WHAT BELIEFS AND INTENDED ACTIONS DO REFORM-PREPARED MATHEMATICS AND SCIENCE TEACHERS CONVEY TO THE WORKPLACE?

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Abstract

This study investigated to what extent, if any, undergraduate mathematics and science courses (content and pedagogy) are taught cumulatively impact teacher interns' beliefs and their teaching practices. The subjects (n=68) were recent graduates of an undergraduate, reform-based upper elementary/middle school mathematics and science teacher preparation program. Survey methodology was used. The survey instrument measured the following constructs: teachers' beliefs about the nature and teaching of mathematics and science; teachers' perceptions about student skills required for success in mathematics and science; and, teachers' intentions about implementing reform activities in mathematics classes and in science classes. Subjects' responses were compared with a large United States database of practicing teachers' responses to identical survey items. Findings indicated that along all measures (many determined to be statistically significant), the new graduates expressed more reform-oriented perspectives concerning subject matter and instruction. These findings strongly suggest that a systematic, reform-based undergraduate science and mathematics program could produce new teachers who entered the workplace with desired perspectives. Continued research in this area was described.

Introduction

This study was conducted within a major research agenda in the mathematics and science education research communities. Researchers are focusing on the possible links between features of teacher preparation programs and the performances of new teachers [1]. The assumption of this research agenda is that teachers teach as they have been taught, and that improvements in the way undergraduate mathematics and science courses and pedagogy courses are taught should result in improvements in the way teacher interns teach when they later become practicing teachers [2]. Thus, for example, engaging teacher interns in group discussions might enhance their support in cooperative learning, and using interdisciplinary teaching in their college courses might encourage them later as classroom teachers to make connections between different subjects (i.e., mathematics and science).

The Maryland Collaborative for Teacher Preparation (MCTP) program, a statewide undergraduate program, was aimed at generating new understandings in reform-based undergraduate mathematics and science teacher preparation. The MCTP program responded to the national and international calls for reform advocated by major United States professional mathematics and science education communities, as well as in international reform documents, such as *Beyond 2000* [3-6].

The program was designed for undergraduate students who planned to become Mathematics and Science Specialists in upper elementary or middle schools. While the teacher interns selected to participate in the MCTP program were in many ways representative of typical teacher interns in elementary teacher preparation programs, they were distinguished by agreeing to participate in a program that consisted of an extensive array of mathematics and science experiences (formal and informal) that made connections between the two disciplines and that placed an emphasis on teaching for understanding.

The MCTP program was systemic. It was a long-term effort (ten years) to improve undergraduate mathematics and science instruction that involved nine teaching and research institutions of the university system of Maryland, in collaboration with community colleges and public school systems. Among the goals of the program was to develop professional teachers who were confident teaching mathematics and science using technology, who could make connections between and among the disciplines, and who could provide an exciting and challenging learning environment for students of diverse backgrounds [6]. The program overview of the MCTP is detailed in a variety of venues [7]. The MCTP was designed around these notable reform-based recommendations:

- new content and pedagogy courses that model inquiry-based, interdisciplinary approaches combined with regular opportunities for teacher intern reflection;
- the participation of faculty in mathematics, science, and methods committed to modeling best teaching practices (especially by diminishing lecture and emphasizing problem solving);
- the development of field experiences in community schools with exemplary teachers trained to serve as mentors;
- the availability of summer internships in contexts rich in mathematics and science; and,
- the support of new teachers by university and school personnel during their first years of teaching.

The MCTP recommendations were aligned with the large body of research that is focusing on the possible links between features of teacher preparation programs and the performances of new teachers [8]. However, the question remains: to what extent, if any, does the way undergraduate mathematics and science courses (subject matter and pedagogy) are taught cumulatively impact teacher interns' beliefs about their teaching practices? It is imperative that reform-based mathematics and science teacher education programs test the assumption that systematic and defined interventions make a positive difference by measuring their effectiveness on how well they nurture beliefs and actions that are consistent with the program's philosophy of learning and teaching.

To document and interpret the effectiveness of the MCTP program, studies from different perspectives were designed. McGinnis, Kramer, Shama, Graeber, Parker, and Watanabe measured MCTP and non-MCTP teacher interns' attitudes and beliefs about mathematics and science teaching, and found the MCTP teacher interns' attitudes and beliefs to be more aligned with overall program goals than the non-MCTP controls [9]. Moreover, they found that over two and one half years, the MCTP teacher interns' attitudes and beliefs continued to move in the desired direction. McGinnis examined faculty discourse (mathematics and science content specialists and pedagogy specialists) in the MCTP [10]. He found that faculty who made up the MCTP speech community (content specialists and pedagogy specialists) expressed similar and different referents to mathematics and science. The findings supported and extended earlier reported studies by Mura in a mathematics teacher preparation program [11, 12]. As stated by McGinnis, in the context of a mathematics *and* a science teacher preparation program, "differences between content discipline experts and content method experts tend to exist in how they conceive their content disciplines" [10]. A key implication of this finding was the recommendation for project managers of reform-aligned teacher preparation projects to anticipate differences in faculty beliefs concerning subject matter and pedagogy and to use that knowledge to devise targeted faculty transformation professional development activities. Such activities would seek to move faculty beliefs and practices in directions that would align with projects' reform-based goals (e.g., science is both a content and a process, and mathematics is more than a tool). The implication made was that as faculty made these changes, the teacher interns they taught would be more likely to exhibit similar reform-aligned beliefs and practices in their classroom teaching.

In this study that used survey methodology, we examined what beliefs and intentions MCTP teachers bring to the workplace. Do MCTP teachers report beliefs that are more aligned with reform-based recommendations than other teachers? We focused our study on the following three research questions.

1) Do MCTP teachers' beliefs about the nature and teaching of mathematics and science align more with reform-based beliefs than with those held by other teachers?
2) Do MCTP teachers' perceptions about the student skills required for success in mathematics and science align more with the reform-based perceptions than perceptions held by other teachers?
3) Do MCTP teachers' intentions about implementing reform activities in mathematics and science classes align more with the reform-based recommendations than with other teachers?

Theoretical Background and Related Research

In many nations around the globe, mathematics and science education is currently going through a process of change [13]. The reform efforts in different countries, such as science education in the United States and the United Kingdom, share important characteristics which are related to a dissatisfaction with how mathematics and science are taught traditionally [3,5,6]. To change the status quo, efforts in the last decade have focused on the enhancement of the teaching profession, under the assumption that upgrading the profession will increase teachers' commitment and motivation. It is assumed that these changes in teacher preparation and professional development will result in better teaching, as defined by the major reform documents, and improved student learning [14]. According to this scenario, the literature suggests efforts to improve the teaching profession on the two main levels outlined below.

Reforms in Teacher Preparation Programs — Such reforms have different foci, from developing extended graduate-level teaching programs, with an emphasis on additional content courses, to programs with the emphasis on pedagogical aspects, such as promoting innovative teaching approaches (e.g., active learning) [2].

