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ABSTRACT

There is considerable interest in preparing science teachers who can implement reform-based practices in schools. However, there are relatively few research programs that have systematically studied the implementation of this teaching innovation over extended time (i.e., the entire undergraduate experience and the first few years of full time teaching practice). One extended research program since 1993 that has examined this critical issue in teacher preparation has been carried out in a National Science Foundation funded project in the Collaboratives for the Excellence in Teacher Preparation Program (CETP), the Maryland Collaborative for Teacher Preparation (MCTP). This session synthesizes and reflects on the key research insights coming from over twenty separate studies conducted within the MCTP Research Program over nine years. A significant finding is that the MCTP new teachers maintain their reform-based orientation over time even as they report that they find many school environments resistant to reform-based practices. (Author)

A Synthesis and Reflection on the Research Findings From a Statewide Undergraduate Program to Prepare Specialist Mathematics and Science Teachers (The Maryland Collaborative for Teacher Preparation)

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A Synthesis and Reflection on the Research Findings From a Statewide Undergraduate Program to Prepare Specialist Mathematics and Science Teachers (The Maryland Collaborative for Teacher Preparation)

Abstract

There is considerable interest in preparing science teachers who can implement reform-based practices in schools. However, there are relatively few research programs that have systematically studied the implementation of this teaching innovation over extended time (i.e., the entire undergraduate experience and the first few years of full time teaching practice). One extended research program since 1993 that has examined this critical issue in teacher preparation has been carried out in a National Science Foundation funded project in the Collaboratives for the Excellence in Teacher Preparation Program (CETP), the Maryland Collaborative for Teacher Preparation (MCTP). This session synthesizes and reflects on the key research insights coming from over twenty separate studies conducted within the MCTP Research Program over nine years. A significant finding is that the MCTP new teachers maintain their reform-based orientation over time even as they report that they find many school environments resistant to reform-based practices.

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A Synthesis and Reflection on the Research Findings From a Statewide Undergraduate Program to Prepare Specialist Mathematics and Science Teachers (The Maryland Collaborative for Teacher Preparation)

Introduction

There is currently considerable interest in preparing science teachers who can implement reform-based practices in schools (Anderson & Mitchener, 1994). However, there are relatively few research programs that systematically study the implementation of this teaching innovation over extended time (i.e., the entire undergraduate experience and the first few years of full time teaching practice). One extended research program since 1993 that has examined this critical issue in teacher preparation has been carried out in a National Science Foundation funded project in the Collaboratives for the Excellence in Teacher Preparation Program (CETP), the Maryland Collaborative for Teacher Preparation (MCTP). Quantitative and qualitative studies have been reported in previous research conference sessions [NARST (last 8 years), AERA (last 6 years), and AETS (three times), and NSTA (once)].

The research program examined in this NARST session/paper was conducted within a macro-research agenda within the mathematics and science education research communities that continues to focus on the possible links between features of teacher preparation programs and the performances of new teachers (Simmons, et al., 1994). Currently, little is known in this context of reform about how newly graduated specialist teachers of mathematics and science from innovative teacher preparation programs are inducted into existing school cultures (Coble & Koballa, 1996). Pekarek, Krockover and Shephardson (1996) asserted that research-based insights of most value will come from studying teacher preparation programs that are seeking to implement recommended innovations in teacher preparation.

This report presents a review of the research program in the Maryland Collaborative for Teacher Preparation (MCTP)[1]. The primary purpose of research on teacher education in the MCTP was to generate new understandings in reform-oriented undergraduate mathematics and science teacher preparation. As such, multiple aspects of the MCTP have been studied methodically by the MCTP Research on Teacher Education Group using diverse methodologies. MCTP Research has been reported in a variety of venues (book chapters, journal articles, research conference presentations, masters and doctoral student reports, and teacher conferences).[2]

Structurally, this report is arranged to successively orient the reader to the MCTP Program, the MCTP Research on Teacher Education Group, the MCTP research questions, the MCTP studies (large and small scale) and results, and projected studies.

Context of The Research Program

The MCTP is a National Science Foundation (NSF) funded statewide undergraduate program for students who plan to become specialist mathematics and science upper elementary or middle level teachers. The MCTP was funded originally in 1993 for up to a five year period, and in 1998 was funded for an additional three years. It is a project in the NSF Collaboratives for Excellence in Teacher Preparation Program (CETP) program. The CETP program "supports large scale systemic projects designed to significantly change

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[1] An earlier draft of this report can be found as a book chapter in McGinnis (2002).
[2] Interested readers are directed to the MCTP's web site which contains an archival set of MCTP research studies grouped under the venues they were presented originally [www.towson.edu/csme/mctp/home.html].

teacher preparation programs on a state or regional basis and to serve as comprehensive national models" (Directorate for Education and Human Resources/National Science Foundation, 1996).

The key assumption of the MCTP is that changes in pre-secondary level mathematics and science educational practices require reform within the undergraduate mathematics and science subject matter and education classes prospective teachers take throughout their teacher preparation program (National Science Foundation, 1993). Theoretically, the MCTP emphasizes the transformation of instructional practices of MCTP undergraduate mathematics, science, and education faculty and of the MCTP school-based cooperating teachers of MCTP students, so that the MCTP future teachers experience directly the successful implementation of reform-based pedagogy in mathematics and science learning contexts (Gardner & Ayres, 1998). Since teachers are known to be highly influenced in their practices by how they were taught, the goal ultimately of the MCTP is to achieve reform by changing the future teachers' instructional classroom practices to reflect standards-based practices.

Specifically, the MCTP was designed around the following salient reform-based recommendations made by the Association for the Advancement of Science [AAAS] (1993), the National Research Council [NRC] (1996), and the National Council of Teachers of Mathematics [NCTM] (1991):

- Development of new content and pedagogy courses that model inquiry-based, interdisciplinary approaches combined with regular opportunities for teacher candidate reflection;

- The participation of faculty in mathematics, science, and methods committed to modeling best teaching practices;
- The development of field experiences in community schools with exemplary teachers trained to serve as mentors; and,
- Summer internships in contexts rich in mathematics and science.

In practice, the MCTP undergraduate courses are taught by faculty in mathematics, science, and education who make efforts to focus on "developing understanding of a few central concepts and to make connections between the sciences and between mathematics and science" (MCTP, 1996, p. 2). Faculty also strive to infuse technology into their teaching practices, and to use instructional and assessment strategies recommended by the literature to be compatible with a constructivist perspective (i.e., address conceptual change, promote reflection on changes in thinking, and stress logic and fundamental principles as opposed to memorization of unrelated facts) (Cobb, 1988; Driver, 1987; Driver, Asoko, Mortimer & Scott, P. ,1994; Tobin, Tippins, & Gallard, 1994; von Glasersfeld, 1989). Salient features of all the MCTP reform-based courses are that faculty lecture is diminished and student-based problem solving is emphasized in cross-disciplinary mathematical and scientific applications. Cooperative learning strategies are used extensively. Statewide, the MCTP offers nearly 90 reformed-based courses in mathematics, science, and methods.

The MCTP Research on Teacher Education Group

The CETP National Science Foundation grant proposal for the MCTP included statements for both an Evaluation Group and a Research Group. As necessitated in the guidelines for such proposals, the proposal included a "Support Group for Project Evaluation" section that stated that the project would conduct formative and summative evaluation. However, the proposal also included an innovative "Support Group for Research on Teacher Education" section that stated the "project's innovative approaches to teacher preparation will be studied by a research group...." (University of Maryland System, 1993, p. 19). Within the funded CETP projects, the MCTP was the only project that included a designated support group to carry out research on teacher education.

In July 1994, Dr. James Fey, MCTP Project Director, designated J. Randy McGinnis (Science Educator), University of Maryland at College Park (UM), and Tad Watanabe (Mathematics Educator), Towson University, to share the leadership of the MCTP Research on Teacher Education Group (McGinnis maintained this position the duration of the MCTP project; Watanabe left in 1996). Anna Graeber, (UM, and Co-Director of the MCTP Methods Group), agreed to serve as an internal consultant to the Research Group. Dr. Kenneth Tobin (science educator, University of Pennsylvania) and the late Catherine Brown (mathematics educator) agreed to serve as external consultants. Doctoral students and graduate fellows who participated in the MCTP research group included: Amy Roth McDuffie, Carolyn Parker, Steve Kramer, Gilli Shama, Karen King, Roberto Vilarrubi, and Mary Ann Huntley.

The MCTP Research Questions

In essence, the primary purpose of research in the MCTP was articulated as the documentation and interpretation of the MCTP undergraduate mathematics and science teacher education program. The unique elements of the MCTP (particularly the instruction of mathematical and scientific concepts and reasoning methods in undergraduate content and pedagogy courses that model the practice of active, interdisciplinary teaching) were targeted for study from two perspectives: the faculty's and the teacher candidates'.

The research questions which were included in the grant proposal were:

1. What is the nature of the faculty and teacher candidates' beliefs and attitudes concerning the nature of mathematics and science, the interdisciplinary teaching and learning of mathematics and science to diverse groups (both on the higher education and upper elementary and middle level), and the use of technology in teaching and learning mathematics and science?

2. How do the faculty and teacher candidates perceive the instruction in the MCTP as responsive to prior knowledge, addressing conceptual change, establishing connections among disciplines, incorporating technology, promoting reflection on changes in thinking, stressing logic and fundamental principles as opposed to memorization of unconnected facts, and modeling the kind of teaching/learning they would like to see on the upper elementary, middle level?

