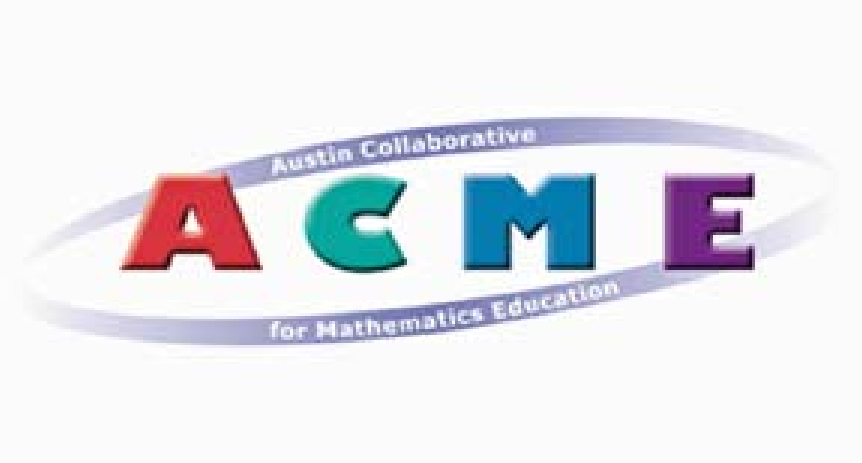
Austin Collaborative for Mathematics Education

2001-02 Final Evaluation



Austin Independent School District
Office of Program Evaluation
October 2002

EXECUTIVE SUMMARY

The Austin Collaborative for Mathematics Education (ACME) was an initiative begun in August of 1997 to improve mathematics education in all elementary and middle school classrooms in Austin Independent School District (AISD) by providing teachers with long term, high quality professional development. This initiative, which was funded by the National Science Foundation (NSF) and the district, supported teachers as they implemented the district's curriculum resources *Investigations in Number, Data, and Space* and *Connected Mathematics Project* (*CMP*). These resources are aligned with the state standards for mathematics in the Texas Essential Knowledge and Skills (TEKS) and the national standards set by the National Council of Teachers of Mathematics (NCTM). These standards focus on broadening the topics taught at all grade levels, developing students' mathematical thinking, and deepening students' conceptual understanding through concrete experiences. The standards contrast with traditional mathematics education which is characterized by rote memorization and computation practice.

ACME professional development was designed to help teachers deepen their knowledge of mathematics content and inquiry-based pedagogy as well as to grow as a community of learners. Every elementary and middle school mathematics teacher, including general education, special education, and bilingual teachers, was expected to participate in two years of summer institutes and follow-up days during the academic year. To promote districtwide change, the ACME project focused on the development of professional school cultures, administrative and teacher leadership, and community and parent involvement.

LESSONS LEARNED FROM THE ACME PROJECT

The ACME project provided model long-term professional development for AISD mathematics teachers. Five years after the project began, implementation was evident in some but not all classrooms in the district. Among AISD teachers who implemented the resources and inquiry-based instruction, most teachers appeared to reach moderate levels of implementation of inquiry-based mathematics. Although AISD has had components of mathematics education reform in place over the course of the NSF grant, reforms have been unstable and inconsistent across the district.

Two main lessons were learned from the implementation of the ACME project in AISD:

1. District and campus leaders needed to demonstrate unyielding commitment to inquiry-based curriculum and instruction, unequivocal expectations for implementation on campuses, and knowledge about high quality implementation. Leaders needed to back implementation solidly before the ACME project rolled out professional development for teachers, which has implications for other AISD initiatives (i.e., the partnership with the Institute for Learning).
2. Teachers with different levels of experience and interest in inquiry-based instruction needed individualized, ongoing support for implementation. To hone pedagogical skills and integrate mathematics content knowledge into instruction, teachers needed more professional development that directly related to their own practice such as coaching, mentoring, and other collaborative opportunities to try out and practice new skills. The ACME project was not designed to provide ongoing support to individual teachers across the district in this way.

ACCOMPLISHMENTS OF THE ACME PROJECT

- The ACME project changed mathematics education in AISD: All AISD elementary and middle school mathematics teachers had high quality materials that focused on key concepts in mathematics and provided activities that made mathematics meaningful for students.
- The ACME project, in conjunction with the state accountability system, helped make mathematics a focus across the district. The length of AISD mathematics lessons and the emphasis on the quality of mathematics instruction improved since the ACME project began.
- The ACME project focused district staff on aligning curriculum to the TEKS. In anticipation of the state's new assessment the Texas Assessment of Knowledge and Skills (TAKS), ACME staff prepared a curriculum framework to help teachers plan lessons using inquiry-based mathematics resources to address the TEKS.
- The ACME facilitators became the backbone of mathematics reform in the district by facilitating professional development, developing products, and negotiating support.

BARRIERS TO REFORM

- The high levels of staff turnover among teachers, principals, project staff, and district administrators made reform difficult to sustain and compromised the quality of implementation in AISD classrooms. As a result, the message that inquiry-based mathematics was the expected curriculum in AISD classrooms was sometimes blurred.
- Opposition to reform efforts under the ACME project was not sufficiently addressed among AISD staff and parents.
- As part of a large urban district, some campuses in AISD were in such crisis that adopting a new approach to instruction was a luxury that staff thought they could not afford. The constraints of the state accountability system also drew attention to test preparation and away from inquiry-based instruction, especially when the case for alignment with the state assessment was questioned.

RECOMMENDATIONS

- Continue to implement inquiry-based mathematics instruction in AISD elementary and middle school classrooms and expand implementation to the high schools because inquiry-based instruction is associated with high student mathematics achievement in the Texas Assessment of Academic Skills (TAAS), especially in problem solving skills (Batchelder, 2001), which should prepare students for the new state assessment, the TAKS.
- Improve the quality of implementation of inquiry-based mathematics instruction as follows:
  a. To promote sustainability, choose curriculum initiatives that align across disciplines and make them mandatory.
  b. Develop and maintain support for inquiry-based instruction especially in light of turnover among administrators. Organize mentoring relationships among administrators supportive of reform and those who are lukewarm or new to the district.
  c. Build on the expertise of teachers (i.e., via mentoring relationships) so that teachers with knowledge and skills in inquiry-based instruction support others' professional development. Resolve constraints on time during the school day to allow for coaching and collaboration to help teachers improve pedagogical skills and content knowledge.

PREFACE

The purpose of this report is to provide local administrators with information that may be useful for decisions about the future course of AISD's mathematics curriculum and instruction and about other initiatives. Teachers, principals, parents, and community members may also benefit from information about implementation of inquiry-based mathematics instruction. An earlier version of this report was submitted to Horizon Research, Inc. (HRI) to complete the 2001-02 Core Evaluation of the Local Systemic Change initiative required for National Science Foundation (NSF) funding.

ACKNOWLEDGEMENTS

We greatly appreciate the time spent by AISD mathematics curriculum staff, AISD elementary and middle school principals, and AISD elementary and middle school mathematics teachers who participated in the evaluation. Without their contributions, this comprehensive evaluation would not have been possible.

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OVERVIEW

In August of 1997, the Austin Independent School District (AISD) launched the Austin Collaborative for Mathematics Education (ACME) initiative to improve mathematics education in all elementary and middle school classrooms using inquiry-based curriculum resources and instruction. The National Science Foundation (NSF) and AISD funded the initiative, which is a collaborative with the Charles A. Dana Center and the University of Texas at Austin. The ACME project served over 3,000 AISD educators who taught about 55,000 students at 74 elementary and 17 middle schools in a district of approximately 77,000 students.

The ACME project offered every elementary and middle school mathematics teacher a minimum of 100 hours of professional development through summer institutes and follow-up sessions for two years. Some teachers also participated in campus support, such as lesson modeling and collaborative planning, and ACME staff supported mathematics specialists who were available to teachers on campuses. The intent of ACME professional development was to build teachers' capacity to deliver effective mathematics instruction to all students, to ensure consistent implementation of quality mathematics curriculum resources across the district, and to provide ongoing support for teachers and administrators as they implemented inquiry-based curriculum and instruction. Specifically, district staff designed ACME professional development and campus support to help teachers grow as a community of learners and deepen their knowledge of mathematics content, pedagogy, and classroom management for inquiry-based mathematics instruction.