Professional Development — These services support teachers beginning with the inductive years, advancing to the early and mid-career stage, and culminating in the master teacher or late career phase [15]. This effort assumes that learning to teach is a developmental process during which teachers progressively refine their beliefs and practices during their years of teaching [16].

The MCTP reform was located primarily under the first type of reform, since it was concerned with formulating new content and pedagogy courses that modeled inquiry-based and interdisciplinary approaches. However, it also has functioned under the second type of reform by supporting, to a limited extent, the graduate new teachers during their first years of teaching [17].

The current approaches to reform in mathematics and science teacher preparation programs, and in-service teacher professional development have led to unprecedented interest in research on the efficacy of such reforms [18]. Gallagher and Richmond stated that, "Despite the seeming efficacy of the goals and claims that underlie current reform, there has been little formal, scholarly effort on the part of the science community to ground the reform carefully in research" [19]. One way to evaluate and understand the role of teachers with respect to educational reform is to examine their beliefs and views toward the discipline that they teach, as well as toward teaching and learning [20].

In recent literature, there is a growing consensus that educational reform efforts are doomed to failure if the emphasis is on developing specific teaching skills, unless the teachers' cognitions, including their beliefs, intentions, and attitudes, are taken into account [13]. There have been a series of studies describing how teacher beliefs about student learning, teaching, and the nature of science impact teaching practices and form barriers to implementation of reform-oriented curricula [19-23]. Anderson and Helms discussed the central role of teachers' values and beliefs in their attempts to initiate change [24]. They pointed out the necessity of changes in teachers' values and beliefs to bring about changes in classroom practice. Grossman and Stodolsky argued that attempts to reform secondary schools will fall short if the teachers' beliefs, norms, and practices are not taken into full account [25]. They concluded that teachers' professional identity is permeated by their beliefs about the nature of subject matter. The professional identity of the teachers, according to Anderson and Helms, is the result of their own education, beginning with the undergraduate major and extending to career-long professional development activities [24].

At present, there is not only substantial evidence that teachers' performances are influenced by their beliefs about teaching and learning, there is also evidence that teachers' beliefs and attitudes are linked to their students' achievement [2, 26-28]. Thus, *it seems that* teachers should be knowledgeable about the types of attitudes they are expected to promote. For example, teachers who see science as a static collection of facts tend toward instructional approaches that rely on "teacher talk" and direction, as well as on student practice and memorization [9]. Mathematics teachers, who view their discipline primarily as an abstract subject, could cause students to have mathematics phobia.

Hashweh examined the effects of the beliefs of thirty-five science teachers, with different science backgrounds and teaching at different educational levels, on their teaching practices [29]. Through the use of a three-part questionnaire consisting of critical incidents, direct questions about teacher strategies of conceptual change, and ratings of the use of importance of specific teaching strategies, Hashweh showed that teachers holding constructivist beliefs: are more likely to detect students' alternative conceptions; have a richer repertoire of teaching strategies; use potentially more effective teaching strategies that focus on student conceptual change; report more frequent use of effective teaching strategies; and, highly valuate these teaching strategies compared with teachers holding empiricist beliefs.

In light of such studies, an important goal of teacher education programs should be to assist teacher interns to develop beliefs and dispositions that are consistent with the reform philosophy [30]. Nevertheless, beliefs are hard to change, as many teacher interns enter education programs with preconceived notions about teaching based on their years in school [28]. Therefore, it is imperative to assess the impact of programs designed to change teachers' beliefs to be more consistent with the reform philosophy.

Recently, Hart introduced the "Mathematics Belief Instrument" (MBI) as a tool for evaluating the effectiveness of teacher education programs in promoting teacher beliefs and attitudes that are consistent with the underlying philosophy of current reform efforts in mathematics education [30,31]. She presented data from fourteen teacher interns, suggesting that participation in a teacher education program that espoused the philosophy consistent with current mathematics education reform could change teachers' beliefs to be more consistent with this philosophy. Wilkins used the MBI tool to investigate and evaluate the potential impact of an elementary mathematics methods course for teacher interns in promoting teachers' beliefs and attitudes that are consistent with the underlying philosophy of current reform efforts in mathematics education [28]. The data from eighty-nine teacher interns suggested a positive relationship between participating in the course and change in teachers' beliefs and attitudes.

Guided by our research questions in the present study, we were particularly interested in the following constructs: teachers' beliefs about the nature and teaching of mathematics and science; teachers' perceptions about the student skills required for success in mathematics and science; and, teachers' intentions about implementing reform activities in mathematics and science classes.

Teachers' Beliefs about the Nature and Teaching of Mathematics and Science

Mathematics and science teachers' knowledge of subject matter, curriculum, and pedagogy goes hand in hand with a set of beliefs about the nature of mathematics and science as disciplines and the way that mathematics and science are most effectively taught. Pajares stressed that beliefs are "the best indicators of the decisions individuals make throughout their lives" [26]. Thus, beliefs play a major role in teacher decision making about curriculum and instructional tasks. There is a complex interaction between teachers' beliefs, which are mental, and teachers' actions, which take place in the social arena. What teachers actually do in the classroom is representative of their beliefs [32].

In the case of subject matter beliefs, different views of mathematics and science as disciplines can be placed on a continuum. Williams, Jocelyn, Martin, Butler, Heid, and Haynes suggest that at one end of the continuum are viewpoints commonly characterized as "external," "abstract," and "formal" [33]. In these frameworks, mathematics and science are seen as codified bodies of knowledge. At the opposite end are the "internal views," which place great significance on the processes of building individual knowledge and establishing accepted knowledge in the discipline. Williams, et al. stressed that teachers who are holding internal views see their field more as a dynamic field and are more inclined to take an active learning approach in their teaching that is characterized by the use of student problem solving. Teachers that hold an external view stress formalisms in their teaching and place a focus on teaching their discipline as a set of algorithms or rules.

In the case of beliefs about students and the ways in which they learn mathematics and science, there is a strong recommendation in the standards that mathematics and science must be for all students. This recommendation is connected to teachers' views about the cognitive demands that mathematics and science make on all students [4,5]. In our survey, we asked if the teachers believed "Some students have a natural talent for math/science and others do not."

The recommendation that mathematics and science must be for all students also aligned with the recommendation for teachers to use different teaching strategies that take into consideration students' different cognitive and motivation levels. Different teaching strategies, recommended by the MCTP project director, were to use innovative teaching approaches, such as: active learning, where students are involved in discussions and debates, and teachers promote student questions in class, as well as involve students in hands-on laboratory experience; and, cooperative learning, where students are engaged in structured cooperative learning activities, including teaching through cooperative problem solving [34-36].

Teachers' beliefs about the ways in which students learn mathematics and science could also be influenced by the teachers' Pedagogical Content Knowledge (PCK), which has been introduced as an element of the knowledge base for teaching [37]. The PCK consists mainly of two key elements: a knowledge of instructional strategies incorporating representations of subject matter; and, an understanding of specific learning difficulties and student conceptions with respect to that subject matter [13]. Another MCTP goal was to promote teachers' PCK and address conceptual change.