Answers to those questions were thought to inform the major research questions driving teacher education research in all subject domains:

1. How do teacher candidates construct the various facets of their knowledge bases?

2. What nature of teacher knowledge is requisite for effective teaching in a variety of contexts?

While the original research questions served to orient the MCTP Research on Teacher Education Group to the major areas of inquiry in teacher preparation, over time specific study questions emerged in response to the interest of members of the MCTP Research on Teacher Education Group and in response to specific inquiries made by NSF staff members about the MCTP. The research questions included:

1. To what extent can educational research be used for evaluation purposes?

2. Is there a difference between the MCTP teacher candidates' and the non-MCTP teacher candidates' attitudes and beliefs about mathematics and science?

3. Do MCTP teacher candidates' attitudes toward and beliefs about mathematics and science change over time as they participate in the MCTP classes?

4. How do the MCTP faculty perceive their own discipline as well as the other discipline (mathematics/science) with which they seek to make connections?

5. How do college faculty "model" good instruction in mathematics and science methods courses for teacher candidates and how is that perceived by the teacher candidates?

6. How do new specialist teachers of mathematics and science who graduate from an inquiry-based, standards-guided innovative undergraduate teacher preparation:

   (1) view their subject disciplines;

   (2) intend to enact their roles as teachers; and,

   (3) compare in their discipline knowledge, beliefs, and intentions concerning mathematics and science to other elementary/middle level teachers?

7. How do experienced specialist teachers of mathematics and science who graduated from an inquiry-based, standards-guided innovative undergraduate teacher preparation:

   (1) view their subject disciplines;

   (2) enact their roles as teachers; and,

   (3) think about what they do when teaching science and mathematics with upper elementary/middle level students?

Since 1994, the MCTP Research on Teacher Education Group has conducted a research program to investigate these questions. Both hypothesis-testing and hypothesisgeneration research strategies have been used. Conceptually, the studies are demarcated between investigations that required a large scale focus (program-wide in scope with a large N) and investigations that required a small scale focus (a specific reform-based course or a case study with a small N).

In addition, as it became apparent that the findings from the MCTP Research on Teacher Education Group's studies were gaining prominence in project evaluation, a theoretical examination of the role of research to inform evaluation was undertaken.

MCTP Studies and Results

As earlier described, the MCTP project programmatically started with two separate groups, one with a focus on evaluation and the other with a focus on research. However, as the project was implemented, the findings from the Research on Teacher Education group increasingly became prominent in program evaluation. This use of research to inform evaluation posed a theoretical problem within the MCTP Research on Teacher Education Group, particularly as the function of the MCTP Evaluation Group was reduced while the function of the MCTP Research on Teacher Education Group was enhanced. The traditional conception of a dichotomy of evaluation and research with distinct, often incompatible, activities was challenged (i.e., evaluation solely for accountability and research solely for knowledge growth). The research question became "To what extent can educational research be used for evaluation purposes?" (Research Question #1). This question was investigated and reported in McGinnis and Watanabe (1998, 1999).

What was learned from a select literature review of evaluation theorists and NSF documents was that contemporary thinking on evaluation proposed multiple purposes: evaluation for accountability (measurement of results or efficiency); evaluation for development (information collected to strengthen institutions); and evaluation for knowledge (acquisition of a more profound understanding in some specific area or field). McGinnis and Watanabe (1999) concluded that research could inform evaluation within the CETP projects in a manner that typically was not done, but was critically needed.

> Evaluation for accountability, which is often thought to be the primary purpose of evaluation, is important and necessary. However, evaluation for development can be of extreme value to the participants in a CETP project, or any large scale teacher preparation project. Moreover, evaluation for knowledge will inform a much wider audience, resulting in long lasting benefits to the educators beyond the specific project. Thus, it appears reasonable that future programs address these multiple perspectives in their evaluation activities. (p. 103).

A. Large Scale Studies. Many of the MCTP Research on Teacher Education Research Questions (#2, #3, #4, and #6), required a program wide data collection. Data collection sources were qualitative (participant interviews) and quantitative (survey).

Survey methodology was used to answer the second research question ("Is there a difference between the MCTP teacher candidates' and the non-MCTP students' attitudes and beliefs about mathematics and science?") and the third research question ("Do MCTP teacher candidates attitudes toward and beliefs about mathematics and science change over time as they participate in the MCTP classes?"). Findings were reported in a series of studies that detailed the history and development of the MCTP instrument, "Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science," as well as results from its administration periodically (McGinnis, Roth McDuffie, Graeber, & Watanabe, 1995; McGinnis, Graeber, Roth McDuffie, Huntley, & King, 1996; McGinnis, Watanabe, Shama, &

Graeber, 1997; McGinnis, Shama, Graeber, & Watanabe, 1997; McGinnis, Kramer, Roth McDuffie, & Watanabe, 1998; McGinnis & Parker, 1999; McGinnis, Kramer, Graeber, & Parker 2001, and McGinnis, Kramer, Shama, Graeber, Parker, and Watanabe, *in press*). See Appendix A for a copy of the MCTP instrument, "Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science."

What we learned from the contrast between MCTP teacher candidates' and non-MCTP teacher candidates' attitudes and beliefs about mathematics and science is presented first. To answer research question #2, we compared MCTP teacher candidates' responses to non-MCTP students' responses by analyzing survey results from the fall 1995 MCTP courses (thirty-three content and pedagogy courses distributed statewide, N=486). The significance levels reported in Tables 1 and 2 were computed using an Analysis of Variance (ANOVA), with "course" and "MCTP vs. non-MCTP" as fixed effects[3]. We found, in general, that MCTP teacher candidates appeared to have started these courses with attitudes and beliefs more in line with program goals than those of non-MCTP students, and for most subscales the gap between these two groups appeared to have widened by the end of the course. The differences between MCTP and non-MCTP students had substantive as well as statistical significance (as evidenced from inspection of the effect sizes). Positively, the means for MCTP teacher candidates during the year indicated they started in the direction the project was aiming, and, in general, they reported an even higher level after a year of college-level instruction in reform-based classes.

--Insert Tables 1 and 2 About Here--

[3] Students in the same course might have correlated test scores, thus violating the MANOVA assumption that all observations are independent. Had we not controlled for the students' course, then it would be possible to obtain spurious results. For example this would have occurred if MCTP teacher candidates had been concentrated in a few courses with particularly high scores on the dependant variables.

An unanticipated finding was that in some cases the gap between MCTP and non-MCTP students widened not because of a move by MCTP students toward higher scores (i.e., in the direction desired by the program) but because of a move by non-MCTP students in the opposite direction. In particular, at the end of a semester non-MCTP students were less likely than they had been at the beginning to agree that they wanted to learn how to use technologies to teach either math or science. They were also less likely to say that they expected college mathematics courses they take to be helpful in teaching elementary our middle school mathematics, or that they expected college science courses to be helpful in teaching elementary or middle school science.

Both the MCTP instructors and the project leadership were troubled by the declines in the subscale scores of non-MCTP students taking MCTP courses. Speculations for these declines based on MCTP instructor feedback were made. The most widely accepted explanation was that the MCTP courses were indeed taught differently, with different emphases, compared to traditional science, mathematics, and education courses that these undergraduate students expected.

What we learned from investigating research question #3 ("Do MCTP teacher candidates attitudes toward and beliefs about mathematics and science change over time as they participate in the MCTP classes?") was encouraging. We analyzed data from seven administrations of the survey, including four in-class surveys during 1995-96, plus three mail-in surveys, administered in December, 1996, in May, 1997, and in December, 1997. Only responses from MCTP teacher candidates who participated in all seven surveys were used in the analysis. Table 3 summarizes how many MCTP students from each institution in the MCTP responded to each survey administration.

--Insert Table 3 About Here--

Figure 1 displays graphically the mean attitude and beliefs scores for MCTP teacher candidates at each of the seven administrations of the survey analyzed.

--Insert Figure 1 About Here--

As is apparent, over the extended period during which we administered the survey, MCTP teacher candidates' attitudes and beliefs moved in the desired direction on all five subscales of the MCTP instrument, "Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science." A MANOVA comparing the first administration of the survey (pre-course survey, Fall 1995) to the last administration of the survey (mail-in, Fall 1997), after controlling for institution as a fixed effect, showed that the change was significant beyond the .001 level. Similarly, an examination of the effect sizes indicated a moderate significant effect. McGinnis, Kramer, Shama, Graeber, Parker, and Watanabe (2002) concluded,

> Based on our analyses, we believe that the MCTP program achieved success in moving prospective upper elementary and middle school teachers' attitudes and beliefs in the desired direction over the 2.5 years during which they completed our survey. In context of the extensive body of literature that points to how difficult it is to assist elementary teachers to look forward to teach science and mathematics (Starr, Zembal-Saul, & Krajcik, 1997) and in the context of discouraging conclusions emerging from studies that report participants' evaluations of reform-based science teacher preparation programs (McGlamery, Edick, & Ostler, 1999; Simmons, et. al., 1999), this study contributes to a more positive narrative. The results of this study are encouraging, in particular, in that they provide support for the positive impact of

reform-based teaching in subject matter courses and in pedagogy courses for prospective elementary and middle level science and mathematics teachers. That is, this study supports the use systemically of standards-based recommendations articulated by Rutherford and Ahlgren (1989) and the National Research Council (1996) to achieve reform in undergraduate science, mathematics, and pedagogy courses. Particularly, this study supports the attention placed on moving prospective teachers' attitudes and beliefs to be in alignment with reform-based perspectives through use of systemic changes in instruction (NRC, 1997).... The findings are educationally significant because they point out which student populations may report differentially the extent that they benefit through systematic reform. For example, our findings suggest that students traditionally resistant to believing that they can teach mathematics and science (i.e., prospective elementary teachers) but who do accept reform-based principles, react positively to standards-based courses as measured on attitude and belief scales. Conversely, students who first encounter reform-based undergraduate courses and who have not endorsed reform-based principles can react in a less positive manner on identical measurement scales.