ACME provided elementary and middle school mathematics teachers with the opportunity to participate in a series of professional development activities over a period of two years. Special education, bilingual, and English as a Second Language (ESL) teachers were also included in the second year of the ACME project. Participants began their professional development with a summer institute lasting two weeks and continued with four to five follow-up days during the academic year. The second year involved a three-day summer institute and three to four follow-up days. Teachers were paid a stipend to attend the summer institutes and follow-up sessions outside school hours. Substitutes were provided to release teachers during the academic year.

In the initiative's first year, ACME professional development began for teachers at the transition between elementary and middle school so that students would have consistent mathematics instruction from one year to the next. In the summer of 1997, fifth and sixth grade teachers began ACME professional development, followed by fourth and seventh grade teachers in the summer of 1998, and second, third, and eighth grade teachers in the summer of 1999. Most kindergarten and first grade teachers began ACME professional development in the summer of 2000. Some kindergarten and first grade teachers, who were not yet targeted for implementation, chose to attend two days of professional development during the 1999-2000 school year because the district adopted the inquiry-based texts in the spring of 1999. Although most schools in AISD implemented ACME professional development by grade levels, eight pilot elementary schools implemented at all grade levels simultaneously. Three pilot middle schools participated in the NSF-funded State Systemic Initiative (SSI), which provided teachers professional development in inquiry-based instruction beginning with sixth grade mathematics teachers in the summer of 1996. Pilot schools received modified summer institutes: fewer days of summer institutes and follow-up sessions, in exchange for campus support such as modeling lessons and conversations about curriculum and instruction. In the 1999-2000 school year, ACME staff continued to work with one pilot school that requested ongoing support.

To accommodate the needs of AISD teachers and administrators, ACME staff adjusted the original design of the ACME project by adding professional development on Saturdays and evenings and adding overviews for late hires. To address teacher turnover (about 20% of teachers leave each year), ACME staff continued to offer summer institutes and follow-up at each grade level for teachers new to the district or who had not yet participated in ACME professional development. In addition, during the fourth year, ACME professional development for middle school teachers was divided into content knowledge and implementation workshops.

Through matching funds, AISD supplied curriculum resources, which consisted of teachers editions and the manipulatives needed for the activities designed in the units. The resources were based on standards set by the National Council of Teachers of Mathematics (NCTM, 1989, 1991, 1995), by the state in the Texas Essential Knowledge and Skills (TEKS), and by AISD's Mathematics Department. In the spring of 1999, the

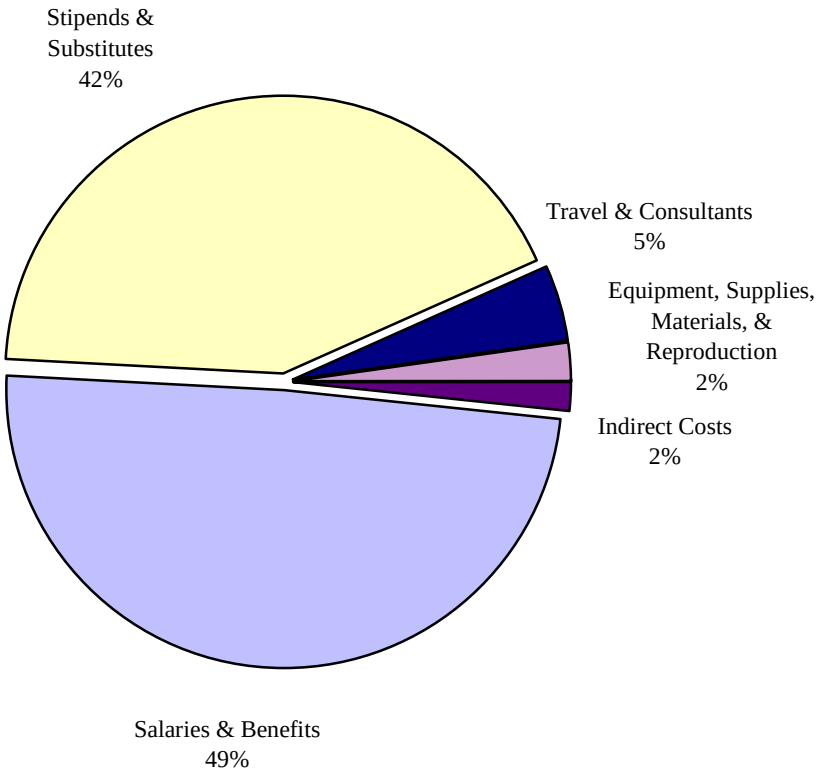
district adopted the curriculum resources of *Investigations in Number, Data, and Space* for elementary grades and *Connected Mathematics* (CMP) for middle grades, and purchased these materials. AISD also adopted the resources of *Math in My World* (English version)/*Matematicas in Mi Mundo* (Spanish version) for elementary grades and *Mathematics: Applications and Connections, Courses 1-3* (English version)/*Matematicas: Aplicaciones y Coneciones, Cursos 1-3* (Spanish version) to supplement TEKS areas not addressed in the other resources.

To foster districtwide change in mathematics education, the ACME project promoted leadership and the development of school cultures in which communities continually improve mathematics teaching and learning. ACME staff provided professional development for district and campus administrators to build knowledge of inquiry-based mathematics curriculum resources and instruction and to help campus leaders develop strategies for supporting teacher implementation. ACME professional development for leaders was needed due to turnover in district and campus administrators. The ACME project also customized ACME professional development for a group of teacher leaders so that they might facilitate sessions and support their peers at the campus level in a variety of ways, including peer coaching, demonstration teaching, and information sharing. To garner parent participation in the mathematics curriculum, the project staff provided schools with materials such as pamphlets and videos in English and Spanish as well as assistance with organizing parent education and involvement (e.g., parent math nights).

NSF Funding for the ACME Project

During the 2001-02 school year, the total expenditure of NSF funds for the ACME project was $1,173,371. The NSF funding per elementary and middle school student was about $21.33 during the final year of the ACME project. About half of the NSF funds, which summed to $580,951, went to the salaries and benefits for ACME staff. The next highest expenditure of NSF funds (42%), which totaled $499,409, went to pay stipends for teachers and substitutes for release time so that teachers could attend ACME professional development. Less than 10% of NSF funds was spent on travel ($25,141), consultants ($29,101), equipment ($7,500), supplies and materials ($6,677), reproduction ($6,000), and indirect costs to AISD ($18,592).

Figure 1. NSF Grant Expenditures for the ACME Project, 2001-02



Source: Finance Records of the ACME project, Summer 2002

DATA SOURCES

Data sources are briefly described in this section so that results can be discussed without describing the data collection repeatedly. NSF subcontracted Horizon Research, Inc. (HRI), a research organization that specializes in science and mathematics curriculum and instruction, to design the data collection methods and measures.

PROFESSIONAL DEVELOPMENT OBSERVATIONS

The evaluators observed and rated five ACME professional development sessions on an 8-point scale using the Professional Development Observation Protocol[1] during the 2001-02 school year. The protocol includes ratings of the design, implementation, mathematics content, pedagogy, leadership content, and culture of the sessions according to National Staff Development Council (NSDC) standards for effective professional development. To vary the types of ACME professional development observed, sessions were selected to include: (a) different campus levels (i.e., elementary and middle schools teachers), (b) different locations (i.e., on campuses and at AISD's Professional Development Academy), and (c) different target audiences (e.g., new to the district, special education, etc.). Two additional professional development sessions for AISD administrators about rigor in mathematics instruction were observed.

LONGITUDINAL CLASSROOM OBSERVATIONS

In Spring 2002, evaluators observed a random sample of 16 mathematics lessons given by teachers who were observed in Spring 1999 and 2000. (Sixteen teachers were originally contacted in Spring 2002, and six randomly drawn teachers were contacted to replace those who were ineligible or declined; one had resigned from AISD; one had become an instructional specialist; and four declined to be observed again.) The evaluators were certified to rate reliably the quality of implementation of inquiry-based mathematics instruction on an 8-point scale using the HRI Classroom Observation Protocol[1]. The protocol includes ratings of the design, implementation, mathematics content, and classroom culture of the lessons. All but one of the classroom observations were in elementary classrooms because the sampling frame of all AISD mathematics teachers included more elementary school teachers than middle school teachers.

[1] For measures, see http://www.horizon-research.com/LSC/manual.

TEACHER INTERVIEWS

Ten randomly selected mathematics teachers, most of whom (8 of 10) had participated in 60 or more hours of ACME professional development, completed phone interviews. (Thirteen teachers were contacted, but two had changed positions in AISD and one declined to participate.) The interviews included questions concerning teachers' thoughts and feelings about ACME professional development, changes in practice, and school and district policies that facilitate or hinder reforms in mathematics education[2].