Teachers' Perceptions about the Student Skills Required for Success in Mathematics and Science

There are different taxonomies that refer to the cognitive skills required from students. Recently, Mayer suggested, in his paper *Rote Versus Meaningful Learning*: *Revising Bloom Taxonomy*, that there are two major categories of students' cognitive skills: retention and transfer [38]. *Retention* is the ability to remember material at some later time in much the same way it was presented during instruction. *Transfer* is the ability to use what was learned to solve new problems, answer new questions, or facilitate learning new subject matter.

Based on his taxonomy, Mayer defines three learning outcomes: no learning, rote learning, and meaningful learning. No learning is the situation in which students cannot recall key terms and facts that they were studying. Rote learning is the situation when students remember the important terms and facts that they studied, but are unable to use this information to do higher level operations, such as problem solving. Meaningful learning is recognized as an important educational goal, in which students can use the information they learned to do higher level operations. It requires that instruction go beyond simple presentation of factual knowledge, and that assessment tasks require more of students than simply recalling or recognizing factual knowledge.

A focus on rote learning is consistent with the view of learning as knowledge acquisition in which students seek to add new information to their memories. Educational objectives for promoting retention are fairly easy to construct. In contrast, a focus on *meaningful learning* is consistent with the view of learning as knowledge construction in which students seek to make sense of their experiences, and educators may have difficulty in formulating, teaching, and assessing learning outcomes aimed at promoting meaningful learning.

One of the goals of the MCTP program was to promote meaningful learning. The faculty in the MCTP mathematics, science, and methods courses were committed to modeling best teaching practices, such as inquiry-based and problem solving approaches [10]. Thus, in our survey, we would need to measure the MCTP graduates' beliefs concerning students' learning skills.

It is noteworthy that, according to the skill "Think in sequential manner" (which appears in our survey), Felder differentiated between students who progress toward understanding sequentially—in a logical progression of small incremental steps—and those students who progress toward a global, holistic understanding in large jumps [39]. Felder claimed that students who fall in both categories (global learners or sequential learners) have the potential to be excellent scientists.

Teachers' Familiarity with Curriculum Materials

Teachers need to be acquainted with curriculum materials appropriate for their discipline, and the level and area they teach. Coble and Koballa reinforce the importance of curriculum knowledge by examples from the past [8]. The science curricula projects developed during the 1960s and 1970s, supported by funding from the National Science Foundation (NSF), offered teachers numerous units and lessons that could be used or adapted to meet their own instructional needs. Research has shown that the students in classes using these curricula learned more and held more positive attitudes toward science than most students in traditional science courses [40].

Williams, et al. suggested that curriculum knowledge today is closely linked to the most recent plans for reform of mathematics and science curricula and teaching, as exemplified in statements of standards for curriculum content and the teaching process [33]. Most notably, the National Council of Teachers of Mathematics' (NCTM) *Curriculum and Evaluation Standards for School Mathematics* and *Professional Standards for Teaching Mathematics* articulate this position [4,31]. The counterparts of these standards for science were those developed by the American Association for Advancement of Science (AAAS) and reported in *Benchmarks for Science Literacy* and more recently, the *National Science Education Standards* and *Beyond 2000* [3,5,6].

It is noteworthy that curriculum knowledge is not limited to the materials and programs from which teachers choose when deciding what to teach, but also includes recommendations for pedagogical approaches, such as alternative methods for teaching and assessing students' understanding. Since the philosophy of the MCTP program was in accord with the latest mathematics and science reform documents, we would need to include in our survey questions about the teachers' familiarity with them.

Teachers' Intentions about Implementing Reform Activities in Mathematics and Science Classes

Since the MCTP program was a standards-based program, its educational goals were in accord with current educational practice reforms advocated by the national mathematics and science reform documents. As such, the MCTP innovation included the premises outlined below. In our survey, we asked the MCTP teachers to report concerning these activities.

Assisting All Students to Achieve High Standards — The AAAS's publication of *Science for All Americans* defined the scientifically literate person as one who: is aware that science, mathematics, and technology are independent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and, uses scientific knowledge and scientific ways of thinking for individuals and social purposes [41]. This call for "science for all" required not just providing guidelines for what students should know and be able to achieve in mathematics and science, but also required providing recommendations of how to teach in class. Such recommendations included instructional models, such as: teaching for understanding, teaching for conceptual change, and constructivist teaching. The published standards for mathematics and science education shared many of the tenets of the constructivist philosophy. In the constructivist paradigm, the student has a more central role. Instruction, activities, and discussion are designed so that the students will manipulate the information and materials to construct the underlying principle that is being taught, emphasizing both hands-on and minds-on exploration of content [33]. In our survey, we asked the MCTP teachers if they were assisting all students to achieve high standards and if they were using the standards-aligned curricula.

Using Authentic Assessments — According to Fey, the most common strategy for assessing student learning in K-16 is through competitive, timed, written quizzes and tests that require individual students to answer a collection of specific short questions or to perform routine calculations to solve well-defined problems or multiple-choice tests [34]. Brooks and Brooks asserted that multiple-choice tests are structured to determine whether students know information related to a particular body of knowledge and their focus is on material, not on personal construction [42]. Authentic assessments, which are defined as tasks and problems already relevant or of emerging relevance to students, also relate to a particular body of knowledge. However, rather than stretching the assessments around specific bits of information, they invite students to exhibit what they have internalized and learned through application.

Teachers' beliefs about assessment and their use of assessment to determine students' progress are an important influence on activities taking place in mathematics and science classrooms [33]. Williams, et al. stressed that because testing drives teaching, most teachers will eventually cease much of their teaching and prepare their students for the reality of having to pass a multiple-choice test. Some students do very well in this sort of testing, but for many others, the forced response testing paradigms do not give accurate readings of their knowledge. Moreover, even students who are successful on standardized tests often have embarrassing gaps in their understanding of key scientific and mathematical ideas [34]. The agreement, in the last decade, on the influence of the assessment approaches to the learning process is reported by leading groups in mathematics and science education, and curriculum and standards documents, such as the *National Science Education Standards* [5]. The MCTP program stressed the importance of authentic assessments and other alternative assessments.

<u>Using Telecommunication-Supported Instruction</u> — It is suggested, "Just as information technology has improved effectiveness in medicine, finance, manufacturing, and numerous other sectors of society, advanced computing and telecommunications have the potential to help students master these complex twenty-first century skills" [43]. Sophisticated computers and telecommunications have unique capabilities for enhancing learning. These skills include: centering the curriculum on "authentic" problems parallel to those adults face in a real-world setting; involving students in virtual communities of practice; utilizing modeling and visualization as a powerful means of bridging between experience and abstraction; supporting sophisticated manipulation of information (e.g., generating, transmitting, sorting, processing, and retrieving information); and, serving as a communication facilitator (e.g., e-mail, group conferencing, and Internet Relay Chat) that enables learning in any time, any place, on any path, and at any pace [44,45].

