table 4 for each subgroup. Means ranging from 1 to ≤ 2.5 indicated agreement ("A") and means ranging from 4.5 to ≤ 6 indicated disagreement ("D") while means ranging from 2.5 to 4.5 tended to express an uncertain ("U") response to the statements. The symbols "+" or "-" indicate whether the response to the post statement tended to move toward or away from the pre statement response i.e. it shows movement toward stronger "A" or "D" or weaker "A" or "D".

Statements associated with teaching and learning in the classroom's micro culture

On both the pre and post questionnaire teachers expressed strong beliefs about 5 statements (items #1, #2, #6, #7, & #9) associated with teaching and learning in the classroom.

insert Table 1 about here

Moreover, teachers strongly agreed with 7 statements on the post questionnaire (items #4, #13, #18, #19, #20, #28, & #31).

The responses to the statements in this subgroup are summarized on Table 2.

insert Table 2 about here

Statements associated with other influences in the school's macro culture on calculator use

Teachers expressed strong beliefs about 4 statements (items #3, #12, #23, & #24) in this subgroup of statements (see Table 3).

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insert Table 3 about here

Moreover, on the post questionnaire they tended to strongly disagree with item #14.

The responses to the statements in this subgroup are summarized on Table 4.

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insert Table 4 about here

Open-ended question responses

Teachers were asked "What do you think would be most helpful in facilitating the integration of calculators into mathematics curriculums?" On both the pre and post questionnaire teachers reported that availability of calculators and inservice programs would most help them use calculators in mathematics. There were 8 items cited on both the pre and post questionnaire (see Table 5).

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insert Table 5 about here

When asked "What do you feel has most hindered calculator use in mathematics programs?" teachers' responses varied (see Table 6) but lack of inservice and lack of calculators were frequently cited as constraints to calculator use in mathematics programs. On the pre questionnaire the most frequently cited constraint to calculator use was teachers' concerns about negative effects of calculator use on students. Teachers cited 6 constraints on the pre questionnaire and 12 on the post questionnaire.

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insert Table 6 about here

When asked "In what ways do students in your classes use calculators?" teachers most frequently reported that they were used for problem solving and for checking problems (see Table 7). A frequent pre questionnaire response was a name of a particular topic in mathematics that calculators might be used for such as decimals or fractions; a frequent post questionnaire response was "for exploring mathematics."

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insert Table 7 about here

Project goals

Teachers' Likert-scale responses to the statements regarding the project goals are presented in Table 9. They strongly agreed that as a result of participating in the project that they improved in their ability to use calculators to explore mathematics concepts.

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insert Table 8 about here

Discussion

Statement responses

The t-test indicated that there were no significant differences between teachers' pre and post responses. However, changes between pre and post responses to some items merit further discussion.

Overall, 12 statements showed a $\geq .5$ change in the response between the pre and post questionnaire (see Table 8). There was a change of ≥ 1 on 2 statements, items #15 and #31. It is disturbing to see that teachers became more uncertain in their beliefs that calculators helped students to learn, retain, and internalize number facts (#15) after 2 years of using calculators with students. Indeed, they agreed that calculators helped students learn number facts on the pre questionnaire but tended to disagreed with the statement on the post questionnaire. This belief was reiterated in their open-ended responses; they said students were not retaining number facts (see Table 5). (Discussion continued in the Implications section.)

Teachers tended to become stronger in their belief that calculators do not cause inequities between students from wealthy and poor backgrounds (#31). Since teachers in this study were given 15 calculators their response to this statement may have changed due to the fact that they had calculators readily available to use in the classroom. Would teachers' responses be the same if the students were responsible for supplying calculators?

On 10 items, there was a change of $\geq .5$ to < 1 in mean responses (see Table 8). Teachers tended to become stronger in their beliefs about many positive effects of calculator use many of which are supported by research studies.

Although the change in the responses indicated teachers' slight agreement that paper-pencil computing techniques that promote understanding should be taught over techniques that are 'speedy' and efficient (#30) there was variability among the responses. Do teachers know that there are different computing techniques or do they only know the traditional algorithm? Judging the merits between teaching computing techniques that promote understanding and evolve from students' work with number and those that are speedy and efficient would be difficult if teachers were not familiar with various computational methods and this may explain varying responses to this item.