TEACHER QUESTIONNAIRES

A random sample of 300 AISD elementary and middle school mathematics teachers were sent questionnaires, and 194 teachers of the 239 eligible returned valid questionnaires (return rate, 81%). One-third (32%) had taught school for 5 years or less, one-third (30%) had taught for 6 to 15 years, and 38% had taught for 16 years or more. The questionnaire surveyed teachers' beliefs about mathematics instruction, preparation, classroom practice, mathematics content knowledge, perceptions of district support, and experiences in ACME professional development[2].

PRINCIPAL QUESTIONNAIRES

All but one of the AISD middle school and elementary principals completed a questionnaire about inquiry-based mathematics and ACME professional development[2].

ADDITIONAL SOURCES

Additional sources of information included interviews with district and ACME project staff[2], observations of district and project meetings, district mathematics curriculum documents, professional development materials, brochures, letters, and newsletters.

[2] For measures, see http://www.horizon-research.com/LSC/manual.

RESULTS

The results are divided into three sections including the quality and impact of ACME project, support for ACME reforms, and the institutionalization of these reforms.

QUALITY AND IMPACT OF THE ACME PROJECT

Three of the five professional development observations conducted during the 2001-02 school year were rated as "beginning stages of effective professional development" in quality on the HRI Professional Development Observation scale[3]. The quality of one session was rated high as "accomplished, effective professional development" on the HRI scale[4], and the quality of one was rated low as "elements of effective professional development."[5] The design, implementation, exploration of pedagogy/materials, and culture of the sessions were rated as moderately effective (i.e., median 3 on a 5-point scale), and the mathematics content was rated as somewhat higher (i.e., median 3.5 on a 5-point scale) than the other areas reflecting current standards for mathematics education.

Culture of ACME Professional Development

According to NSDC standards, the culture of professional development needs to allow opportunities for teachers to be both learners and reflective practitioners. This section presents an analysis of the degree to which ACME professional development provided teachers with such opportunities during the 2001-02 school year.

Atmosphere of Trust, Respect, and Openness

On the basis of the five professional development observations, the atmosphere of trust, respect, and openness to ideas in most ACME professional development sessions made them conducive to open communication. In general, ACME facilitators and participants communicated ideas together freely and demonstrated respect for other people's values and experiences. In one example, teachers appeared to be comfortable

[3] At this level, professional development is purposeful and engaging for many participants, but is somewhat limited (e.g., classroom applications and student understanding are discussed superficially).
[4] Accomplished, effective professional development engages participants in mathematics content and/or pedagogy in a collegial atmosphere and helps teachers develop skills and strategies for classroom practice.
[5] Professional development provides opportunities for participants to discuss and explore mathematics content or pedagogy, but facilitation and culture limit the accessibility of knowledge and teaching practices.

expressing their needs for ideas about how to launch a unit in question, for garnering participation from students, and about every day experiences that would help students grasp mathematics concepts in the unit. In this example, teachers appeared to treat each other as colleagues even though some of them may have just met.

Although overall the atmosphere of ACME professional development was open, in two observations the sessions appeared to restrain open communication. In one session, a formal presentation appeared to limit participation. In another session, the ACME facilitator asked questions that appeared to have one correct response rather than opening the floor to different ideas.

Participant Engagement

In the five ACME professional development sessions, participants' attitudes toward the relevance and usefulness of the activities were mixed as in previous years. Some participants appeared to engage fully in ACME professional development activities, whereas others appeared to be attending because they were expected to do so. In two sessions, most of the participants seemed to seek out help from the ACME facilitators and other participants and to leave the session with new ideas about how to implement the lesson and about how to teach the content in their classrooms. In another session, about one-fourth of the participants came ready to share their experiences of implementing the resources in their classrooms, about one-half of the participants quietly attended, and the remaining one-fourth of the participants openly rejected the sessions (e.g., stating that the resources would not work with their students).

Although incomplete engagement may be directly linked to variations in facilitation style, it may also be linked to teachers' not feeling they have a say in ACME professional development. Responses to the Spring 2002 teacher questionnaire suggested that a number of teachers did not feel involved in the design of ACME professional development. Thirty-six percent of the teachers who responded indicated that they were "not at all involved in planning their mathematics-related professional development" and 10% indicated that they were involved "to a great extent."

Reflection on Implications for Practice

According to observations, all sessions included small or large group discussions in which participants shared implications for practice. Although in some sessions many

participants discussed implications for practice, in other sessions—due to format or facilitator style—only a few participants were outspoken. From teachers' perspectives, opportunities to reflect on the implications of ACME professional development for their practice were moderate as indicated by responses to teacher questionnaires. Although 21% of respondents indicated that they were "not at all given time to reflect on what I've learned and how to apply it to the classroom" and only 4% of the respondents indicated that they were "to a great extent"; all other responses fell between the two extremes. AISD mathematics teachers needed more opportunities to reflect on applications in ACME professional development.

Summary of the Culture of ACME Professional Development

In sum, the culture of ACME professional development provided teachers who attended with opportunities to exchange ideas with colleagues and ACME facilitators about inquiry-based mathematics instruction and to discuss implications for practice. It appeared that a number of participants would take useful strategies back to their classrooms. However, this was not the case for all participants. Alternative professional development that included observation and reflection (e.g., mentoring and coaching) might have been more effective for helping teachers implement inquiry-based pedagogy.

Deepening Teachers' Mathematics Content Knowledge

In the 2001-02 school year, as before, ACME professional development helped teachers deepen their mathematics content knowledge over areas addressed in the curriculum resources in several specific ways. ACME facilitators provided activities in which participants solved problems to explore mathematics content, to reflect on their experiences as adult learners, and to consider their students' experiences. In other activities, participants examined the conceptual understandings evident in student work. Often in ACME professional development, participants worked through specific activities from the curriculum resources, and ACME staff facilitated discussions to clarify the concepts and to explore multiple representations of problems. ACME facilitators also presented materials about the development of student mathematics understanding (e.g., the development of number concept) embedded in the resources. Additionally, participants studied the state standards for mathematics by grade level.

Mathematics Content in the Curriculum Resources

In the 2001-02 school year as in previous years, ACME professional development generally focused on key conceptual understandings embedded in the resources such as number sense, computation strategies, measurement, algebraic thinking, and geometry. Some topics were emphasized more than others. The extent to which ACME facilitators made mathematics concepts explicit varied. In one session, for example, ACME facilitators led a rich discussion of everyday knowledge about negative numbers in which teachers considered the pedagogical advantages and disadvantages of different everyday situations. In another session where participants played the games from the resources, some teachers discussed modifications for students with disabilities, but discussion of mathematics content was left up to the participants and was inconsistent around the room. To advance teachers' content knowledge, convergence of evidence from the observations suggested that ACME facilitators could have probed teachers more.

In all of the professional development observations made during the 2001-02 school year, mathematics content knowledge was presented accurately. The degree of new understandings varied; some teachers shared new insights concerning mathematics content and other teachers focused on how to use the materials. The mathematics content appeared to be accessible to teachers overall, although logistics may have limited accessibility at times (e.g., handouts unclear or presented quickly).

Needs of Teachers

The degree to which mathematics content addressed the needs of AISD teachers was not well documented because gains in teacher content knowledge were not formally measured. As in previous years, ACME facilitators informally assessed the extent to which teachers were deepening their mathematics content knowledge through conversations and observations during ACME professional development.

Teacher reports indicated that ACME professional development had an impact on mathematics content knowledge for a portion of teachers. According to teacher questionnaire data gathered in Spring 2002, about one-third of the teachers who responded (37%) found that participation in ACME professional development increased their mathematics content knowledge, whereas 39% of the teachers who responded were neutral about increases and 23% of the teachers reported no increase in their mathematics content knowledge. In contrast, more than half of the teachers who responded (53%)

reported that participation in ACME professional development increased their "ability to implement high quality mathematics instructional materials." This difference suggested that more teachers who participated in ACME professional development appeared to learn about working with the materials than learned about mathematics content.