Many teachers realize that telecommunications have the potential to revolutionize instruction and are interested in using this resource with their students. However, they need models, support, and practice to integrate telecommunications into curricula and a way to connect these activities to learning outcome [46]. One of the goals of the MCTP program was to employ faculty in mathematics, science, and methods committed to modeling best teaching practices. This included faculty who sought to infuse technology and telecommunications into their teaching practices.

<u>Making Connections between the Sciences and between Mathematics and the Sciences</u> — Currently, widespread support exists for teaching mathematics and science in an integrated

fashion in the school curriculum as articulated by the prominent mathematics and science reform documents, such as the *National Science Education Standards* [5]. Integration is advocated as a means by which students can develop deeply organized knowledge structures that are richly interconnected. However, there is no consensus about the definition of integrated mathematics and science [47]. The clarification of the meaning of integration is more than a matter of semantics. In particular, some individuals define integration as situations in which traditional disciplinary boundaries (e.g., mathematics and science) are significantly blurred or even lost. In such cases, students are typically asked to solve problems or reach decisions on matters of everyday relevance, and they are unaware of whether they are using/learning mathematics or using/learning science. On the other hand, many individuals define integration in a manner that maintains traditional disciplinary boundaries, and the focus of instruction stresses the interactions between mathematics and science. This second situation can also be labeled as interdisciplinary [48]. The MCTP promoted the interdisciplinary position. The goal of the MCTP was to promote the development of teachers who were confident teaching mathematics and science, and who could make connections between and among the disciplines [10]. This philosophy was in accord with the assumption that the growth of mathematical and scientific knowledge has also been accompanied by increasing specialization in research fields, and mathematics and science in secondary schools tend to be organized in ways that honor those specializations. However, recent developments have demonstrated that progress on major scientific problems usually requires integration of mathematics strategies; and likewise, mathematics that is detached from life experience is seen by many students as irrelevant [34].

Research Design and Methodology

To examine what beliefs and intended actions the MCTP graduates brought to their classrooms, we decided that a research design using survey methodology would be appropriate. Our goal was to assess the effectiveness of the MCTP program. As such, we needed to collect the total population of MCTP graduates' reported beliefs about mathematics and science, and their intentions toward the teaching of those subjects so that we could: 1) describe our sample; and, 2) compare our sample (total and disaggregated by level and subject) with a larger, more representative sample of practicing mathematics or science teachers.

Instrument Development — We decided to craft a survey that used existing reported survey items to which practicing teachers had previously responded. Thus, we could make a comparison between the MCTP graduates' responses concerning beliefs about subject matter, mathematics/science, and intentions regarding instruction of mathematics/science with responses by representative practicing teachers in the workplace. This strategy required us to examine the literature for accepted and reported surveys that measured practicing teachers' constructs. We then targeted and developed a new survey for the MCTP sample consisting primarily of items taken verbatim from those reported surveys.

We found success in our search when we inspected survey data reported in the *National Science Board, Science and Engineering Indicators—1998* [14]. Specifically, we found existing valid and reliable surveys that measured: "Teacher beliefs about the nature and teaching of mathematics and science," 1994-95; "Teacher perceptions of the student skills required for success in mathematics and science," 1994-95; "Teachers' knowledge of the standards," 1994-1995; and, "Percentage of mathematics and science teachers implementing reform activities," 1996 [33,49,50]. Upon inspection, we determined that these instruments were based on items used in the Third International Mathematics and Science Study (TIMSS).

From these existing surveys, we crafted a new 51-item survey (see Appendix A), "MCTP Teachers' Actions and Beliefs of Mathematics and Science," consisting of forty-five previously administered items taken from those reported surveys. We added two items to our survey that related to a unique aspect of the MCTP, making connections between mathematics and science in instructional practice (items 40, 47). We added another item that asked about the teacher's familiarity with the *National Science Education Standards* (item 33), and we also included four items that asked for background information (items 48-51) [5].

The items in the new MCTP survey can be divided into four categories.

1) Teachers' beliefs about the nature and teaching of mathematics (see Appendix A, items 1-9) and science (items 10-18). An example for one such item was: "Is mathematics/science primarily an abstract subject?"
2) Teachers' perceptions about the student skills required for success in mathematics (items19-24) and science (items 25-30). An example for one such item was to ask if learners needed to "Think in sequential manner."
3) Teachers' intentions about implementing reform activities in mathematics classes (items 34-40) and in science classes (items 41-47). An example for one such item was to ask if they intended to use standards-aligned textbooks and materials in their instructional practices.
4) Teachers' familiarity with standards documents and benchmarks for mathematics (item 31) and science (items 32, 33) literacy. An example for one such item was to ask if they were familiar with the *National Science Education Standards* [5].

With respect to this last category, we did not present and discuss data regarding the section titled, "Teachers' familiarity with standards documents and benchmarks for mathematics and science…" in this paper. These data were of interest to the project leaders, but were assessed as provisional due to the limited number of items.

Subjects — We sent out our survey by mail to the MCTP program's graduates three times: in Spring 1999 to all graduates from 1997 to that date (n=57); in Fall 1999 (n=28); and, in Fall 2000 (n=28). From these 113 graduates, we received sixty-eight surveys, with approximately 70% from those who had just graduated from college and 97% from new teachers with less than two years of teaching experience. Our total response rate was about 60%, moderately high for survey research of this type. Responses came from graduates of all seven of the MCTP participating institutions with baccalaureate programs. We attribute the high level of response partially to these strategies for increasing a return rate to mail-in surveys: sending a token honorarium such as a $2 bill or a $1 coin in the first mailing and a $20 honorarium in our final mailing; sending a subsequent reminder letter with another copy of the instrument; and, using e-mail and telephone reminders. To enhance the validity of our analysis, we conducted a non-response bias check in both administrations by randomly selecting a sample of eight non-responding MCTP graduates. Upon contact, we encouraged them to complete the survey. Using both the Pearson chi-squared statistic and the Cochran-Armitage Trend statistic, early and late response groups were compared on all fifty-one items. No significant differences were detected.

For the first survey administration, the majority of the sampled MCTP graduates (approximately 70%) were recent graduates who had not started teaching, while 97% were in their first or second year of full-time practice. The instructional level of the employed MCTP new teachers ranged from first grade to eighth grade (see Appendix B).

Data Analysis — We conducted three levels of data analysis. For our first level of data analysis, we examined our data to see how the MCTP graduates responded to each item, by frequency and percent. For our second level of data analysis (i.e., comparing our sample responses with a larger, more representative sample of practicing teachers), we used inferential statistics. For our third level of data analysis (i.e., comparing the responses of our sample over the three administrations separated across time), we manually examined the data for any noticeable differences before application of inferential statistics. Since responses were nearly identical between the first administration and our final administration on all items, an inferential analysis was not required.