Additional large scale studies in the MCTP were qualitative in design. In a study that was designed to answer research question #4 ("How do the MCTP faculty perceive their own discipline as well as the other discipline (mathematics/science) with which they seek to make connections") MCTP faculty statewide were interviewed (McGinnis & Watanabe 1996). Theoretically, the MCTP faculty were viewed as constituting a discourse community made of two primary speech communities (each of which contained discipline content experts and pedagogy experts): Mathematics Teaching Community and the Science Teaching Community (see Figure 2).

--Insert Figure 2 About Here---

What was learned from the comparison of the mathematics content specialists' and the mathematics methods specialist discourse on mathematics was that they expressed different referents to mathematics in the same speech community. In discussing mathematics, individuals in the mathematics content group referred to mathematics as an immense, hierarchical and logically structured body of knowledge which existed as a separate reality transcending the physical universe. In contrast, individuals in the mathematics methods group referred to mathematics as modeling the physical universe and as a telling determinant of a person's personality or worldview. In both groups the notion of mathematics as something that existed in the mind that was linked with thinking was expressed.

In discussing science, both the mathematics and the mathematics methods content groups expressed that science was linked with the physical universe. This was expressed as science as being found in nature and in particular substances. Individuals in the mathematics groups differed in several ways in which they referred to science. The mathematics content group expressed a broad array of referents to science, many of which were linked to its structure as a discipline as constructed by humans over time. Science was referred to as a type of "truth," a "mind-set," and as "theories." This was in contrast to individuals in the mathematics methods group who expressed a utilitarian vision of science as defined through a mathematics filter: science provided a motivation and a physical context for the doing of mathematics. See Tables 4 and 5.

--Insert Table 4 and Table 5 About Here----

A comparison of the science content specialists' and the science methods specialists' discourse on science revealed both similarities and differences on this same referent. In discussing science, a similarity between some members of the groups was the belief that science was characterized by modeling of physical phenomena. Key differences between the groups discussing science involved some members of the science content specialist group expressing the beliefs that science is information, compartmentalized into discrete disciplines, and specific topics while some members of the pedagogy content specialist group expressed that science consisted of content and process (the way of doing science). In discussing mathematics, a similarity found between some members of the groups was that they believed mathematics was a tool to be used in science. Key differences between the groups discussing mathematics involved some members of the science content specialist group expressing the beliefs that mathematics is also terms, calculations, operations, the quantification of qualitative explanations, and that mathematics is really more than as is perceived by those engaged in doing science. See Tables 6 and 7.

--Insert Table 6 and Table 7 About Here----

McGinnis and Watanabe (1996) concluded,

> These findings support and extend recent assertions that differences between content discipline experts and content methods experts tend to exist in how they conceive their content disciplines (Mura, 1993, 1995). In collaborative projects such as the MCTP in which both content and methods experts equally participate, and in which there are specific project goals that relate to making connections between disciplines and how they are taught, this recognition can assist project directors engage in sense-making and in devising strategies to implement project goals. (p.34)

In a study that was designed to investigate research question #5 ("How do college faculty "model" good instruction in mathematics and science methods courses for teacher candidates and how is that perceived by the teacher candidates"), Watanabe, McGinnis, and Roth McDuffie (1997) analyzed interview data collected statewide from a large sample of MCTP instructors and MCTP teacher candidates. Instructor and student perspectives on modeling good instruction were analyzed. What was learned from that study was that the MCTP instructors primarily sought to model good instruction for teacher candidates by connecting classroom discussions and activities to precollegiate contexts, and by creating student-focused mathematics and science classrooms. Strategies used by the instructors to model good instruction in mathematics, science, and pedagogy undergraduate courses were cooperative group activities, use of equipment and manipulatives, and extended classroom discussions. The teacher candidates voiced that they noticed the efforts made by the MCTP instructors to model good instruction. They stated that they learned the most in MCTP classroom contexts that held an expectation that they would find solutions to student-generated questions. An unresolved issue was whether there was a role for pedagogical conversation in undergraduate mathematics and science coursework designed especially for teacher candidates.

In another study, Watanabe and Huntley (1998) examined MCTP instructors' thoughts on modeling good instruction in their courses by making connections between mathematics and science. What was learned from analyzing many MCTP instructor interviews was that they identified benefits and barriers to making connections between the disciplines at the collegiate level similar to those reported by school teachers. Watanabe and Huntley concluded,

> In spite of challenges they have faced, many MCTP mathematics and science instructors appear to have developed an increased respect and appreciation for each other's discipline, and they remain interested in making meaningful connections between mathematics and science....Many continue to grapple with the questions, like "What should be the nature of mathematics and science connections?" and "What is the nature of mathematics or science in relationship to the other discipline?" (p. 24)

Similarly, McGinnis (in press) and McGinnis, Graeber, Roth-McDuffie, Huntley and King (1996) reported on a discourse analysis of MCTP faculty conversations regarding making connections between mathematics and science. Figure 3 contains a list of the MCTP faculty's emerging conversation themes by category with elaboration.

--Insert Figure 3 About Here---

The McGinnis and Parker (2001) quantitative study was designed to answer research question #6 ("How do new specialist teachers of mathematics and science who graduate from an inquiry-based, standards-guided innovative undergraduate teacher preparation: view their subject disciplines; intend to enact their roles as teachers; and, compare in their beliefs and intentions concerning mathematics and science to other elementary/middle level teachers). This study reported results of an application of survey methodology that permitted contrast between self-report MCTP new graduates' beliefs and actions with self-reports of a large sample of full time teachers. A new instrument was crafted to measure the constructs of interest of the program's graduates, "MCTP Teacher's Beliefs and Actions of Mathematics and Science." This 51-item instrument included 45 items reported in the National Science Board's 1998 Science & Engineering Indicators (NSB-98-1). See Appendix B for a copy of the MCTP instrument, "MCTP Teacher's Beliefs and Actions of Mathematics and Science."

The survey was administered three times over a three-year period (1999/2000/2001) (N=68). The total response rate was 60%. A nonresponse bias check indicated no significant difference between respondents and nonrespondents. A statistical examination indicated that in a preponderance of areas the MCTP graduates' and employed new teachers' responses were more in alignment with a reform-based orientation than were responses by the national sample of teachers. A summary of the findings by instrument subscale follows.

Nature and teaching of mathematics. The MCTP graduates' responses differed significantly ($p<.05$) from the national sample (n=478) on several beliefs. Specifically, they were less likely to believe: that mathematics is primarily an abstract subject; that mathematics should be learned as sets of algorithms or rules that cover all possibilities; that a liking for and understanding of students are essential for teaching mathematics; and, that more than one representation should be used in teaching a mathematics concept. A disaggregated analysis of the MCTP middle school mathematics teachers' responses (N=14) compared with a national sample of middle school teachers (N=246) on the same construct found that the MCTP middle school mathematics teachers differed significantly ($p<.05$) from the national sample on two beliefs. They were less likely to believe that mathematics is primarily an abstract subject, and they were less likely to believe that if students are having difficulty, an effective approach was to give them more practice by themselves during the class. See Tables 8-1 and 8-2.

--Insert Tables 8-1 and 8-2 About Here--

Nature and teaching of science. The MCTP graduates differed significantly ($p<.05$) from the national sample (N=478) on several beliefs. Specifically, they were less likely to believe : that science is primarily a formal way of representing the real world; that science is primarily a practical and structured guide for addressing real situations; that a liking for and understanding of students are essential for teaching science; that it is important for teachers to give students prescriptive and sequential directions for science experiments; and, that students see a science task as the same task when it is represented in two different ways. However, they were more likely to believe that if students get into debates in class about ideas or procedures covering the sciences, it can harm their learning. A disaggregated analysis of the MCTP middle school science teachers' responses (N=9) found that in comparison with the national sample of middle school science teachers (N=232), the MCTP middle school science teachers differed significantly ($p<.05$) on two beliefs. They were *less likely to believe* that it is important for teachers to give students prescriptive and sequential directions for science experiments. However, they were more likely to believe that science is primarily a practical and structured guide for addressing real situations. See Tables 9-1 and 9-2.

--Insert Tables 9-1 and 9-2 About Here--

Perceptions of Student Skills Required for Success in Mathematics. The MCTP graduates differed significantly ($p<.05$) from the national sample on several beliefs. Specifically, they were *less likely to think:* it is very important for students to remember formulas and procedures, and to think in a sequential manner. A disaggregated analysis of the MCTP middle school mathematics teachers' responses compared with the national sample found that the MCTP teachers differed significantly from the national sample on one belief. Specifically, they were less likely to think it is very important for students to think in a sequential manner. See Tables 10-1 and 10-2.