Additionally, teacher reports of preparedness in specific mathematics content areas (e.g., pre-algebra, algebra, geometry and spatial sense, data collection and analysis, probability, and technology in support of mathematics) increased between Spring 1998 and Spring 2002, although the level of preparedness was moderately high from the start (i.e., increasing from 70 to 75 on a 100-point scale). In teacher interviews, most of the 10 randomly sampled teachers stated that the impact of ACME professional development on them and their teaching was to change their classroom practice or student outcomes, but none stated that the ACME project increased their preparedness in content knowledge. Thus, participation in ACME professional development appeared to help more teachers learn about using the materials and change their practice than did it increase teachers' mathematics content knowledge.

Classroom Observations of Teachers' Mathematics Content Knowledge

The 16 lessons selected for longitudinal classroom observations were drawn from random samples of elementary and middle school mathematics teachers in the early years of the ACME project[6]. In almost half of the lessons observed (7 out of 16), teachers advanced in the level of implementation between observations in Spring 1999 and Spring 2002; about one-third of the teachers (5 out of 16) decreased in level of implementation; and one-fourth of the teachers (4 out of 16) did not change. Observers rated most of the lessons (9 out of 16) in the Spring of 2002 as at the "beginning stages of effective instruction"[7] according to the HRI protocol; five observations were rated as having "elements of effective instruction"[8]; and two observations were rated as "accomplished,

[6] One middle school teacher was agreed to participate in the Spring 2002 observation. This teacher and the observer decided which of the classes to observe by finding a time that was mutually convenient.

[7] Lessons engaged students in problem-solving, but the quality of the lesson was limited. The lesson may have lacked teaching strategies that pushed students to deep understandings or may have muddled conceptual knowledge with inaccurate or superficial exploration of mathematics content.

[8] Lessons showed little evidence of standards-based instruction. Students passively received information from the teacher or were involved in activities that lacked purpose and that were unlikely to enhance mathematical thinking

effective instruction"[9]. The results from this small longitudinal sample supported the findings from larger samples observed in Spring 1999 and Spring 2000 (50 and 48 observations, respectively); the ACME project appeared to help a majority of teachers implement inquiry-based mathematics at beginning levels, while a small proportion presented high levels of implementation, and some teachers did not implement well.

In-depth analysis of the 16 classroom observations suggested that although some teachers may have deepened their mathematics content knowledge, in many cases the pedagogical decisions made before and during the lessons limited the content that students explored. For example, one teacher, a self-declared "Investigations Man," was articulate and clear about the geometry embedded in the lesson and appeared to become more confident in his content knowledge over time. His difficulties with classroom management (e.g., not keeping students on task, not providing enough materials for some tables, and missing "teachable moments" by not spending enough time with groups of students to correct inaccuracies) continued to limit the depth of conceptual understanding that most students might have developed by participating in the activity. Another teacher in a previous observation followed the lesson in the curriculum resources, but limited exploration of mathematics by organizing students to work individually. In Spring 2002, this teacher focused on how to draw pictures for story problems and appeared to miss occasions for students to gain understanding of the mathematics underlying the lesson.

Some teachers were still notably unsure about the mathematics content underlying the resources. In the pre-observation interview of one lesson, for example, the teacher, who had participated in more than half of the expected ACME professional development (66 hours), stated that she had to study spatial orientations before teaching a lesson on flips, rotations, and translations of grid patterns. During the lesson, when a student showed the teacher his work, she told him that he had flipped his grid pattern incorrectly though the observer noted that he had not. Thus, some teachers continued to struggle with the mathematics content knowledge embedded in the resources.

Summary of Deepening Teachers' Mathematics Content Knowledge

Overall, ACME professional development appeared to have some impact on teachers' mathematics content knowledge, but some continued to lack conceptual

[9] Lessons were engaging and helped most students successfully solve mathematical problems and develop conceptual understanding.

understandings limiting the quality of instruction. Although some teachers taught the conceptual understandings that they developed during ACME professional development, others appeared to have difficulties translating their understandings into student learning. Particularly limiting were the decisions teachers made before and during lessons that made student exploration of content knowledge superficial or inaccurate.

Familiarizing Teachers with the Resources and Pedagogy

The curriculum resources were a central focus of ACME professional development; the resources served as the vehicle for learning about mathematics content knowledge and about inquiry-based pedagogy as well. About half to three-quarters of the time spent in most ACME professional development centered on the resources. The sessions included a variety of activities to help teachers become familiar with the resources including the following: (a) conducting a scavenger hunt; (b) playing the games from the resources to explore the underlying mathematics; (c) discussing teachers' classroom experiences with the resources to address organization of the materials and classroom management; and (d) teachers' modeling lessons from the resources.

ACME facilitators addressed pedagogy to advance student conceptual understanding through the resources in the following ways: (a) modeling inquiry-based pedagogy; (b) making explicit the questions asked to push participants' thinking to new levels; (c) providing opportunities for teachers to discuss strategies to facilitate student thinking about content; (d) discussing inquiry-based pedagogy, student learning, and mathematics curriculum; (e) examining videos of AISD teachers' implementing inquiry-based pedagogy and student dialogue; and (f) assessing student work.

Pedagogical Content Knowledge

During the 2001-02 professional development observations, although some discussions of pedagogical content knowledge were planned, more often these discussions appeared to emerge spontaneously based on teachers' expressed interests. In an activity concerning negative numbers, one teacher asked the ACME facilitators about the benefits of teaching inequalities through a mnemonic tool: Dialogue with the ACME facilitator ensued. In this session, teachers also discussed advantages and disadvantages of real-life applications to teach negative numbers. In another session, in which teachers

played games in units of the resources, the discoveries that teachers made about mathematics content and pedagogy were hit or miss.

Key Mathematics Concepts in Units

During the 2001-02 professional development observations, ACME facilitators discussed key concepts of the lessons in question, which hit on the big picture of the unit, but the focus on key concepts varied. In the past, ACME facilitators stated that it was not possible, nor their intention, to address all topics or all lessons in units, but to focus on select key concepts. At times ACME facilitators had teachers engage in activities in the resources, but the link between key concepts and the unit's big picture was not addressed.

Inquiry-Based Pedagogy

From the start, ACME professional development has evolved to integrate new strategies for helping teachers learn more about inquiry-based pedagogy. The ACME project has moved from discussing handouts on open-ended questioning strategies to the analysis of videotapes of teachers' mathematics lessons, including those of AISD teachers. Similarly, in addition to addressing the needs of diverse learners through discussions about extensions and adaptations of materials in general, ACME staff added sessions designed for teachers of special education and gifted and talented students. The examination of effective assessment strategies has moved from helping teachers with the "how tos" of developing rubrics to sharing systematized methods for assessing student work that emphasized student thinking and conceptual understanding.

These components of ACME professional development appeared to have met the needs of a majority of AISD mathematics teachers. Over half (51%) of the teachers who responded to the 2002 questionnaire, for example, agreed that ACME professional development increased their "understanding of how children think about/learn mathematics," one-third of the teachers (32%) were neutral, and a proportion (16%) disagreed. On the basis of classroom observations, teachers probably needed more emphasis on how students learn to change their instruction, however.

Modeling Effective Pedagogy

Since the ACME project began, ACME facilitators have designed professional development to model effective pedagogy, although facilitation skills and design implemented varied. As noted in previous years, turnover in ACME facilitators resulted

in the loss of skilled facilitators and the need for new ACME staff to build skills. In 2001-02, all but two ACME facilitators primarily asked open-ended questions to model and promote participant exploration of mathematics concepts and pedagogy and provided opportunities for participants to share ideas about content and pedagogy. For many ACME facilitators, these skills evolved with experience and professional development. In 2001-02 professional development observations, a few ACME facilitators, however, modeled traditional pedagogy, which limited discussion and reflection among participants (see "Culture of ACME Professional Development," pp. 6-7).

Discussing Effective Pedagogy

Over the course of the ACME project, ACME facilitators integrated a variety of techniques to address effective pedagogy, and the approaches evolved from simplistic (i.e., handouts of open-ended questions) to complex. In the fourth year of the ACME project, some ACME professional development for middle school teachers involved collaborative planning and implementation of a lesson, adapted from Japanese lesson study model described in Stigler & Hiebert's (1999) *The Teaching Gap*. Participants planned a lesson with a teacher leader, observed the lesson, and discussed the instruction and resultant student work. These sessions had a powerful impact on the buy in of participants, yet many middle school mathematics teachers did not attend. In addition, videotapes of mathematics lessons that were nationally available and of AISD teachers' lessons were explored for student to student and teacher to student dialogue.