We first made comparisons by total MCTP response and the national sample of practicing eighth grade teacher response. We made the assumption that since the MCTP graduates were certified to teach up to eighth grade that the samples were comparable groups. We wanted to ascertain if the MCTP graduates were different in any way from practicing teachers on a range of items that could be linked to reform-based perspectives. However, we were sensitive to possible arguments that the groups were incomparable; i.e., the MCTP graduates were not necessarily employed teachers at the time they responded to the survey or, if they were, they taught at different levels and subjects. Therefore, to test if those differences between the samples made a difference, we next performed a comparison between disaggregated MCTP samples by employed new teacher's level (elementary or middle school) and by subject focus (mathematics or science). What follows are our results reported by instrument section (representing our targeted constructs).

Findings

We report our findings according to the three categories of interest in the MCTP survey. First, we examined to what extent the MCTP responses aligned with the philosophy of the MCTP program, and then we made a comparison between the MCTP graduates and the national sample of teachers. When it was possible to analyze by teaching level (elementary or middle school) we reported that, also.

Findings: Teachers' Beliefs about the Nature and Teaching of Mathematics and Science

In this section, teachers were asked to rate on a scale from 1 (strongly disagree) to 4 (strongly agree) eighteen statements concerning their beliefs about the nature and teaching of mathematics (see Appendix A, items 1-9) and science (see Appendix A, items 10-19). Tables 1 and 2 show the national sample and MCTP responses, the percentages in these tables reflecting the combined proportion of teachers who either agree or strongly agree with the statements.

<u>Teachers' Beliefs about the Nature and Teaching of Mathematics</u> — Table 1 shows the findings concerning teachers' beliefs about the nature and teaching of mathematics. The national sample group, in this section, was composed of eighth grade mathematics teachers (n=246) who were surveyed in 1995 as part of the Third International Mathematics and Science Study (TIMSS).

Table 1
Comparison of MCTP New Teachers' Beliefs about the Nature and Teaching of Mathematics with Those of MSEG Sample by Percentage Agreeing or Strongly Agreeing

Item	National[1] %	MCTP[2] %	MCTP[3] %
1. Math is primarily an abstract subject.	31.0	10.4***	0.0***
2. Math is primarily a formal way of representing the real world.	79.1	74.2	57.1
3. Math is primarily a practical and structured guide for addressing real situations.	88.8	85.3	85.7
4. Math should be learned as sets of algorithms or rules that cover all possibilities.	35.2	19.7*	14.2
5. A liking for and an understanding of students are essential for teaching math.	96.5	86.8***	92.9
6. If students are having difficulty, an effective approach is to give them more practice by themselves during the class.	22.4	13.2	0.0***
7. More than one representation should be used in teaching a math concept.	98.3	94.1	100
8. Some students have a natural talent for math and others do not.	81.4	73.1	92.9
9. Basic computational skills on the part of the teacher are sufficient for teaching elementary school math.	17.3	26.5	14.3

*$P < .05$ **$P < .01$ ***$P < .001$

[1] National Center for Education Statistics, *Mathematics and Science in the Eighth Grade: 1995*, Middle school mathematics teachers, n=246

[2] MCTP Graduates' Beliefs and Actions of Mathematics and Science, n=68.

[3] MCTP-middle New Teacher's Beliefs and Actions of Mathematics and Science, Middle school mathematics teachers, n=14.

The MCTP graduates' responses toward the nature and teaching of mathematics differed significantly ($p < .05$) from the national sample on several beliefs. Specifically, they were *less likely* to believe: that mathematics is primarily an abstract subject (10.4% MCTP, 31.0% National); that mathematics should be learned as sets of algorithms or rules that cover all possibilities (19.7% MCTP, 35.2% National); and, that a liking for and an understanding of students are essential for teaching (86.8% MCTP, 96.5% National).

These differences aligned with the reform philosophy, since a major goal of the MCTP program was "science and mathematics for all" [34]. A way to achieve this goal was to "produce new teachers who are confident teaching mathematics and science" and who believe that mathematics and science are not primarily abstract subjects [51]. Teachers who can provide an exciting and challenging learning environment for students of diverse backgrounds believe that learning the process of mathematics and science is more important than having a collection of facts or a set of algorithms that cover all possibilities.

A disaggregated analysis of MCTP middle school mathematics teachers' responses (n=14) compared with the national sample on the same construct found that MCTP middle school mathematics teachers differed significantly ($p < .05$) from the national sample on two beliefs (Table 1). Interestingly, not a single MCTP middle school teacher believed that mathematics is primarily an abstract subject (0% MCTP middle, 31.0% National); or that if students are having difficulty, an effective approach is to give them more practice by themselves during the class (0% MCTP middle, 22.4% National). We speculate that the emphasis on cooperative learning in the MCTP program promoted the MCTP teachers' beliefs that it is more effective when students practice in groups instead of practicing by themselves.

<u>Teachers' Beliefs about the Nature and Teaching of Science</u> — Table 2 shows the findings concerning teachers' beliefs about the nature and teaching of science. The national sample group, in this section, was eighth grade science teachers (n=232) who were surveyed in 1995 as part of the Third International Mathematics and Science Study (TIMSS).

Table 2

Comparison of MCTP Graduates' Beliefs about the Nature and Teaching of Science with Those of National Sample by Percentage Agreeing or Strongly Agreeing

Item	National[1] %	MCTP[2] %	MCTP[3] %
10. Science is primarily an abstract subject.	18.2	15.4	44.4%
11. Science is primarily a formal way of representing the real world.	84.3	70.8**	88.9%
12. Science is primarily a practical and structured guide for addressing real situations.	88.0	77.9*	100%**
13. Some students have a natural talent for science and others do not.	62.0	55.2	33.3%
14. A liking for and an understanding of students are essential for teaching science.	89.6	79.4*	88.9%
15. It is important for teachers to give students prescriptive and sequential directions for science experiments.	75.8	45.5***	33.3%*
16. Focusing on rules is a bad idea. It gives students the impression that the sciences are a set of procedures to be memorized.	32.0	41.2	55.5%
17. If students get into debates in class about ideas or procedures covering the sciences, it can harm their learning.	2.8	7.4***	11.1%
18. Students see a science task as the same task when it is represented in two different ways.	42.8	27.4*	33.3%

*$P < .05$ **$P < .01$ ***$P < .001$

[1] National Center for Education Statistics, *Mathematics and Science in the Eighth Grade: 1995*, Middle school science teachers, n=232.

[2] MCTP Graduates' Beliefs and Actions of Mathematics and Science (2001), n=68.

[3] MCTP-middle New Teacher's Beliefs and Actions of Mathematics and Science (2001): Middle school science teachers, n=9

The MCTP graduates' responses differed significantly ($p < .05$) from the national sample on six items (items 11, 12, 14, 15, 17, 18). They were *less likely* to believe: that science is primarily a formal way of representing the real world (70.8% MCTP, 84.3% National); that science is primarily a practical and structured guide for addressing real situations (77.9% MCTP, 88.0% National); and, that a liking for and an understanding of students are essential for teaching science (79.4% MCTP, 89.6% National). While these differences between the national sample and the MCTP graduates were statistically significant, the percentages suggest that they might not be educationally significant.