--Insert Tables 10-1 and 10-2 About Here--

Perceptions of Student Skills Required for Success in Science. The MCTP graduates differed significantly ($p<.05$) from the national sample on several beliefs. Specifically, they were *less likely to think* : it is very important for students to remember formulas and procedures, and to think in a sequential manner. A disaggregated analysis of the MCTP middle school mathematics teachers' responses compared with the national sample found that the MCTP middle school mathematics teachers differed significantly ($p<.05$) from the national sample on one belief. Specifically, they were more likely to think it is very important for students to support solutions. See Tables 11-1 and 11-2.

--Insert Tables 11-1 and11-2 About Here--

Teachers use of instructional practices in mathematics. The MCTP elementary school teachers (N=29) differed significantly from the national sample of elementary teachers (N=473) on all practices. They were *more likely to* : assist all students to achieve high standards; provide examples of high-standard work; use authentic assessments; use standards aligned curricula; use standards-aligned textbooks and materials; and, use telecommunication-supported instruction. Also, 93.1% stated that would make connections with science in their practices. The MCTP middle school mathematics teachers differed significantly from the national sample (398) on several actions. They were more likely to: assist all students to achieve high standards; provide examples of high-standard work; use authentic assessments; use standards-aligned curricula; and, use telecommunication-supported instruction. Also, 92.31% stated that they made connections with science in their practices. See Tables 12-1 and 12-2.

--Insert Tables 12-1 and 12-2 About Here--

Teachers use of instructional practices in science. The MCTP elementary school teachers differed significantly from the national sample on all practices. They were *more likely to*: assist all students to achieve high standards; provide examples of high-standard work, to use authentic assessments; use standards aligned curricula; use standards-aligned textbooks and materials; and, use telecommunication-supported instruction. Also, 96.6% stated that they made connections with mathematics in their practices. The MCTP middle school science teachers differed significantly from the national sample (N=39) on several practices. They were more likely to: assist all students to achieve high standards, to use authentic assessments; use standards-aligned curricula; use standards-aligned textbooks and materials; and, use telecommunication-supported instruction. Also, 100% stated that they made connections with mathematics in their practices. See Tables 13-1 and 13-2.

--Insert Tables 13-1 and 13-2 About Here--

McGinnis, Parker, and Graeber (2000) concluded:

> The goal of the MCTP is to produce new teachers who are confident teaching mathematics and science using technology, who can make connections between and among the disciplines, and who can provide an exciting and challenging learning environment for students of diverse backgrounds. Along all measures, the present analysis provides evidence that the graduates of this program hold perspectives that support these aims. The present analysis also provides a striking comparison between the perspectives of practicing MCTP teachers and other teachers at the same level and subject specialization. Along all measures (many determined to be statistically significant) the MCTP new teachers express more reform-oriented perspectives concerning subject matter and instruction. These findings suggest strongly that a systematic, reform-based undergraduate science and mathematics program can produce new teachers who enter the workplace with desired perspectives. Whether these perspectives impact instructional choices over time in the desired direction of the

> reform movement remains undetermined. However, our results suggest that at least initially the reform-oriented perspectives do convey to the workplace. (p. 10).

B. Small Scale Studies.

Small case studies qualitative in design were also used to inform research question #5 ("How do college faculty "model" good instruction in mathematics and science methods courses for teacher candidates and how is that perceived by the teacher candidates"). The Roth McDuffie & McGinnis (1996) and Roth McDuffie, McGinnis & Graeber (2000) study reported the effects of a reform-based introductory undergraduate mathematics class, and the efforts of a mathematics professor to teach such a class were examined using the students', professor's, and researchers' perspectives. Analysis of the data indicated that both the teacher candidates and the mathematics professor took an important first step toward enculturation into a reform-based vision of mathematics learning and teaching. Roth McDuffie, McGinnis & Graeber (2000) concluded,

> A major implication gained from this study is that the college students who experienced a reform-based mathematics classroom early in their undergraduate program completed *a first step* in achieving the vision for reform of mathematics education: constructing an initial model of mathematics teaching and learning which embraces the ideals of the reform movement. The students' prior conceptions and experiences of mathematics instruction was that mathematics teaching and learning is procedural and rule-based. However, being in a classroom where reform-based teaching was modeled and where students were engaged in active learning through meaningful problem solving and collaboration enabled the students to construct a new model of mathematics teaching and learning.... Another major implication is that

> professors teaching a reform-based class in which they model reform-based teaching practices consistent with the reform documents should anticipate taking on many aspects of a "pioneer" venturing into new territory....In contrast to his teacher candidate students, [the MCTP mathematics professor] was enculturated into the practice of reform-based teaching and learning by experiencing it as a *teacher*. He was "learning by doing" (p. 247-248).

The McGinnis, Roth McDuffie, and Parker (1999) and McGinnis, Roth McDuffie, Graeber, and Parker (2000) study similarly focused on research question #5. In this study an elementary science methods course instructor made efforts to connect mathematics and science. Some of the students in the class were participants in a National Science Foundation funded project to prepare students interested in teaching mathematics and science in grades 4-8. The same methods class included students whose areas of emphasis did not include this special interest or the accompanying experiences. The content knowledge of the these two groups and their perceptions about a) their preparedness to teach science, b) appropriate science learning environments, c) a rationale for connections between mathematics and science, and d) the role of a science methods course were contrasted. Also included in this practitioner-research study were the perceptions of the science methods instructor, the mathematics methods instructor, and two graduate research assistants. McGinnis, Roth McDuffie, Graeber, and Parker (2000) concluded,

> In regard to [the MCTP science methods professors'] goal of helping students understand the connections between mathematics and science, while he achieved some level of success in this goal, we need to consider Steen's (1994) warning. While McGinnis's course did not promote the idea of mathematics only as a tool for doing

science, the teacher candidates did not seem to view mathematics as more than this when discussing the *discipline* of mathematics... This finding serves as evidence that by viewing the disciplines from a connected perspective, a limited view of mathematics can emerge even when that view is not held or promoted by the science methods instructor. However, when discussing the *processes* of science and mathematics, the students perceived many commonalties (e.g., investigation and problem solving) and demonstrated a more developed understanding of these processes in each discipline. Again this finding is consistent with Steen's (1994) recommendations that in making connections between mathematics and science we should focus on the methodologies of the disciplines (i.e., focus on the commonalties of *how* we do mathematics and science) rather than on *what* is common between mathematics and science.

When comparing the two groups of teacher candidates, at the beginning of the semester we see fairly stark contrasts in their perceptions about their preparedness to teach their vision of an effective learning environment, and their understanding of connections between mathematics and science. Quite predictably, the CETP teacher candidates had perceptions that were consistent with their experiences in the CETP program, while the non-CETP candidate relied on more traditional, lecture-based preparation. However, at the end of the semester, after sharing the common experience of being in a science methods course which was based on CETP goals, both groups expressed similar ideas on the above issues. The difference at the end of the semester was not in the basic terminology used or the fundamental ideas expressed, but rather, in the *depth and sophistication* of understanding conveyed in the comments. Consistently, the CETP teacher candidates offered comments that were more developed in the way they explained their ideas, and they provided more specific examples of their thinking as compared to the non-CETP candidates. With a background of more experiences in this type of learning environment and with more opportunities to reflect on their thinking and learning (and the implications for their own teaching), the CETP students articulated a well-developed philosophy of teaching science. Whereas, the non-CETP students just had begun this process.

This study suggests that this one-semester course was enough to influence the perceptions (and, by implication, their beliefs) of both groups of teacher candidates. However, we believe the impact was not enough to allow the non-CETP teacher candidates to "catch up" to the CETP teacher candidates in developing a carefully thought-out philosophy of teaching and learning. Clearly, the efforts made by the CETP mathematics and science content instructors to teach in a reform-based manner made a difference in how receptive the CETP teacher candidates were in the science methods to the pedagogical innovation of making connection between science and mathematics. The question remains as to whether either group has been affected enough by the reform-based CETP courses and only the reform-based science methods course to bring about reform-based teaching in their future classroom practices.