Through AISD's partnership with the Institute for Learning, in January 2002 videotapes that demonstrated academic rigor in mathematics lessons were presented and offered to principals; the meeting did not include a discussion of pedagogy though. In another 2001-02 professional development session for new hires and other teachers new to inquiry-based instruction, in an activity in which teachers shared personal stories of learning mathematic participants discussed different pedagogical approaches. Although participants discussed effective pedagogy during activities, longitudinal classroom observations suggested that teachers might have benefited from individualized support that focused on actual practice, effective pedagogy, and building student understanding.

Teachers' Beliefs about Mathematics Instruction

Since the ACME project began, some elementary and middle school mathematics teachers have changed what they think about effective mathematics instruction. In interviews, ACME staff and AISD teachers concurred that changes in teaching practices and students' experiences in mathematics were major effects of the ACME project. One ACME facilitator reported that an effect of the ACME project was that "People have started to think differently about how students learn math." As one teacher stated, "[ACME] has improved [my teaching]…; if you truly buy in, I think it's improved children's math. I'm a believer. There's more math verbalization for kids…; kids are concentrating more on thinking, not just the right answer…. You can't help but bring out problem solving, kids were not doing that before." Additionally, another ACME staff member stated, "We've had people change the way they teach." One teacher stated, "It has made me a better teacher for teaching math strategies." Another teacher reported, "I do a lot more of hands on activities with manipulatives than I did before, a lot more of cooperative groups than just the regular book and paper."

Overall, the attitudes of AISD mathematics teachers about mathematics teaching and learning have been positive toward reforms and have changed little since the ACME project began. On the basis of longitudinal data from questionnaires, teachers have continued to endorse inquiry-based strategies for effective mathematics instruction (e.g., developing conceptual understanding, providing concrete experiences before abstract, engaging students in hands-on activities, making connections to other disciplines, etc.; AISD teachers responses were consistently at about 90 on a 100-point scale when these attitudes were measured in Springs 1998, 1999, 2000, and 2002). Statistical analysis indicated no significant changes in teachers' attitudes toward inquiry-based instructional strategies between Spring 1998 and Spring 2002.

Overall, teachers' self-reported beliefs about how they teach mathematics have remained constant since the ACME project began. On questionnaire responses, teachers reported consistently moderate levels (about 58 on a 100-point scale) of investigative practices for students (e.g., hands-on activities, long-term investigations or projects, and journal writing) and consistently moderate levels (about 55 on a 100-point scale) of integrating calculators and computers into mathematics lessons between Spring 1998 and Spring 2002. Teachers have continued to report moderately high levels (about 70 on a

100-point scale) of traditional teaching practices (e.g., homework assignments, worksheet problems, and short-answer tests) since the ACME project began. Teacher questionnaire responses about implementing investigative culture in mathematics lessons (e.g., student explanations of reasoning, seating that facilitates student discussion, cooperative learning groups, consideration of alternative approaches to problems) increased somewhat (from 85 to 88 on a 100-point scale, a small, but statistically significant increase, $p < .05$) between Spring 1998 and Spring 2002.

Classroom Observations of Pedagogy and Use of Resources

In depth analysis of the 16 longitudinal classroom observations indicated that many of the teachers whose lessons revealed **moderate implementation** of inquiry-based mathematics instruction in Spring 2002 used the resources mechanically, modifying the lessons or omitting key components. These modifications limited opportunities for students to explore mathematics content and deepen their understandings. For example, in one observation, the teacher carried out a lesson that had students play a game involving spatial relations. By leaving out the target location, counting, practicing directions, and choosing sizes of steps became the activity, rather than estimating the steps to a target. In another observation, the teacher inadvertently made the lesson more rigid than the design in the resource; students focused on what to draw and lost sight of the mathematics concepts underlying the lesson.

For teachers whose lessons were rated as **effective instruction**, teachers implemented the materials and demonstrated flexibility and decision-making during the lesson. In one lesson in Spring 2002, the teacher reviewed problem solving in addition and subtraction and gave students opportunities to discuss and use multiple strategies for working the problems. The instruction of this teacher improved from Spring 1999 when she was not yet implementing and focused on getting students to produce one right answer. Another teacher who implemented at high levels had embraced the resources and inquiry-based instruction before the first observation. She consistently treated most of her students as competent mathematicians; students were eager to participate in lessons and they demonstrated facility with using multiple strategies to solve problems.

For teachers whose lessons integrated elements of inquiry-based instruction but who were **not implementing well**, the conceptual understanding of the lessons was minimized. In one observation, for example the teacher spent 20 minutes of the lesson

describing instructions for what students should do at each center. Throughout the lesson, he visited groups and iterated the instructions rather than ask probing questions to push student understanding. He also omitted a discussion of strategies for solving problems included in the resources, which cut short opportunities for students to learn by thinking about other solution strategies. Nevertheless, by his implementing the resources, his students were engaged in the activities and worked together on the problems. Although this teacher did not implement inquiry-based instruction well, participation in ACME professional development helped him use the resources in his classroom and switch from student activities focused on pedantic instruction and passive student learning to interactive problem solving.

Summary of Familiarizing Teachers with the Resources and Pedagogy

In conclusion, the ACME project appeared to help teachers become familiar with the resources, but many teachers still needed help improving their pedagogical skills geared toward deepening students' conceptual understanding. Many teachers appeared to have changed the resources that they used in their mathematics lessons and had increased somewhat the investigative culture in their lessons (such as expectations of explanations of reasoning, cooperative learning groups, multiple strategies to solve problems). On the basis of longitudinal classroom observations, the implementation of inquiry-based instruction by many AISD teachers needs improvement in pedagogical content knowledge and effective instruction that would promote student understanding.

Ongoing Support as Teachers Implement Resources

To provide support for teachers as they implemented the resources in their classrooms, the ACME project asked teachers to attend three to five follow up days during the school year for two years. These sessions addressed key lessons in the curriculum resources that teachers were expected to implement from the scope and sequence for each grade level and other topics. In the first few years of the ACME project, teachers at eight pilot schools benefited from model teaching, coaching, and other contact with ACME facilitators on their campuses and had short summer institutes. As part of the District Improvement Plan, teachers at campuses at risk for being designated "low performing" by the Texas Education Agency (TEA) due to student

TAAS scores received assistance from ACME facilitators for the past two years (Batchelder, 2002).

Teachers' Opportunities to Discuss Implementation

During the 2001-02 school year, opportunities for teachers to discuss implementation of the inquiry-based resources were not widespread (see Table 1). In Spring 2002, a majority of teachers who responded to the questionnaire (66%) reported that they did not participate in study groups during the academic year. This percentage was twice as high as in Spring 1999 (32%). Because the ACME project was implemented by grade level, in Spring 2002 many teachers had completed the prescribed two years of ACME professional development and no longer participated in follow up days during the academic year. Unless campus staff organized study groups or other professional learning opportunities on inquiry-based mathematics instruction at their schools or the teachers were new to AISD, most AISD mathematics teachers probably did not participate in ACME professional development during the 2001-02 school year. Thus, ongoing conversations about implementing the inquiry-based resources were limited for most teachers. In some cases, teachers may have participated in related professional development as part of AISD's partnership with the Institute for Learning, but those opportunities varied by campus (see Piñon, Samii-Shore, & Batchelder, 2002).

Table 1. Percentage of Teachers Participating in Study/Discussion Groups by Frequency, Spring 1999 and Spring 2002

	Percentage of Teachers Participating in Academic Year Study/Discussion Groups			
	0 times	1-2 times	3-4 times	5 or more times
Spring 1999	32	24	24	20
Spring 2002	66	25	4	5

Source: Teacher Questionnaires, Spring 2002

Through ACME professional development, many teachers took advantage of opportunities to discuss implementation, but sometimes discussions did not meet teachers' needs. In a Spring 2002 teacher interview, one teacher stated, "[ACME professional development] was good because I was able to talk with other first grade

teachers who were teaching it." In professional development observations over the course of the ACME project, teachers often shared practical ideas about implementing the resources, and at times the relative effectiveness of different strategies was discussed. Sometimes teachers perceived ACME facilitators as overly directive, which restrained discussions among teachers. In one Spring 2002 interview, the teacher said, "The follow-up sessions could have been better if teachers had been allowed to brainstorm about how they taught a lesson rather than having the facilitators have teachers do it the way that [the facilitators] had envisioned and then critiquing that."

Individualized Support for Implementation

In the 2001-02 school year, a small proportion of AISD elementary and middle school teachers reported participating in individualized support for implementing inquiry-based mathematics instruction (e.g., coaching and mentoring, see Table 2). As indicated by teachers' responses to questionnaires, the number of teachers who participated in this support decreased from Spring 1999 to Spring 2002.