More pronounced differences, however, were found concerning the statements "It is important for teachers to give students prescriptive and sequential directions for science experiments" (45.5% MCTP, 75.8% National); and, "Students see a science task as the same task when it is represented in two different ways" (27.4% MCTP, 42.8% National). The differences on these items probably reflect the fact that MCTP teachers were exposed during their studies to research in science education. They became aware of students' alternative conceptions in science and to the recommendation to involve students in inquiry and investigative approaches rather than to give students prescriptive and sequential directions for science experiments.

In this respect, it is relevant to discuss the concept of Pedagogical Content Knowledge (PCK) which Shulman introduced as an element of the knowledge base for teaching [37]. The PCK consists mainly of two key elements: a knowledge of instructional strategies incorporating representations of subject matter, and an understanding of specific learning difficulties and student conceptions with respect to that subject matter [13]. One of the MCTP program goals was to promote teachers' PCK and address conceptual change. It has been widely documented that different representations of essentially the same tasks often trigger responses that differ and sometimes even clash [52,53]. Exposure to such research could be the cause for the fact that MCTP graduates were less likely to believe that "Students see a science task as the same task when it is represented in two different ways."

The sixth statement (Table 2, item 17), in which the MCTP graduates' responses differed significantly from the national sample, runs counter to the MCTP reform philosophy. The MCTP teachers were *more likely to believe* that if students are allowed classroom debates about ideas or procedures covering the sciences, it can harm their learning (7.4% MCTP, 2.8% National). The percentage of MCTP teachers agreeing with this statement is not high (five students out of sixty-eight); however, we would expect that no MCTP graduate would agree with this statement, given that the MCTP program promoted student discourse.

The analysis of the MCTP middle school science teachers' responses (n=9) found that the MCTP middle school science teachers differed significantly ($p < .05$) from the national sample on two beliefs (Table 2). They were *less likely to believe* that it is important for teachers to give students perspective and sequential directions for science experiments (33.3% MCTP middle, 75.8% National) and *more likely to believe* that science is primarily a practical and structured guide for addressing real situations (100% MCTP middle, 88% National). We suspect that the reform recommendations to relate science to everyday life and to use real-life problems in teaching science promoted teachers' beliefs that science is primarily a practical and structured guide for addressing real situations.

Findings: Teachers' Perceptions about the Student Skills Required for Success in Mathematics and Science

In this section, teachers were asked to rate on a scale from 1 (not important) to 3 (very important) the importance of particular kinds of skills for success in the discipline. These skills have elements ranging from remembering through understanding to thinking creatively. The items in this section (see Appendix A) are parallel across the two disciplines: mathematics (items 19-24) and science (items 25-30). The national sample group, in this section, was eighth grade mathematics (n=246) and science (n=232) teachers who were surveyed in 1995 as part of the Third International Mathematics and Science Study (TIMSS). The national sample and the MCTP graduates' responses are shown in Figures 1 and 2. The percentages in these figures were rounded and reflect the percentage of teachers who chose the category "very important." The statistically significant differences between the national sample and the MCTP graduates are denoted by underlining the percentages and putting them in boldface.

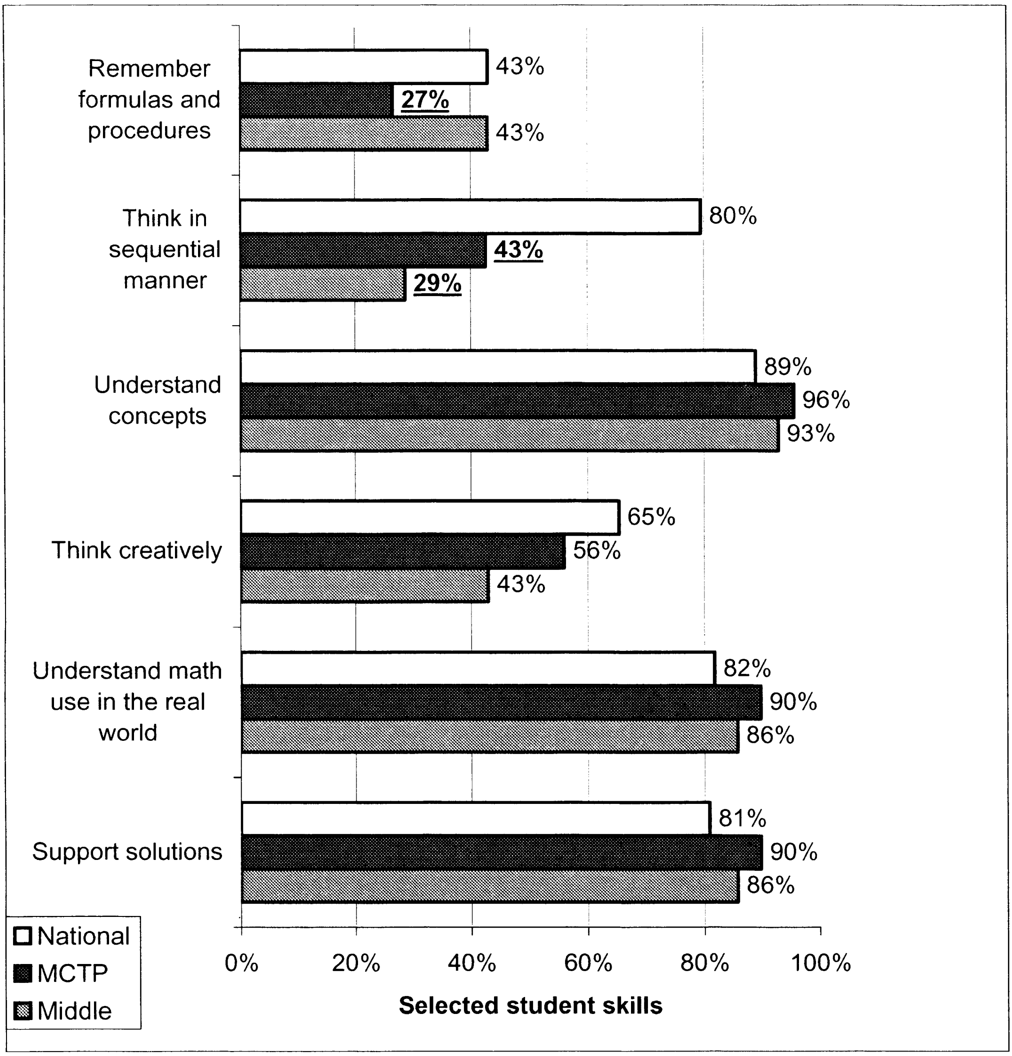

Figure 1. Comparison of MCTP Graduates' perceptions of the student skills required for success in mathematics with those of MSEG sample by percentage responding "Very Important."