To answer to sixth research question ("How do new specialist teachers of mathematics and science who graduate from an inquiry-based, standards-guided innovative undergraduate teacher preparation: view their subject disciplines; intend to enact their roles as teachers; and, compare in their beliefs and intentions concerning mathematics and science to other elementary/middle level teachers?") an interpretative methodology was also used. In

McGinnis, Parker, and Graeber (2000a, 2000b, 2000c) a case study was conducted of a small sample of MCTP new teachers (N=5 first year, N=3 second year) in their first two years of full time teaching. The purpose of this exploratory longitudinal qualitative study was to present a detailed description and interpretation of what happens in schools to new teachers who are prepared to enact reform-based practices in mathematics and science. The researchers documented differential experiences and perceptions of new specialist teachers of mathematics from both inside (the teachers' and their students') and outside perspectives (principals' and investigators'). Documented discussion centered on a teacher socialization framework as suggested by Veenman (1984). Insights were framed in two components: the individual's intentions, needs, and capabilities, and the institutional demands, supports and constraints. The major finding was that from the new teachers' perspective, the school culture was a major factor in whether reform-aligned mathematics and science teaching was regularly implemented by the new MCTP teachers. In instances where the new teachers' perceived that their school cultures offered a lack of support for their intent to implement reform-based practices the new teachers exhibited differing social strategies (resistance, moving on, and exit). McGinnis, Parker, and Graeber (2000c) concluded,

> First, our research suggests that a reform-based mathematics and science teacher preparation program can recruit, educate, and graduate a cadre of new teachers who are employed by school districts. Our rich documentation presents evidence that new teachers from such a teacher preparation program have the capabilities and intentions to teach mathematics and science in a reform-minded manner that makes connections between the disciplines by using high quality science and mathematics. Second, our research suggests that the school context in which the new teachers began their

teaching practices is a major factor in whether reform-minded mathematics and science teaching is regularly implemented. The supports and constraints an individual teacher encounters on a daily basis, particularly from individuals with potential coercive power over their work lives, are noticed by new teachers and influence their curricular, instructional, and assessment actions. Finally, if our findings are supported by future research, to enact reform and to retain new reform-prepared teachers a key implication is that the new teachers fare better when they are employed in supportive, reform-oriented school cultures rather than in other environments. While our findings show that in situations in which reform-based teaching is discouraged some reform-prepared new teachers do not leave but elect to continue their careers by altering their practices to fit in with extant traditional practices, the loss of reform in those contexts is a costly impact. We posit that if better matches are made initially between reform-prepared teachers and school cultures, the extent and the quality of reform-based practices in mathematics and science teaching will increase as will the retention of more newly prepared teachers within school cultures. We also wonder what can reasonably be done in teacher preparation to more adequately prepare new, reform-minded teachers to enact reform-based practices in school cultures that are not initially supportive? We believe a first step would be to alert them to the process of socialization in school cultures.

In addition, McGinnis (2001) reported on the use of teaching cases to provide insight on what happens to MCTP new teachers in the workplace. Eight MCTP elementary and middle level new mathematics and science teachers reported their first hand diverse perspectives on the successes and challenges they faced in implementing reform-based pedagogy.

Recommended Future Studies

Additional studies are needed particularly to answer the seventh research question ("How do experienced specialist teachers of mathematics and science who graduated from an inquiry-based, standards-guided innovative undergraduate teacher preparation: view their subject disciplines; enact their roles as teachers; and, think about what they do when teaching science and mathematics with upper elementary/middle level students?").

Specifically, what was not clear from the qualitative McGinnis, Parker, and Graeber (2000) study was from the new teachers' perspective the degree of influence of the school level (elementary vs. middle level), the district's curricula in mathematics and science, the differing teaching responsibilities of mathematics or science, and the inservice induction professional development experiences had on their perception of school culture as a receptive environment to implement reform-based practices. That is, an examination of the construction of school culture (over time) by high quality, new teachers and its connection with the teachers' implementation of reform-oriented content classroom teaching was incomplete. What is required is a similar study that examines a range of MCTP graduates, diverse in years of teaching experience, by level of practice (elementary or middle level), and by subject concentration (mathematics or science)

Also, what was not determined from the quantitative McGinnis, Parker, and Graeber (2001) study was if the MCTP graduates would maintain their initial reported beliefs. Future plans are to survey again the same MCTP graduates after they have gained significant full time classroom teaching experience. This research strategy will permit the researchers to compare the MCTP graduates' first survey responses (made primarily during the first few months of full time teaching) to responses made after significant teaching experience (up to three years). Movement away from reform-oriented beliefs and instructional practices will be identified as well as areas that remain positive.

Finally, an additional study relating to research question #6 ("How do new specialist teachers of mathematics and science who graduate from an inquiry-based, standards-guided innovative undergraduate teacher preparation...compare in discipline knowledge concerning mathematics and science to other elementary/middle level teachers") is needed. The subject focus should be mathematics. That type of study will complement the science subject focus reported in McGinnis, Roth McDuffie, and Parker (1999) and McGinnis, Roth McDuffie, Graeber, and Parker (2000).

Conclusion

As presented, the research program conducted within the MCTP was encompassing in its quest to examine what could be learned from an innovative undergraduate upper elementary/middle level teacher preparation program for specialist mathematics and science teachers. As summarized in this report, much has been learned through the studies that apply directly to the evaluation of the MCTP, and more expansively, to the other CETP projects and science education in general. The expectation is that the MCTP research findings will assist in future examination and progress in mathematics and science teacher preparation.

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Appendix A: MCTP Survey Instrument

"Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science"

Section One: Background Information

1. Sex:
   a. Male b. Female

2. Ethnicity:
   a. African-American b. Asian/Pacific Islander c. Caucasian
   d. Hispanic e. Other

3. Number of completed college credits:
   a. 0- 30 b. 31-60 c. 61-90 d. 91+ e. post-baccalaureate

4. Major or area of concentration:
   a. Education/Mathematics b. Education/Science
   c. Education/Mathematics & Science d. Education/Other Subject(s)
   e. Not in teacher certification program

Section Two: Attitudes and Beliefs

Below, there is a series of sentences. Indicate on your bubble sheet the degree to which you agree or disagree with each sentence.

Your choices are:

A	B	C	D	E
strongly agree	sort of agree	not sure	sort of disagree	strongly disagree

There are no right or wrong answers. The correct responses are those that reflect your attitudes and beliefs. *Do not spend too much time with any statement.*

5. I am looking forward to taking more mathematics courses.

6. I enjoy learning how to use technologies (e.g., calculators, computers, etc.) in mathematics classrooms.

7. I like mathematics.

8. Calculators should always be available for students in mathematics classes.

9. In grades K-9, truly understanding mathematics in schools requires special abilities that only some people possess.

10. The use of technologies (e. g., calculators, computers, etc.) in mathematics is an aid primarily for slow learners.

11. Mathematics consists of unrelated topics (e.g., algebra, arithmetic, calculus and geometry).

12. To understand mathematics, students must solve many problems following examples provided.

A	B	C	D	E
strongly agree	sort of agree	not sure	sort of disagree	strongly disagree

13. Students should have opportunities to experience manipulating materials in the mathematics classroom before teachers introduce mathematics vocabulary.

14. Getting the correct answer to a problem in the mathematics classroom is more important than investigating the problem in a mathematical manner.

15. Students should be given regular opportunities to think about what they have learned in the mathematics classroom.

16. Using technologies (e.g., calculators, computers, etc.) in mathematics lessons will improve students' understanding of mathematics.

17. The primary reason for learning mathematics is to learn skills for doing science.

18. Small group activity should be a regular part of the mathematics classroom.

19. I am looking forward to taking more science courses.

20. Using technologies (e.g., calculators, computers, etc.) in science lessons will improve students' understanding of science.

21. Getting the correct answer to a problem in the science classroom is more important than investigating the problem in a scientific manner.

22. In grades K-9, truly understanding science in the science classroom requires special abilities that only some people possess.

23. Students should be given regular opportunities to think about what they have learned in the science classroom.

24. Science is a constantly expanding field.

25. Theories in science are rarely replaced by other theories.

26. To understand science, students must solve many problems following examples provided.

27. I like science.

28. I enjoy learning how to use technologies (e.g., calculators, computers, etc.) in science.

29. The use of technologies (e. g., calculators, computers, etc.) in science is an aid primarily for slow learners.

30. Students should have opportunities to experience manipulating materials in the science classroom before teachers introduce scientific vocabulary.

31. Science consists of unrelated topics like biology, chemistry, geology, and physics.

32. Calculators should always be available for students in science classes.

33. The primary reason for learning science is to provide real life examples for learning mathematics.

34. Small group activity should be a regular part of the science classroom.

ITEMS 35--45 ARE FOR ONLY THOSE INTENDING TO TEACH

A	B	C	D	E
strongly agree	sort of agree	not sure	sort of disagree	strongly disagree

35. I expect that the college mathematics courses I take will be helpful to me in teaching mathematics in elementary or middle school.

36. I want to learn how to use technologies (e.g., calculators, computers, etc.) to teach mathematics.

37. The idea of teaching science scares me.

38. I expect that the college science courses I take will be helpful to me in teaching science in elementary or middle school.

39. I prefer to teach mathematics and science emphasizing connections between the two disciplines.

40. The idea of teaching mathematics scares me.

41. I want to learn how to use technologies (e.g., calculators, computers, etc.) to teach science.

42. I feel prepared to teach mathematics and science emphasizing connections between the two disciplines.

43. Area of teaching certification
a. elementary (grades 1-8) b. secondary mathematics (5-12)
c. secondary science (5-12) d. other

44. I intend to teach grades
a. K - 3 b. 4-8 c. 9-12 d. post-secondary e. undecided

45. I am a student in the Maryland Collaborative for Teaching Preparation.
    a. yes b. no

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Appendix B: MCTP Survey Instrument

MCTP Teacher's Actions And Beliefs Of Mathematics And Science

SECTION I.
To what extent do you agree or disagree with each of the following statements?

Choices:

(A)	(B)	(C)	(D)
Strongly disagree	Disagree	Agree	Strongly agree

<u>Mathematics</u>
1. is primarily an abstract subject.
2. is primarily a formal way of representing the real world.
3. is primarily a practical and structured guide for addressing real situations.
4. should be learned as sets of algorithms or rules that cover all possibilities.
5. A liking for and understanding of students are essential for teaching math.
6. If students are having difficulty, an effective approach is to give them more practice by themselves during the class.
7. More than one representations should be used in teaching a math concept.
8. Some students have a natural talent for math and others do not.
9. Basic computational skills on the part of the teacher are sufficient for teaching elementary school math.