Table 2. Percentage of Teachers Participating in Various ACME Professional Development, Spring 1999 and Spring 2002

	Percentage of Teachers Participating in Various ACME Professional Development		
	Coaching with a Classroom Observation	Assistance from a Teacher Leader on Campus	Assistance from an ACME Facilitator
Spring 1999	34	28	55
Spring 2002	13	18	28

Source: Teacher Questionnaires, Spring 2002

This level of support generally appeared to satisfy some teachers' perceptions of the support needed. In Spring 2002, 42% of teachers who responded to the questionnaires reported that "I receive support as I try to implement what I've learned," whereas 28% of the teachers who responded were neutral about support and 29% of the teachers reported that they did not receive support. However, as noted in the early years of the ACME project, teachers continued to comment informally that they "want to see

what [inquiry-based instruction] looks like." Informal comments like this one indicated that the amount and format of individualized support did not meet all teachers' needs.

Availability of Materials and Supplies

A key feature of the ACME project was the materials and supplies provided for implementing inquiry-based instruction. Nearly all of the randomly sampled teachers interviewed (8 out of 10) considered "getting the materials needed for instruction," including manipulatives, copies of student sheets, and teachers editions, to be the most helpful aspect of the ACME project. From matching funds, AISD purchased curriculum resources and kits for all elementary and middle school mathematics teachers. (The original plan to purchase one kit for every two teachers was changed midway through the ACME project in response to teacher feedback.) Additionally, after the first year of the ACME project, AISD provided packets of key student sheets for all elementary and middle school mathematics teachers to reduce teachers' photocopying load. Keeping track of campus inventories of resources, kits, and student sheets continued to be a challenge due to staff turnover, as in previous years.

Summary of Ongoing Support as Teachers Implement Resources

In sum, according to the original design of the ACME project, ongoing support to teachers as they implemented the resources and inquiry-based instruction was delivered en masse through follow up days during the academic year. Outside of these workshops, a small number of AISD mathematics teachers benefited from individualized support in the form of mentoring or coaching. Over the course of the ACME project, teacher collaboration in support of inquiry-based mathematics instruction was documented in some cases, but was transient and depended on physical proximity (i.e., teachers on the same campus or whose classrooms were next to each other; see Batchelder & Christian, 1999). Most AISD mathematics teachers implementing inquiry-based resources did not benefit from the support of peers who had high levels of competence in inquiry-based instruction. Organized structures with teacher leaders supporting other teachers on campus across the district were not common. Evidence from longitudinal classroom observations suggested that this lack of individualized support in the ACME design might explain why many AISD elementary and middle school mathematics teachers attained moderate levels of implementation but did not advance to high levels.

Summary of the Impact of ACME Professional Development

In general, the ACME project provided professional development so that a proportion of AISD elementary and middle school mathematics teachers implemented quality inquiry-based curriculum resources. Mathematics content knowledge and pedagogical skills did not appear to advance significantly for most teachers. Although the ongoing support during the academic year appears to have helped teachers implement the materials, support has not yet been sufficient to help a large number of teachers reach high levels of implementation. Organizational structures that would support reflection on teaching practice and lead teachers to improve the quality of instruction were absent. These structures might also provide more opportunities for teachers to continue improving their mathematics content knowledge.

Limitations on the Implementation of ACME Professional Development

The ACME project called for all elementary and middle school mathematics teachers, including special education, bilingual, and English as a Second Language (ESL) teachers, to participate in 100 hours of ACME professional development. According to questionnaires completed by a random sample of mathematics teachers in the targeted grade levels in Spring 2002, only 17% of teachers participated in 100 hours or more of ACME professional development. (This number is similar to 14% of teachers who had participated in 100 hours or more included in the Fall 2001 sampling frame on the basis of the ACME project database of teacher attendance at ACME professional development.) The evidence does not support the claim that the percentage of teachers who completed ACME was low due to teacher turnover; twice as many teachers who stayed in AISD teaching positions completed 100 hours or more of ACME professional development as did teachers who left AISD.[10] Among teachers who responded, 38% reported participating in 20 to 59 hours of ACME professional development, ranging from three to eight days, and 21% of the teachers reported participating in 60 to 99 hours of ACME professional development, ranging from nine to fifteen days. Twelve percent of the teachers who responded reported participating in 1 to 19 hours of ACME professional development, and 13% of the teachers reportedly did not participate at all.

[10] Chi-square analysis from the ACME project database of teacher attendance indicated that the proportion of teachers who completed 100 hours or more of ACME professional development was twice as high for teachers who stayed in AISD teaching positions (16%) as for teacher who left the district (8%).

Thus, most AISD teachers did not complete the ACME professional development plan, and the greatest percentage of teachers participated in about half of the plan.

Three factors stood out as contributing to the lack of full participation of mathematics teachers in the ACME professional development. One factor was that teacher attendance at ACME professional development was never mandatory. Early on, Education Austin argued that participation in ACME professional development should not be mandatory because attendance was not written in teachers' contracts. ACME project staff and district leaders used the word "expected" rather than "required" to communicate the district policy concerning attendance. Accountability for teacher attendance was negotiated between principals and ACME project staff. ACME staff developed annual records to document which teachers at each campus had participated in which summer institutes, follow up days during the school year, and other related ACME professional development. Following up with teachers was left to the discretion of campus administrators, whose support for inquiry-based mathematics education has varied. Changing district leadership, which resulted in discontinuous support for the mathematics initiative, also contributed to a lack of full participation in ACME professional development. A third factor was that unclear messages about how teachers in AISD should teach what mathematics might have given fodder to an expectation of some AISD teachers that like many programs before, "This too shall pass." As one teacher stated, "Austin has a tradition of bringing in new things, and that's great, every couple of years, and they don't keep any one thing long enough." Whereas some teachers were concerned that the initiative would not last, others were said to be waiting for the ACME project to pass.

SUPPORT FOR ACME REFORMS

This section examines the progress made in garnering support for the ACME vision of exemplary mathematics education among key stakeholders (i.e., the K-12 education system and the community) and in aligning district and school policies and practices with that vision.

Garnering Support for the ACME Vision

Support for teaching mathematics according to the ACME vision of exemplary mathematics education has recently begun to solidify from key stakeholders in the

district. Despite changes in district leadership (including three different superintendents, new directors of curriculum and instruction, and several different directors of the mathematics department), the curriculum resources of *Investigations in Number, Data, and Space* and *Connected Mathematics (CMP)* have remained the major foundations of the elementary and middle school curriculum of the district. As each new leader joined the district, program staff struggled, however, to garner support for the resources and inquiry-based teaching practices. For more than a year, the current administration has endorsed these resources and practices verbally and in print, and the resources form the basis of the mathematics scope and sequence presently under construction. District data linking to levels of teacher implementation of inquiry-based mathematics instruction to student achievement on the state assessment TAAS helped increase support for reforms among district and campus level staff (see Batchelder, 2001). In addition, through the district's partnership with the Institute for Learning at the University of Pittsburgh (whose vision supports ACME reforms in mathematics education), campus and district level administrators and curriculum specialists participated in professional development geared towards improving instructional leadership. In the 2001-02 school year, one focus of this professional development for leaders was rigorous mathematics, which bolstered understanding of the ACME vision of mathematics education.

Teacher Implementation of the Resources and Inquiry-Based Pedagogy

Although implementation of the ACME vision of exemplary mathematics education has increased since the ACME project began, implementation of *Investigations in Number, Data, and Space* and *Connected Mathematics (CMP)* is not evident in every elementary and middle school classroom in the district. Many teachers reportedly implement at least some of these resources in their classrooms, and many principals expect their teachers to do so. The percentage of principals surveyed who reported that 90% to 100% of teachers at their schools "are implementing at least some of the LSC-designated instructional materials" has steadily increased since 1999; at 50% of campuses in 1999, at 60% of the campuses in 2000, and at 69% of the campuses in 2002, most teachers were implementing some of the resources. These principal reports indicated increases in implementation; yet, the questionnaire did not ask about full implementation.