National Center for Education Statistics, *Mathematics and Science in the Eighth Grade: 1995*, Middle school mathematics teachers, n=246
MCTP Graduates' Beliefs and Actions of Mathematics and Science, n=68.
MCTP-middle New Teacher's Beliefs and Actions of Mathematics and Science: Middle school mathematics teachers, n=14.

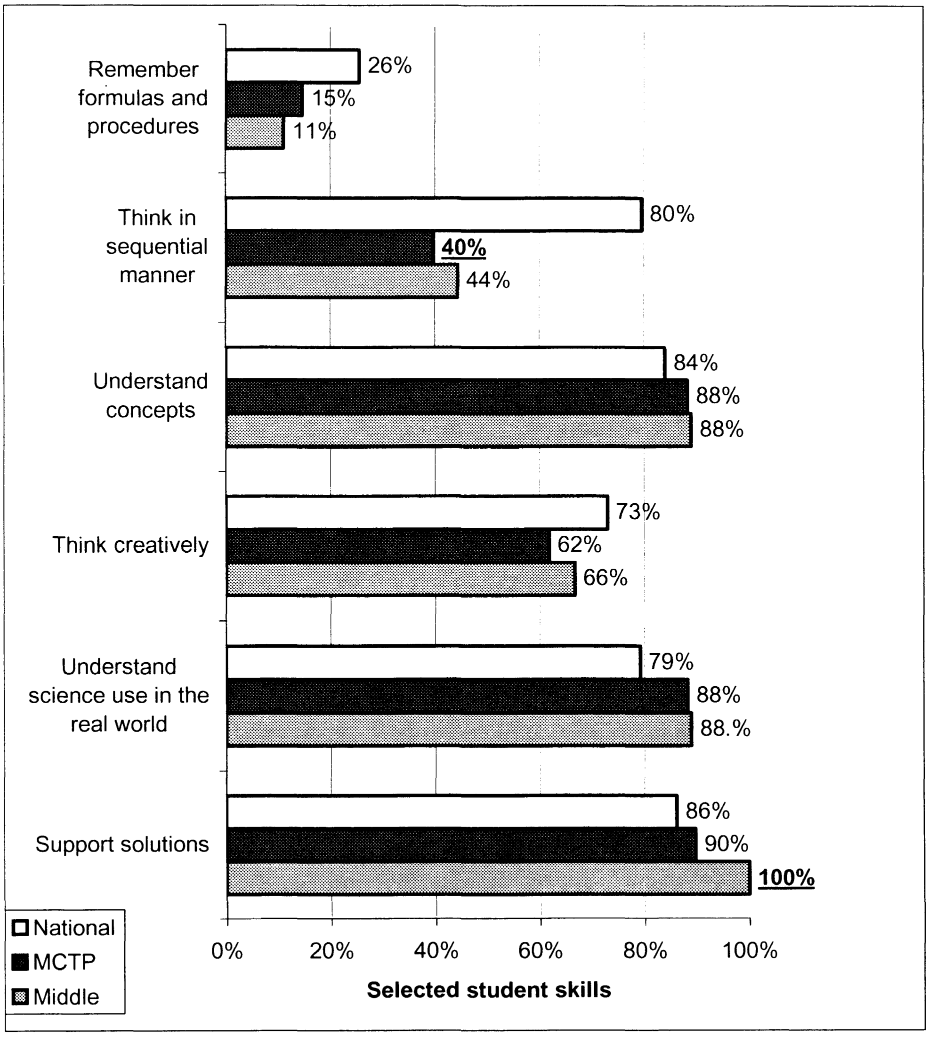

Figure 2. Comparison of MCTP graduates' perceptions of the student skills required for success in science with those of MSEG sample by percentage responding "Very Important."

National Center for Education Statistics, *Mathematics and Science in the Eighth Grade: 1995*, Middle school science teachers, n=232.
MCTP Graduates' Beliefs and Actions of Mathematics and Science, n=68.
MCTP-middle New Teachers' Beliefs and Actions of Mathematics and Science: Middle school science teachers, n=9.

The findings show that there was substantial agreement between the MCTP graduates and the mathematics and science teachers from the national sample on the aptitudes and skills students need to succeed in learning mathematics and science. Over 80% of the teachers consider it "very important" for students to understand concepts, to understand how the subjects are used in the real world, and to be able to support their results and conclusions.

However, there are some areas of difference in these views. The MCTP teachers were *less likely to think* it is very important for students to remember formulas and procedures in **mathematics** (27% MCTP, 43% National). Interestingly, there were no such differences between the national sample and the MCTP teachers in the case of remembering formulas and procedures in **science**. However, inspection of the data show that, in the case of science, both populations (15% MCTP, 26% National) were *less likely to think* that it is very important to remember formulas and procedures in **science** in comparison to mathematics.

The fact that the MCTP graduates were less likely to mark "remember formulas and procedures" as "very important" is aligned with the reforms recommendation to put the emphasis on meaningful learning (characterized by a focus on understanding) instead of rote learning (characterized by memorization of facts). As earlier reported, Mayer's taxonomy, while not rejecting the importance of "remembering," emphasized that learning in school should be expanded to include a wider range of cognitive processes, such as the ability to use what was learned to solve new problems, answer new questions, or facilitate learning new subject matter [38].

Differences between the MCTP teachers and the national teachers were significant also concerning the importance of "Think in sequential manner" in mathematics (43% MCTP, 80% National) and in science (40% MCTP, 80% National). In all, Figures 1 and 2 show that the MCTP graduates identified "Think in sequential manner" and "Think creatively" as being less important than "Understand concepts," "Understand math use in the real world," "Understand science use in the real world," and "Support solutions." This might be connected with recent theories about how students' backgrounds may influence the manner in which they prefer to engage with content. Felder, referring to college science students, stressed that students are characterized by significant different orientations toward content, and teachers should not desire to change their preferred orientations, but to modify their teaching practices to accommodate and reach all students [39]. In the case of "Think in sequential manner," Felder defines sequential learners as students who absorb information and acquire an understanding of material in small connected chunks, as opposed to global learners who take information in seemingly unconnected fragments and achieve understanding in large, holistic leaps. Felder suggests that sequential learners can solve problems with an incomplete understanding of the material and may lack a grasp of the big picture. Global learners work in a more all-or-nothing fashion; they may appear slow and do poorly on tests until they grasp the big picture, but once they have it, they often can see connections to other subjects that escape sequential learners.

The analysis of the MCTP middle school mathematics and science teachers' responses found that the MCTP middle school teachers differed significantly ($p < .05$) from the national sample on two perspectives (Figures 1 and 2). Mathematics teachers were *less likely to believe* that it is important for mathematics students to think in a sequential manner (29% MCTP, 80% National), and science teachers were *more likely to believe* that it is very important for students to support solutions (100% MCTP, 86% National).