<u>Science</u>
10. is primarily an abstract subject.
11. is primarily a formal way of representing the real world.
12. is primarily a practical and structured guide for addressing real situations.
13. Some students have a natural talent for science and others do not.
14. A liking for and understanding of students are essential for teaching science.
15. It is important for teachers to give students prescriptive and sequential directions for science experiments.
16. Focusing on rules is a bad idea. It gives students the impression that the sciences are a set of procedures to be memorized.
17. If students get into debates in class about ideas or procedures covering the sciences, it can harm their learning.
18. Students see a science task as the same task when it is represented in two different ways.

SECTION II.
To be good at mathematics [science] at school, how important do you think it is for students to [fill in the blank with each of the items below] ?
Choices:

(A)	(B)	(C)
Not important	Somewhat important	Very Important

<u>In Mathematics</u>
19. remember formulas and procedures?

20. think in sequential manner?
21. understand concepts?
22. think creatively?
23. understand math use in real world?
24. support solutions?

In Science
25. remember formulas and procedures?
26. think in sequential manner?
27. understand concepts?
28. think creatively?
29. understand science use in real world?
30. support solutions?

SECTION III.
What is your familiarity with the reform documents?
Choices:

(A)	(B)	(C)	(D)	(E)
Not at all extent	Small extent	Fairly	Moderate extent	Great

31. Mathematics standards document (Curriculum and Evaluation Standards for School Mathematics).
32. Science standards document Benchmarks for Science Literacy.
33. Science standards document National Science Education Standards.

SECTION IV.
Please indicate if you use (or would use if you taught mathematics and science) the instructional strategies listed below.
Choices:
(A) No (B) Yes

In Mathematics
34. Assisting all students to achieve high standards.
35. Providing examples of high-standard work.
36. Using authentic assessments.
37. Using standards aligned curricula.
38. Using standards-aligned textbooks and materials.
39. Using telecommunication-supported instruction.
40. Making connections with science.

In Science
41. Assisting all students to achieve high standards.
42. Providing examples of high-standard work.
43. Using authentic assessments.
44. Using standards aligned curricula.
45. Using standards-aligned textbooks and materials.

46. Using telecommunication-supported instruction.
47. Making connections with mathematics.

SECTION V

48. If you have taught since graduation, for what duration?
    a. in beginning year b. 1 to 2 years c. 3 to 4 years d. > 4 years

49. If applicable, what grade level are you teaching this year?
    a. 1 or 2 b. 3 or 4 c. 5 or 6 d. 7 or 8 e. other

50. If applicable, are you a specialized teacher (by content)?
    a. yes b. no

51. If you are a specialized teacher, what is your content area?
    a. mathematics b. science c. both mathematics and science d. other

The preparation of this instrument was supported in part by a grant from the National Science Foundation (Cooperative Agreement No. DUE 9814650).

Table 1

Attitudes and Beliefs of MCTP vs. Non-MCTP Teacher Candidates, Pre-course Surveys (1995-96)

Variable	MCTP M	Non-MCTP M	SD	Effect Size
Beliefs about Math & Science	3.98	3.81	.52	.33
Attitudes towards Math & Science	3.81	3.33	.86	.56 [a]
Beliefs about teaching Math & Science	4.11	4.02	.47	.19 [a]
Attitudes towards learning to teach M&S	4.51	4.25	.69	.38 [a]
Attitudes towards teaching M&S	3.48	3.06	.84	.50 [b]

Note. [a] Significant beyond the .05 level. [b] Significant beyond the .001 level.

Table 2

Attitudes and Beliefs of MCTP vs. Non-MCTP Teacher Candidates, Post-Course Surveys (1995-96)

Variable	MCTP M	Non-MCTP M	SD	Effect Size
Beliefs about Math & Science	3.95	3.69	.56	.46 [b]
Attitudes towards Math & Science	3.78	3.34	.84	.52 [c]
Beliefs about teaching Math & Science	4.23	4.00	.50	.46 [c]
Attitudes towards learning to teach M&S	4.50	3.97	.79	.67 [c]
Attitudes towards teaching M&S	3.44	3.14	.82	.37 [a]

Note. [a] Significant beyond the .05 level. [b] Significant beyond the .01 level. [c] Significant beyond the .001 level.

Table 3

Number Of MCTP Teacher Candidates Surveyed in Each Administration

Institution	Pre-course survey Fall '95	Post-course survey Fall '95	Pre-course survey Spring '96	Post-course survey Spring '96	Fall '96 Survey	Spring '97 Survey	Fall '97 Survey
A	9	7	3	3	8	15	9
B	23	13	22	25	5	11	2
C	10	10	8	9	9	12	9
D	34	22	18	20	11	18	17
E	20	8	6	5	15	16	14
Total	96	60	57	62	48	72	51

Table 4

Mathematics Teaching Faculty's Talk About Mathematics

Group	Conversation Referents
Mathematics content specialist	Mathematics is different topics
	Mathematics is hierarchical
	Mathematics is a body of knowledge/content
	Mathematics is different topics
	Mathematics is a form of reality
	Mathematics is a form of logic
Mathematics methods specialist	Mathematics is a cognitive endeavor
	Mathematics is modeling
	Mathematics can define people's personalities

n = 7, 5 mathematicians, 2 mathematics educators.

Table 5

Mathematics Teaching Faculty's Talk About Science

Group	Conversation Referents
Mathematics content specialist	Science is found in nature
	Science is substances
	Science is theories and predictions
	Science is tentative
	Science is a way of knowing/a view of the world
	Science explains the experiential world
	Science is a type of truth
	Science is a human construction
	Science is many disciplines
Mathematics methods specialist	Science is patterns in the physical environment
	Science is a context for problems

n = 7, 5 mathematicians, 2 mathematics educators.

Table 6

Science Teaching Faculty's Talk About Science

Group	Conversation Referents
Science content specialist	Science is modeling observable phenomena
	Science is progressive
	Science is specific topics
	Science is compartmentalized into discrete disciplines
	Science is information
	Science is experimenting
Science Methods Specialist	Science is a lifelong process
	Science is an inquiry that involves models and explanation
	Science is questioning
	Science is content and process
	Science is a serendipitous thing

n = 11, 8 scientists, 3 science educators.

Table 7

Science Teaching Faculty's Talk About Mathematics

Group	Conversation Referents	
Science content specialist	Mathematics is	something you can have or possess
	Mathematics is	an equation for straight lines
	Mathematics is	terms
	Mathematics is	calculations
	Mathematics is	measurements of data
	Mathematics is	problem solving
	Mathematics is	basic operations
	Mathematics is	a tool to do science
	Mathematics is	quantification of qualitative explanations
	Mathematics is	really more than as is perceived by scientists
Science Methods Specialist	Mathematics is the visual display of data	
	Mathematics is a tool to be used	

n = 11, 8 scientists, 3 science educators.

Table 8-1. Comparison of MCTP Graduates' Beliefs about the Nature and Teaching of Mathematics with A National Sample by Percentage Agreeing or Strongly Agreeing

Item	MCTP[1]	National[2]	χ^2	p
1. Math is primarily an abstract subject.	10.4%	31.0%	12.19	.0005*
2. Math is primarily a formal way of representing the real world.	74.2%	79.1%	.81	.3678
3. Math is primarily a practical and structured guide for addressing real situations.	85.3%	88.8%	.71	.3989
4. Math should be learned as sets of algorithms or rules that cover all possibilities.	19.7%	35.2%	6.27	.0123*
5. A liking for and understanding of students are essential for teaching math.	86.8%	96.5%	12.56	.0004*
6. If students are having difficulty, an effective approach is to give them more practice by themselves during the class.	13.2%	22.4%	2.99	.0839
7. More than one representation should be used in teaching a math concept.	66.7%	98.3%	5.06	.0245*
8. Some students have a natural talent for math and others do not.	73.1%	81.4%	2.55	.1106
9. Basic computational skills on the part of the teacher are sufficient for teaching elementary school math.	26.5%	17.3%	3.33	.0681

[1] MCTP Graduates' Beliefs and Actions of Mathematics and Science (2001), n=68.
[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000), n=478.

Table 8-2. Comparison of MCTP Middle Level Teachers' Beliefs about the Nature and Teaching of Mathematics with a National Sample by Percentage Agreeing or Strongly Agreeing

Item	MCTP[1]	National[2]	*t*	*p*
1. Math is primarily an abstract subject.	0.0%	31.0%	-7.95	.0000*
2. Math is primarily a formal way of representing the real world.	57.1%	79.1%	-1.60	.1332
3. Math is primarily a practical and structured guide for addressing real situations.	85.7%	88.8%	-.32	.7511
4. Math should be learned as sets of algorithms or rules that cover all possibilities.	14.2%	35.2%	-.210	.0558
5. A liking for and understanding of students are essential for teaching math.	92.9%	96.5%	-.52	.6132
6. If students are having difficulty, an effective approach is to give them more practice by themselves during the class.	0.0%	22.4%	-7.47	.0000*
7. More than one representation should be used in teaching a math concept.	100%	98.3%	1.70	.1149
8. Some students have a natural talent for math and others do not.	92.9%	81.4%	1.55	.1448
9. Basic computational skills on the part of the teacher are sufficient for teaching elementary school math.	14.3%	17.3%	-.30	.7711

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Middle school mathematics teachers. n=14.

[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000): Eighth-grade mathematics teachers. n=246.