The ACME project has contributed to garnering support for the ACME vision for mathematics education by facilitating the professional development of a group of teachers and teacher leaders who are enthusiastic about and devoted to implementing inquiry-based teaching practices. Teacher turnover, including resignations, retirement, and transfers across AISD, at the rate of about 20% per year (AISD, 2002) continued to threaten the district's ability to maintain and grow teacher support and implementation in classrooms. In addition, longitudinal classroom observations suggested that many teachers were still developing the pedagogical content knowledge embedded in the resources; some teachers were observed to implement lessons mechanically and maintained their original level of implementation over the course of the ACME project rather than advancing their pedagogical skills. Teacher interviews and spontaneous comments suggested that some teachers continued to consider supplementing the inquiry-based curriculum resources with other resources necessary so that students would learn what is required to pass the state assessment, TAAS. Although the ACME project has addressed teacher concerns about alignment between the resources, the state standards, and the state assessment, in teacher interviews some teachers were beginning to accept the case for alignment while others were not.

Support from Principals

The ACME project has struggled to achieve consistent support for reforms from principals. Although principals have continued to endorse highly the teaching strategies supported by the resources *Investigations in Number, Data, and Space* and *Connected Mathematics (CMP)* on principal questionnaires, some AISD principals communicate equivocal support for implementation. A district policy of site-based management established several years before the ACME project has lingered and challenged districtwide implementation. Some teachers reportedly appreciated principal support that backed their decisions to "teach what kids need to succeed," which often detracted from implementation and reflected a superficial understanding of the mathematical concepts and skills embedded in the resources. Similarly to teachers, principal turnover threatened the momentum and stability of support for reforms in mathematics education. For the past five years, over one-third of elementary and middle school principals in the district were new to their jobs with 1-3 years of experience as administrators. Between 1998 and 2000, over half of AISD elementary and middle school principals were new to AISD

having 1-3 years of experience as principals in the district. In 2002, the proportion of AISD elementary and middle school principals who were new to the district had decreased to 31%. The partnership with the Institute for Learning has increased principal support for the resources and inquiry-based teaching practices, including recent professional development to clarify what constitutes rigorous mathematics instruction. The continuation and further development of support from principals may depend on the continuation of partnership with IFL.

Support from the Community

Support from the community has been lukewarm. Teachers continued to report low rates of parental involvement in their classrooms and in school activities; teachers also reported that parents expressed neither support nor opposition to inquiry-based mathematics. Support from institutions of higher education, including partners at the University of Texas at Austin, has been minimal and fluctuating over the course of the ACME project. Recent talks between ACME project staff and the University of Texas faculty, however, have centered on improving pre-service education regarding teachers' mathematics content knowledge.

Summary of Garnering Support for the ACME Vision

In conclusion, support for implementing the curriculum resources *Investigations in Number, Data, and Space* and *Connected Mathematics (CMP)* and inquiry-based teaching practices has come from teachers, principals, and district leaders within the district. The partnership with the Institute for Learning has recently solidified support for implementation among leaders. Support for reforms improved, but has not yet reached a level such that most AISD elementary and middle school students learn from these resources and teaching practices from year-to-year.

Aligning Policy and Practices with the ACME Vision

In addition to support for the ACME vision of effective mathematics education, district and school policy and practices can enable the implementation. This section examines policy and practices that might enable reforms in AISD mathematics education.

Curriculum Framework, Resources, and Assessment

As of Spring 2002, the bellwhether in the alignment of district and school policy and practices with the ACME vision of effective mathematics education was the decision

to base the new curriculum framework on the curriculum resources *Investigations in Number, Data, and Space* and *Connected Mathematics (CMP).* The framework consists of a list of student skills, teaching practices, student work products, and assessments that align with the state standards Texas Essential Knowledge and Skills (TEKS) and the new state assessment Texas Assessment of Knowledge and Skills (TAKS). ACME project staff made the case for this decision. Most teachers surveyed considered themselves well supplied with investigative mathematics materials, and many teachers interviewed reported that the resources and manipulatives were the most helpful aspect of the ACME project. District matching funds ensured that every AISD elementary and middle school teacher had the resources and materials needed for implementation. In addition, through the ACME project, the district provided copies of student sheets for every elementary and middle school mathematics classroom, which addressed teacher concerns about time spent photocopying and helped teachers who implemented the resources.

Time for Inquiry-Based Mathematics Instruction

During the ACME project, the district emphasized mathematics instruction, and ACME project staff advocated for time needed to implement lessons centered on problem-solving, conceptual understanding, and number sense. The district's policy of 90 minutes of mathematics per day at all elementary schools and a few targeted middle schools provided time for inquiry-based instruction. Changes since the ACME project's inception in the length of mathematics lessons that teachers reported reflected emphasis on mathematics instruction. In 1998, only 37% of teachers reported that a typical mathematics lesson lasted 61 minutes or more, whereas in 2002, 57% of teachers reported that mathematics lessons lasted 61 minutes or more. This increase occurred despite the switch from block scheduling in most middle schools. Note that the majority of mathematics teachers who responded reported lessons of at least an hour or more, rather than 90 minutes which would reflect the policy of 90-minute mathematics lessons.

Time for Teacher Collaboration

Although the ACME project brought teachers together for professional development institutes, the amount of time available for collaboration and reflection was not sufficient from teachers' perspectives. On teacher questionnaires, over half of the teachers responding reported that they did "not at all" have time to work with other

teachers as part of ACME professional development and to reflect on what was learned. Nearly half of the teachers also indicated that the time available to plan and prepare lessons and to work with other teachers "inhibits effective instruction." If planning time was insufficient, district policy needs reconsideration. As the district continues to develop professional development on campuses with instructional coaches and with assistance from IFL, policy and practice that supports teacher collaboration and reflection about instruction may improve.

Summary of Support for ACME Reforms

In sum, AISD is transitioning toward an overall context that is supportive of inquiry-based resources and teaching practices. Support from district leadership has stabilized, and many principals and teachers embrace these resources and practices, although support from the community is lukewarm. The curriculum framework, the availability of curriculum resources and materials, and the emphasis placed on mathematics instruction has established a foundation for inquiry-based mathematics. A lack of time available for teachers to plan and collaborate to improve their mathematics instruction has detracted from advancing the quality of implementation of inquiry-based mathematics in the district.

INSTITUTIONALIZATION OF THE ACME REFORMS

In addition to district funds, NSF funds were essential to implement the ACME project. This section addresses the degree to which components of the ACME project have become institutionalized and will continue in AISD after NSF funding ends.

Sustainability of the ACME Reforms

At the end of the ACME project, some components appeared to provide a foundation on which ACME reforms might be sustained and broadened. In the summer of 2002, the district planned to continue professional development for new elementary and middle school mathematics teachers provided by district facilitators, some of whom had developed strong facilitation skills (although the number of district mathematics facilitators could decrease because facilitators lost to attrition will not be replaced due to budget constraints). The district also planned to provide all elementary and middle school mathematics teachers with ongoing professional development by extending the instructional coaches program to all campuses. This ongoing support, which capitalized

on existing organizational structures such as teacher planning time, could help teachers who are currently implementing inquiry-based resources to deepen their content knowledge and pedagogical skills. Several factors including the quality of the instructional coaches' facilitation skills, the focus on student learning, the depth of reflection on teaching practice, and the district's emphasis on inquiry-based mathematics instruction should determine the impact of this plan.

Other components supported this foundation for ACME reforms. The fact that the new curriculum framework was based on the inquiry-based curriculum resources further strengthened sustainability of ACME reforms. At the end of the ACME project, efforts were underway to make these resources non-negotiable for elementary and middle school campuses. Future textbook adoptions, however, will determine whether the curriculum framework continues to be based on these or other inquiry-based resources. The district's partnership with IFL also helped to sustain and broaden the foundation of support for ACME reforms in mathematics instruction. Professional development activities provided through the partnership helped new and current principals and district-level leaders develop a shared vision for rigorous, inquiry-based mathematics instruction. Through these activities, AISD was working to make campus administrators accountable as instructional leaders; for example, administrators' monthly meetings are presently moving from discussing management issues to focusing on instruction (e.g., in a recent meeting, one activity involved principals planning a mathematics lesson).

This foundation for sustaining ACME reforms was unstable at the end of ACME project, however. Textbook adoptions and changes in the partnership with IFL, for example, could undermine commitment to inquiry-based mathematics instruction.