Teachers' views of what helps and constrains calculator use

Teachers reported that inservice programs and availability of calculators are most helpful in integrating calculators into mathematics. Likewise, many teachers reported that lack of inservice and calculators were constraining calculator use. The teachers were given 15 calculators and an overhead calculator as a part of the project, however, on the post questionnaire some said they needed one calculator per child in the classroom while others, who previously had some calculators, were glad to now have one calculator per student.

Some teachers seemed to feel empowered to use calculators. One reported on the post questionnaire,

> I learned a great deal in the workshop and college course that I teach on using the calculator in the classroom. However, I have found that actually teaching with the calculators has been the best learning experience. I have not felt hindered by anything. We use the calculator on a daily basis.

Teachers' view of how students use calculators

The increase in using calculators for problem solving and exploring was a positive step toward Standards-like, constructivist mathematics. However, some teachers mentioned using calculators for computation and some teachers said they were used only for computations such as checking work and for grade averages. One teacher said her students used calculators "to check their progress, along with mental math activities." Another teacher said "Checking estimation, story problems, proving a process or a concept." Although calculators might now be a part of the mathematics program, these responses suggest that using calculators for computation continues to be the way they are used in many classrooms.

Project goals

The teachers tended to agree that they met the project's goals (see Table 8). Their strongest responses indicated that they improved in their ability to use calculators to explore concepts, and secondly, that they have become part of a cadre of teachers who advocate calculator use. One teacher said,

> Before this project, I never even knew the difference between an arithmetic and an algebraic calculator. I now do many more things with problem solving.

Another teacher said,

> Calculators are a part of my mathematics program. I have begun my last two years by introducing the calculator, its different functions, keys, etc. anticipating its use

> within my classroom throughout the year. I'm not sure I would have done that without your support.

Teachers commented on the ways they encouraged other teacher to use calculators. Typical responses were similar to this teacher's comment,

> I have encouraged teachers in my building to use calculators in various strands and have shared ideas, NCTM books, and calculators.

Overall, the response concerning the project goals were strong. Teachers expressed a positive attitude toward calculators and toward the professional development activities they engaged in during the project. However, comments about continuing professional growth after the project were sparse; only one teacher mentioned presenting at the state conference after the project.

Implications

NCTM's Curriculum and Evaluation Standards for School Mathematics (1989) restated NCTM's 1970's position advocating calculator use. This is not a new idea in mathematics education. However, the results of this study show that there was little change in the teachers' beliefs about calculators after the project support ended and little movement toward more Standards-like, constructivist mathematics. Students were using calculators, but one needs to question what they were doing with the calculators and whether or not the mathematics in the classroom was indeed more Standards-like. There is evidence from the Likert-scale responses and open-ended responses to suggest that computation with standard algorithms and checking answers using calculators was an important part of many mathematics programs. However, after the project the teachers tended to express a positive attitude toward its goals.

Moreover, the results suggest that teachers' concerns about students 'knowing' number facts and computing techniques (see Table 9) have not yet been resolved and that those concerns are affecting calculator use. On one level this suggest that changes in teachers' perspective of mathematics needs to take place to help them develop a constructivist philosophy and on another more practical level it suggests that K-4 mathematics teaching and learning also need to be aligned with this philosophical perspective to resolve the middle grade teachers concerns.

The teachers understood that extensive use of calculators made estimation and mental calculation increasingly important skills to be taught and that this belief increased after having taught with calculators for 2 years. However, it appears they may need help in generating solutions to the "knowing facts" problem because the solution may lie outside of their classroom. Indeed, the more uncertain responses in the subgroup related to other factors influencing calculator use in schools suggests that teachers give little thought to other factors in the macro school culture that affect teaching and learning. If their view of mathematics is limited to the perspective of their classroom and grade level they may not understand that the long term solution to their concerns about number facts may lie outside their classroom in primary grade mathematics programs. Given a more macro view of curriculum and what affects the classroom, one would need to question whether or not teachers are in leadership positions in their schools to articulate and ameliorate the needs for developing students number sense across the grade levels. The involvement of other school personnel, such as curriculum directors and administrators, are needed to solve this problem.