Table 9-1. Comparison of MCTP Teachers' Beliefs about the Nature and Teaching of Science with A National Sample by Percentage Agreeing or Strongly Agreeing

Item	MCTP[1]	National[2]	χ^2	*p*
10. Science is primarily an abstract subject.	15.4%	18.2%	.31	.5782
11. Science is primarily a formal way of representing the real world.	70.8%	84.3%	7.32	.0068*
12. Science is primarily a practical and structured guide for addressing real situations.	77.9%	88.0%	5.24	.0221*
13. Some students have a natural talent for science and others do not.	55.2%	62.0%	1.14	.2865
14. A liking for and understanding of students are essential for teaching science.	79.4%	89.6%	6.00	.0143*
15. It is important for teachers to give students prescriptive and sequential directions for science experiments.	45.5%	75.8%	26.56	.0000*
16. Focusing on rules is a bad idea. It gives students the impression that the sciences are a set of procedures to be memorized.	41.2%	32.0%	2.26	.1326
17. If students get into debates in class about ideas or procedures covering the sciences, it can harm their learning.	7.4%	2.8%	13.38	.0003*
18. Students see a science a task as the same task when it is represented in two different ways.	27.4%	42.8%	5.37	.0205*

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001), n=68.
[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000), n=478.

Table 9-2. Comparison of MCTP Middle Level Teachers' Beliefs about the Nature and Teaching of Science with a National Sample by Percentage Agreeing or Strongly Agreeing				
Item	MCTP[1]	National[2]	*t*	*p*
10. Science is primarily an abstract subject.	44.4%	18.2%	1.55	.1590
11. Science is primarily a formal way of representing the real world.	88.9%	84.3%	.43	.6811
12. Science is primarily a practical and structured guide for addressing real situations.	100%	88.0%	4.14	.0033*
13. Some students have a natural talent for science and others do not.	33.3%	62.0%	-1.79	.1112
14. A liking for and understanding of students are essential for teaching science.	88.9%	89.6%	-.06	.9500
15. It is important for teachers to give students prescriptive and sequential directions for science experiments.	33.3%	75.8%	-2.64	.0299*
16. Focusing on rules is a bad idea. It gives students the impression that the sciences are a set of procedures to be memorized.	55.5%	32.0%	1.38	.2036
17. If students get into debates in class about ideas or procedures covering the sciences, it can harm their learning.	11.1%	2.8%	-1.59	.1509
18. Students see a science a task as the same task when it is represented in two different ways.	33.3%	42.8%	-.58	.5752

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Middle school science teachers. n=9.

[2] National Center for Education Statistics, <u>Mathematics and Science in the Eighth Grade</u> (2000): Eighth-grade mathematics teachers. n=232.

Table 10-1. Comparison of MCTP Graduates' Perceptions of Student Skills Required for Success in Mathematics with Those of National Sample by Percentage Responding " Very Important."

Item	MCTP[1]	National[2]	χ^2	P
19. Remember formulas and procedures?	26.5%	43.0%	6.73	.0095*
20. Think in sequential manner?	42.6%	79.5%	43.02	.0000*
21. Understand concepts?	95.6%	88.9%	2.89	.0891
22. Think creatively?	55.9%	65.4%	2.35	.1255
23. Understand math use in the real world?	89.7%	81.7%	2.67	.1025
24. Support solutions?	89.7%	80.8%	3.19	.0743

[1] MCTP Graduates' Beliefs and Actions of Mathematics and Science (2001), n=68.
[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000), n=478.

Table 10-2. Comparison of MCTP Teachers' Perceptions of Student Skills Required for Success in Mathematics with Those of MSEG Sample by Percentage Responding " Very Important."

Item	MCTP[1]	National[2]	t	p
19. Remember formulas and procedures?	42.9%	43.0%	-.01	.9943
20. Think in sequential manner?	28.6%	79.5%	-4.11	.0012*
21. Understand concepts?	92.9%	88.9%	.53	.6024
22. Think creatively?	42.9%	65.4%	-1.63	.1275
23. Understand math use in the real world?	85.7%	81.7%	.41	.6879
24. Support solutions?	85.7%	80.8%	.48	.6394

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Middle school mathematics teachers. n=14.

[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000): Eighth-grade mathematics teachers. n=246.

Table 11-1. Comparison of MCTP Graduates' Perceptions of Student Skills Required for Success in Science with Those of National Sample by Percentage Responding "Very Important."

Item	MCTP[1]	National[2]	χ^2	p
(1) Remember formulas and procedures?	14.7%	25.5%	3.79	.0517
26. Think in sequential manner?	39.7%	79.6%	50.04	.0000*
27. Understand concepts?	88.2%	84.0%	.82	.82
28. Think creatively?	61.8%	73.0%	3.70	.0546
29. Understand math use in the real world?	88.2%	79.2%	3.08	.0795
30. Support solutions?	89.7%	86.1%	.66	.4148

[1] MCTP Graduates' Beliefs and Actions of Mathematics and Science (2001), n=68.
[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000), n=478.

Table 11-2. Comparison of MCTP Teachers' Perceptions of Student Skills Required for Success in Science with Those of MSEG Sample by Percentage Responding "Very Important."

Item	MCTP[1]	National[2]	*t*	*p*
25. Remember formulas and procedures?	11.1%	25.5%	-1.28	.2349
26. Think in sequential manner?	44.4%	79.6%	-2.09	.0696
27. Understand concepts?	88.9%	84.0%	.46	.6611
28. Think creatively?	66.7%	73.0%	-.39	.7065
29. Understand math use in the real world?	88.9%	79.2%	.88	.4052
30. Support solutions?	100%	86.1%	4.63	.0017*

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Middle school science teachers. n=9.

[2] National Center for Education Statistics, Mathematics and Science in the Eighth Grade (2000): Eighth-grade science teachers. n=232.

Table 12-1. Comparison of MCTP Elementary School Teachers' Use of Instructional Practices in Mathematics with Those of National Sample by Percentage Responding "Yes".

Item	MCTP[1]	National[2]	t	p
34. Assisting all students to achieve high standards.	100%	77%	7.67	.0000*
35. Providing examples of high-standard work.	100%	63%	8.81	.0000*
36. Using authentic assessments.	100%	55%	10.00	.0000*
37. Using standards aligned curricula.	100%	64%	9.00	.0000*
38. Using standards-aligned textbooks and materials.	92.9%	66%	4.28	.0002*
39. Using telecommunication-supported instruction.	64.3%	20%	4.61	.0001*
40. Making connections with science.	93.1%	-------	-------	--------

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Elementary school teachers. n=29.

[2] Public School Teacher Survey on Education Reform (1996). n=473.

Table 12-2. Comparison of MCTP Middle School Mathematics Teachers' Use of Instructional Practices in Mathematics with Those of TSER Sample by Percentage Responding "Yes."

Item	MCTP[1]	National[2]	t	p
34. Assisting all students to achieve high standards.	100%	85%	7.14	.0000*
35. Providing examples of high-standard work.	100%	66%	8.10	.0000*
36. Using authentic assessments.	100%	49%	9.27	.0000*
37. Using standards aligned curricula.	92.9%	72%	2.63	.0208*
38. Using standards-aligned textbooks and materials.	85.7%	72%	1.33	.2062
39. Using telecommunication-supported instruction.	69.2%	27%	3.09	.0093*
40. Making connections with Science.	92.3%	-------		

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Middle school mathematics teachers. n=14.
[2] Public School Teacher Survey on Education Reform (1996). n=396.

Table 13-1. Comparison of MCTP Elementary School Teachers' Use of Instructional Practices in Science with Those of National Sample by Percentage Responding "Yes."

Item	MCTP[1]	National[2]	t	p
41. Assisting all students to achieve high standards.	100.0%	71%	9.06	.0000*
42. Providing examples of high-standard work.	100.0%	48%	14.86	.0000*
43. Using authentic assessments.	100.0%	44%	13.33	.0000*
44. Using standards aligned curricula.	96.4%	66%	5.71	.0000*
45. Using standards-aligned textbooks and materials.	85.7%	58%	3.70	.0010*
46. Using telecommunication-supported instruction.	75.0%	17%	6.57	.0000*
47. Making connections with mathematics.	96.6%	-------	-------	-------

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Elementary school teachers. n=29.
[2] Public School Teacher Survey on Education Reform (1996). n=473.

Table 13-2. Comparison of MCTP Middle School Science Teachers' Use of Instructional Practices in Science with Those of National Sample by Percentage Responding "Yes."