Barriers to the Institutionalization of ACME Reforms

At the end of the ACME project, several factors hinder full implementation and institutionalization of ACME reforms. The knowledge base and pedagogical skills in inquiry-based mathematics of teaching staff is unstable. Teacher turnover might foster declines in support for and capacity to teach inquiry-based mathematics because district hiring policies have not emphasized experience in inquiry-based mathematics instruction. One mechanism that could promote implementation, such as a system for evaluating existing teachers built on inquiry-based knowledge and teaching practice, for example, is not being developed. Another limiting factor will be a shift in financial resources for

inquiry-based instructional materials. After the ACME project, central office will no longer purchase mathematics instructional materials, although guidelines for campuses about purchases are planned. Another factor that limits full implementation of ACME reforms is the fledgling stage of development of organizational structures that promote learning communities on campuses and provided ongoing support (i.e., the plan for instructional coaches on every campus). Finally, concerns about changes to the new state assessment TAKS seem to be driving changes in support for inquiry-based mathematics instruction. The Texas Education Agency will implement passing requirements on the mathematics test for students in the 5th grade in the Spring 2005 and for students in the 8th grade in Spring 2008. While the new district policy of adding skill practice to elementary and middle school mathematics, for example, is linked to impending increases in the stakes of the TAKS, the policy communicates a lack of confidence in inquiry-based resources and instruction. In sum, at the end of the ACME project, policies and practices that might communicate unequivocal support for implementation of ACME reforms are not firmly in place.

Summary of the Institutionalization of ACME Reforms

In sum, at the end of the ACME project, policies and practices that had potential to promote the institutionalization of ACME reforms are changing. Instructional coaches on every campus who would provide ongoing support for teachers are new, and the commitment to and quality of professional development for implementing inquiry-based mathematics is undetermined. Concerns about the new, high stakes state assessment TAKS challenge implementation of inquiry-based instruction. The curriculum frameworks under the new curriculum director prescribe skills embedded in the state standards TEKS and inquiry-based instructional practices embedded in the resources and IFL's Principles of Learning. District assessments to monitor student understanding during the year and inform teachers' instructional decisions are under construction, and the effectiveness in supporting implementation of inquiry-based mathematics instruction is uncertain. Other policies and practices that could communicate commitment to and enable implementation are not yet established.

SUMMARY AND RECOMMENDATIONS

Districtwide implementation was central to the design of the ACME project to ensure that students in every AISD elementary and middle school mathematics classroom benefit from rigorous instruction. Although the ACME project provided model long-term professional development for AISD mathematics teachers, five years after the project began, implementation was evident in some but not all classrooms in the district. Among the teachers who implemented the resources and inquiry-based instruction, about one-fourth appeared to attain high quality implementation that would engage most students in rigorous mathematics instruction. Most AISD teachers appeared to reach moderate levels of implementation of inquiry-based mathematics. Although AISD has had components of mathematics education reform in place over the course of the NSF grant, reforms have been unstable and inconsistent across the district.

LESSONS LEARNED FROM THE ACME PROJECT

Two main lessons were learned from the implementation of the ACME project in AISD. For one, district and campus leaders needed to demonstrate unyielding commitment to inquiry-based curriculum and instruction, unequivocal expectations for implementation on campuses, and knowledge about high quality implementation (see, for example, St. John, Century, Eggers-Pierola, Houghton, Jennings, & Tibbitts, 1999). Throughout the ACME project, uncertainty about leaders' commitment to the implementation of inquiry-based instruction surfaced in various places. Instead, district and campus leaders needed to back implementation solidly before the ACME project rolled out professional development for teachers. This lesson now has implications for other AISD initiatives such as the partnership with the Institute for Learning that began by educating leaders, but has yet to provide comprehensive professional development for teachers. Although leaders need to support implementation of reforms, teachers too need to learn about new teaching practices and attain new pedagogical skills through professional development opportunities (Piñon, Samii-Shore, & Batchelder, 2002).

Another lesson concerned the need for ongoing support for teachers with different levels of experience and interest in inquiry-based instruction. To develop high quality implementation of inquiry-based mathematics instruction, teachers needed more support than was available through long-term professional development focused on the

curriculum resources. To hone their pedagogical skills and integrate mathematics content knowledge into instruction, teachers needed more professional development that directly related to their own practice; discussing implications for their practice in workshops is not enough. Teachers needed to see firsthand what strong implementation looks like, to have opportunities to reflect on specific incidences from their own practice, and to develop pedagogical skills that focus on improving student understanding. To attain high quality implementation, teachers needed coaching, mentoring, and other collaborative opportunities to try out and practice new skills. The ACME project was not designed to provide ongoing support to individual teachers across the district in this way.

ACCOMPLISHMENTS OF THE ACME PROJECT

During the five year grant, the ACME project achieved the following accomplishments in AISD:

- The ACME project influenced changes in the resources and materials, content, and activities that many AISD elementary and middle school mathematics teachers use to teach their students mathematics. All AISD elementary and middle school mathematics teachers have access to high quality materials that focus on a range of key concepts in mathematics and that provide activities that make mathematics meaningful for a wide range of students.
- The ACME project, in conjunction with the state accountability system, helped make mathematics instruction a focus across the district. The length of AISD mathematics lessons increased, and the emphasis placed on the quality of mathematics instruction has improved since the ACME project began.
- The ACME project focused district staff on aligning curriculum to the state standards, the TEKS. Although some disagreements arose about the degree of alignment, the ACME project was key to the dialogue about alignment and what effective mathematics instruction looks like. In anticipation of the state's impending new assessment, the ACME project prepared ACME facilitators to develop a curriculum framework that might help teachers plan lessons using inquiry-based mathematics resources to address the TEKS.
- The ACME professional development facilitators became the backbone of the ACME project. In addition to facilitating, they designed ACME professional development, district scope and sequences, curriculum frameworks, guides for

parents, and Spanish language versions of materials, among other products. They listened to and addressed teacher concerns, had conversations with administrators, spoke to concerned parents, and negotiated with the teachers' union. They also assisted campuses and teachers whose students were not passing the TAAS.

BARRIERS TO REFORM

The three key barriers that infringed on mathematics reform in AISD follow:

- The high levels of staff turnover among teachers, principals, project staff, and district administrators made reform difficult to sustain, and compromised the quality of implementation in AISD classrooms. Annually, about one-fifth of AISD's teachers leave campuses through resignations and transfers, and about one-third of AISD principals have three or fewer years of experience as administrators in the district. ACME project staff changed midway through the NSF grant. The district also had three different superintendents over the course of the project, in addition to other changes in district leadership. As some people left the district, knowledge and support for the ACME project left with them, and ACME staff had to re-establish support with newcomers. As a result, the message about mathematics reforms in AISD classrooms was sometimes blurred.
- Opposition to reform efforts under the ACME project was not sufficiently addressed. AISD teachers have seen initiatives come and go, and some teachers have therefore come to expect that new initiatives will be short-lived, negotiable, or optional. Wherever campus leadership had not demonstrated the expectation for inquiry-based mathematics instruction, teachers' decisions about instructional practice then become the de facto curriculum in place. Additionally, parents did not always understand the mathematics lesson activities in inquiry-based mathematics curricula and preferred to see students learn mathematics with a textbook rather than a game.
- As part of a large urban district, some campuses in AISD were in such crisis that adopting a new approach to instruction was a luxury that staff felt they could not afford. Moreover, the constraints of the state accountability system often drew attention to test preparation and away from inquiry-based instruction, especially when the alignment with the state assessment was questioned.

RECOMMENDATIONS

On the basis of this longitudinal evaluation, AISD should implement the following recommendations:

- Continue to implement inquiry-based mathematics instruction in AISD elementary and middle school classrooms and expand implementation to the high schools. The new state assessment, the Texas Assessment of Knowledge and Skills (TAKS), will be more challenging than the current state assessment, the TAAS, and will involve more problem solving and conceptual understanding. Because inquiry-based instruction is associated with high student academic achievement on the TAAS mathematics, especially in problem solving skills (Batchelder, 2001), this curriculum should prepare students to demonstrate mathematics achievement on the TAKS.
- Improve the quality of implementation of inquiry-based mathematics instruction:
  a. To promote sustainability, choose curriculum initiatives that align across disciplines and make them mandatory.
  b. Develop and maintain administrative support for inquiry-based mathematics instruction, especially in light of turnover among administrators. Organize mentoring relationships between administrators supportive of reform and those who are lukewarm or new to the district.
  c. Build on the expertise of teachers through mentoring relationships so that teachers with knowledge and skills in inquiry-based instruction can support the professional development of others (see Stein, D'Amico, & Israel, 1999). Resolve constraints on time during the school day creatively to allow for collaboration and coaching that would help teachers improve pedagogical skills and content knowledge (see Raywid, 1993; Hackman & Berry, 2000).

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