Conclusions

The teachers expressed positive attitudes or dispositions toward calculators after participating in a 6 month project but no significant change occurred in their beliefs about calculators 2 years after the project. Mathematics teacher educators and the research community need to consider the positive benefits of short professional development programs in the reform movement. The teachers expressed positive attitudes about the project's goals -- to improve their understanding of mathematics content, to improve their facility in use of fraction calculators, to improve their methods of using calculators as an instructional tool, to prepare a cadre of teachers who understood the mathematics content of the new curriculum, and to show teachers how to continue their professional development in mathematics after project support ended. However, to influence teachers' beliefs, more on going support is needed. Mathematics teacher educators and the research community need to consider how to reach into the school culture to support teachers' development of constructivist beliefs.

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Table 1

Responses Associated with Teaching and Learning in the Classroom Micro Culture

	Statement	Pre Mean (SD)	Post Mean (SD)
1.	Instructional strategies using calculators need to be introduced, developed, and encouraged in middle grade mathematics programs.	***1.400*** (.507)	***1.250*** (.447)
2.	If calculators are used in school mathematics programs, students no longer need to know paper-pencil computing techniques.	**5.667** (.488)	**5.750** (.447)
4.	If used extensively in middle grade programs, calculators will become a 'crutch' to students and negatively effect mathematics thinking ability.	4.867 (1.877)	**5.062** (.854)
6.	There is a need to know, and better understand, how to incorporate calculator use into the regular mathematics instructional program.	***1.200*** (.414)	***1.438*** (.512)
7.	Calculators are tools that allow students to focus more attention on mathematics concept development and understanding.	***1.467*** (.640)	***1.438*** (.512)
9.	Students who use calculators lose sight of the importance of mathematics.	**5.133** (.743)	**5.312** (.873)
11.	Lack of instructional time in middle grade mathematics programs makes it difficult to introduce and use calculators.	3.867 (1.598)	3.875 (1.586)

table continues

	Statement	Pre Mean (SD)	Post Mean (SD)
13.	Extensive use of calculators makes estimation and mental calculation increasingly important skills to be taught.	2.267 (1.163)	***1.375*** (.500)
15.	Using calculators helps students learn, retain, and internalize number facts.	2.867 (1.356)	3.938 (1.340)
17.	Students who use calculators in middle grade mathematics programs do not understand the basic operations as well as those not using calculators.	4.733 (1.033)	5.000 (.816)
18.	Calculators make more mathematics content teachable through the use of student explorations---trial-error, guess-test, etc.	2.188 (1.047)	***1.562*** (.512)
19.	Calculators confuse and inhibit middle grade students' learning of mathematics.	4.875 (.885)	**5.438** (.512)
20.	Using calculators decreases student motivation in mathematics class.	5.000 (1.265)	**5.750** (.447)
21.	Students who use calculators learn mathematics better than those who do not use them.	2.600 (.986)	3.062 (1.237)
22.	Calculator use benefits student achievement in problem solving.	2.500 (1.592)	***1.938***(1.181)
28.	Using calculators causes students to forget how to do paper-pencil calculations.	4.562 (.892)	**5.188** (.834)

table continues

	Statement	Pre Mean (SD)	Post Mean (SD)
30.	If calculators are used in middle school mathematics programs, paper-pencil computing techniques that promote understanding should have precedence over techniques that are 'speedy' and efficient.	4.062 (1.124)	3.438 (1.413)
31.	Using calculators in middle grade mathematics programs will contribute to learning inequities between students from wealthy and poor backgrounds.	4.286 (1.490)	**5.312** (.873)

Note: A mean written in ***boldface and italic*** print indicates ***strong agreement*** (mean range is ≥1, and < 2), and a mean written in **boldface** print indicates **strong disagreement** (mean range is > 5, and ≤ 6).

Table 2

Summary of Responses Associated with Teaching and Learning in the Classroom Micro Culture

Statement	Pre	Post	direction of change	change
1.	A	A	+	.150
2.	D	D	+	-.083
4.	D	D	+	-.195
6.	A	A	-	-.238
7.	A	A	+	.029
9.	D	D	+	-.179
11.	U	U	+	-.008
13.	A	A	+	.892
15.	A	D	*	-1.071
17.	D	D	+	-.267
18.	A	A	+	.626
19.	D	D	+	-.563
20.	D	D	+	-.750
21.	A	D	*	-.462
22.	A	A	+	.562
28.	D	D	+	-.626
30.	U	D	-	.624
31.	D	D	+	-1.026

Key: "A"--agree; "D"--disagree; "+" -- post mean moves toward stronger agree or disagree; "-" post mean moves toward lesser agree or disagree; "*" post mean changes orientation; "0" no change between pre and post mean.

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