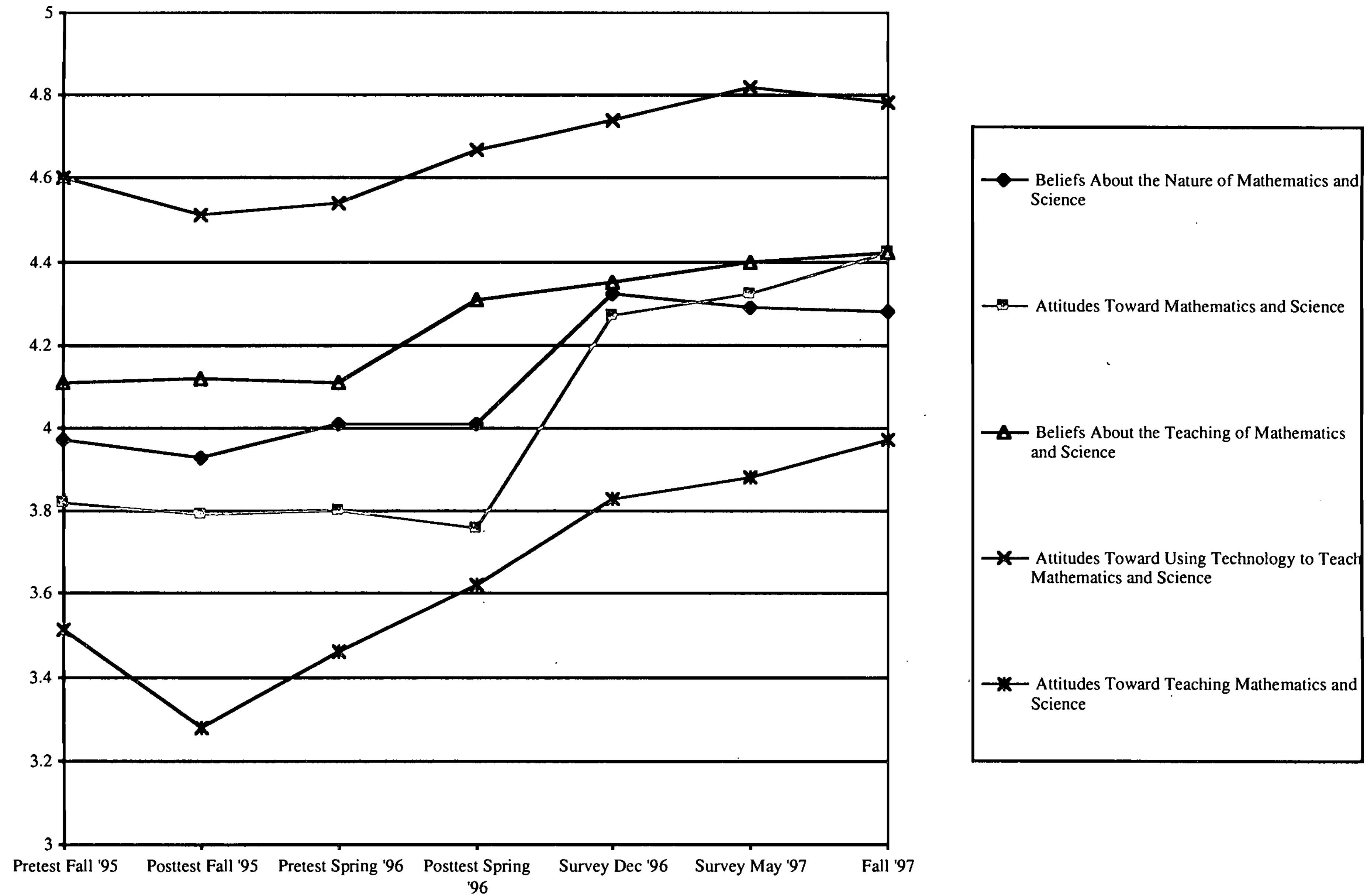
Item	MCTP[1]	National[2]	t	p
41. Assisting all students to achieve high standards.	100.0%	78%	5.00	.0011*
42. Providing examples of high-standard work.	88.9%	64%	2.06	.0730
43. Using authentic assessments.	100.0%	42%	10.36	.0000*
44. Using standards aligned curricula.	100.0%	65%	8.14	.0000*
45. Using standards-aligned textbooks and materials.	100.0%	60%	9.09	.0000*
46. Using telecommunication-supported instruction.	75.0%	29%	2.85	.0247*
47. Making connections with mathematics.	100.0%	-------		

[1] MCTP Teacher's Beliefs and Actions of Mathematics and Science (2001): Middle school science teachers. n=9

[2] Public School Teacher Survey on Education Reform (1996). n=396.

Figure Caption

Figure 1. The mean attitude and beliefs scores for MCTP teacher candidates at each of the seven administrations of the survey analyzed.



5
4.8
4.6
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4
3.8
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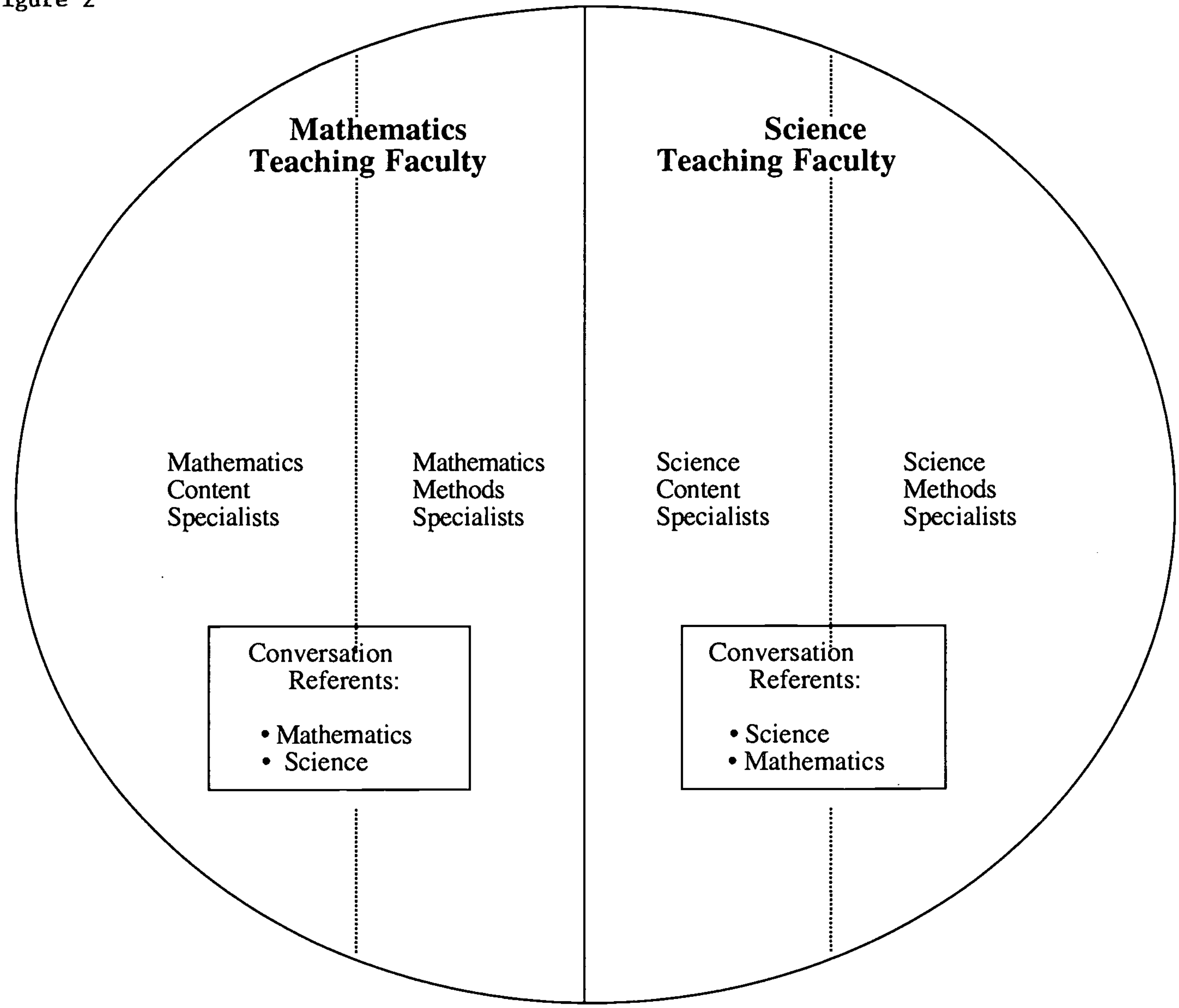
3
Pretest Fall '95
Posttest Fall '95
Pretest Spring '96
Posttest Spring '96
Survey Dec '96
Survey May '97
Fall '97
Beliefs About the Nature of Mathematics and Science
Attitudes Toward Mathematics and Science
Beliefs About the Teaching of Mathematics and Science
Attitudes Toward Using Technology to Teach Mathematics and Science
Attitudes Toward Teaching Mathematics and Science

Figure 1

Figure Caption

Figure 2. MCTP teaching faculty discourse community.

Figure 2


Mathematics
Teaching Faculty
Science
Teaching Faculty
Mathematics
Content
Specialists
Mathematics
Methods
Specialists
Science
Content
Specialists
Science
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Specialists
Conversation
Referents:
• Mathematics
• Science
Conversation
Referents:
• Science
• Mathematics

Figure 3. Themes in the integration of mathematics and science in MCTP courses: Faculty perspective

Figure 3

Emerging Themes In The Integration Of Mathematics And Science In MCTP Courses: Faculty Perspective

Theme One: Issue of Boundary

"Discipline integrity"

How much of time/energy, if any, should be spent on the other discipline?

Theme Two: Issue of Competency

"Faculty expertise"

Am I knowledgeable enough about mathematics/science to attempt making connections in my instruction?

Theme Three: Issue of Fit

"Forced or natural"

Is the inclusion of the other discipline appropriate in a particular circumstance?

Theme Four: Issue of Type of Representation

"Discipline or tool"

Does the inclusion of the other discipline lead to new understanding of both disciplines?

Theme Five: Issue of Language

"Semantic concern"

Are identical words/terms used to convey differing meanings in different disciplines?

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