Findings: Teachers' Intentions about Implementing Reform Activities in Mathematics and Science Classes

In this section, teachers were asked to report on the kind of reform activities they are implementing in their classrooms (items 34-47). Tables 3 and 4 summarize the MCTP graduates' responses and the national sample. The percentages in these figures were rounded and they reflect the percentage of teachers who chose to answer "yes." The national sample groups, in this section, were public elementary and secondary school mathematics and science teachers who answered a survey in 1996 [14].

Table 3

Comparison of MCTP School Teachers' Use of Instructional Practices in Mathematics with Those of National Sample by Percentage Responding "Yes"

Item	Elementary School		Middle School	
	MCTP[1]	National[2]	MCTP[3]	National[2]
34. Assisting all students to achieve high standards.	100***	77	100***	85
35. Providing examples of high-standard work.	100***	63	100***	66
36. Using authentic assessments.	100***	55	100***	49
37. Using standards-aligned curricula.	100***	64	93*	72
38. Using standards-aligned textbooks and materials.	93***	66	85	72

39. Using telecommunication-supported instruction.	64***	20	69***	27
40. Making connections with science.	93	-------	92	-------

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

[2]Public School Teacher Survey on Education Reform: Elementary and middle school (1996), n=152.

[3]MCTP Teacher's Beliefs and Actions of Mathematics and Science: Middle school mathematics teachers, n=14.

Table 4
Comparison of MCTP School Teachers' Use of Instructional Practices in Science with Those of National Sample by Percentage Responding "Yes"

Item b	Elementary School		Middle School	
	MCTP[1]	National[2]	MCTP[3]	National[2]
41. Assisting all students to achieve high standards.	100***	71	100**	78
42. Providing examples of high-standard work.	100***	48	88.9	64
43. Using authentic assessments.	100***	44	100***	42
44. Using standards-aligned curricula.	96***	66	100***	65
45. Using standards-aligned textbooks and materials.	86**	58	100***	60
46. Using telecommunication-supported instruction.	75***	17	75*	29
47. Making connections with mathematics.	97	-------	100	-------

[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: : elementary and middle school (1996), n=95.

[3]MCTP Teachers' Beliefs and Actions of Mathematics and Science (2001): Middle school mathematics teachers, n=9.

The MCTP elementary school mathematics teachers differed significantly from the national sample on all mathematical teaching practices. They say that 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 they would make connections with science in their practices.

The MCTP middle school mathematics teachers differed significantly from the national sample on several actions. They say that 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.

The MCTP elementary school science teachers differed significantly from the national sample on all practices. They say that 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, 96.6% stated that they made connections with mathematics in their practices.

The MCTP middle school science teachers also differed significantly from the national sample on several practices. They say that 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.

Overall, it seems that except for "Using telecommunication-supported instruction," most or all of the MCTP mathematics and science teachers in both levels of instruction (elementary and middle school) reported that they use or intended to use each of the instructional practices that were included in this section. Actually, all of the instructional practices that appear in this section are recommended by the MCTP program. The call for "science and mathematics for all" dictates that teachers have to assist all students to achieve high standards and, in order to reach all of the students, there is a need to use different assessment strategies, since for many students the conventional testing paradigms do not give accurate readings of their knowledge [34]. Interestingly, only about 70% of the MCTP mathematics and science teachers reported using telecommunication-supported instruction; these percentages are low in comparison to the other practices that MCTP teachers reported that they use. However, they are high in comparison to the national group reports of using telecommunication-supported instruction. These results probably reflect not only the MCTP philosophy to enhance technology and telecommunication-supported instruction, but also the time difference. Currently, educators (teachers, developers, researchers, students) are much more aware of the potential of Internet technology than they might have been eight years ago [45].

Results and Discussion

The goal of the MCTP was to produce new teachers who were confident teaching mathematics and science using technology, who could make connections between and among the disciplines, and who could provide an exciting and challenging learning environment for students of diverse backgrounds. As such, the goals of the MCTP were in alignment with other reform-oriented undergraduate mathematics and science teacher preparation programs. The present analysis provides quantifiable evidence that the graduates of this program held perspectives that aligned with the MCTP reform-based goals. 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 expressed more reform-oriented perspectives concerning subject matter and instruction. These findings strongly suggest that a systematic, reform-based undergraduate mathematics and science program can produce new teachers who enter the workplace with desired perspectives. One might infer that the MCTP teachers expressed beliefs that they thought were consistent with our reform ideas, but this is also a step toward change. As stated by Haney, Lumpe, and Czerniak, "The beliefs that teachers hold regarding reform ideas are truly at the core of educational change..." [54]. This is why comparison with other teachers is so important, since they did not express these thoughts.

It is intriguing, however, that among all of the other positive findings, our analysis showed one anomalous result. When the MCTP graduates were compared with the entire sample of practicing teachers, the MCTP graduates were more likely to believe that if students engaged in classroom debates about ideas or procedures covering the sciences, it could harm their learning ($p<.0003$). While the percentage of MCTP graduate responses was low (7.4%), the result even at this level was surprising given that the MCTP program promoted learner discourse throughout. Furthermore, since the new MCTP middle school teachers' responses to this item were not determined to be statistically different from the sample of practicing middle school teachers, 11.1% also expressed this view. We speculate that for some new teachers the notion of student debate may be a threatening occurrence linked to a loss of classroom management, a prominent consideration of new teachers.

Limitations

One limitation of this study is that our survey was forced to use the same questions from the original surveys in order to compare between populations (MCTP and others). For example, in our survey items in which we asked about practice, the use of a 5-point Likert scale would have been our preference instead of "yes" and "no" responses. However, the original survey items used the "yes" and "no" responses, so we used the same.

Also, since not all of the MCTP graduates became eighth grade teachers, we recognize this as another limitation. As a result of this possible inability to compare with the national eighth grade sample, we recommend a guarded interpretation of the comparison between the total samples.

Educational Implications

The 1990s were exciting times within the mathematics and science teacher preparation communities. The reform movement (as guided by recommendations in the mathematics and science standards documents) influenced all aspects of the professional development of mathematics and science teachers, particularly in undergraduate teacher preparation. The present study adds empirical data to the discussion on the impact of large scale, reform-based undergraduate teacher preparation programs on teachers' beliefs and intentions concerning mathematics and science if the research-based recommendations are used systematically throughout the interns' program [55].

The study also illuminates one area of needed research—the impact of the workplace on graduates of such high quality programs. To what extent do reform-prepared mathematics and science teachers maintain their beliefs and intended instructional actions as they are inducted in schools? Policy makers, educators, and community members concerned with mathematics and science education need this information to design and maintain effective learning and teaching environments for the twenty-first century.

Continued Research

McGinnis, Marbach-Ad, and associates are currently engaged in continued research that builds directly on the findings from this study. This research is being supported by the National Science Foundation [56]. A new undergraduate preparation model for upper elementary/middle school science is being tested that incorporates comprehensive connections among the mathematics and sciences; including, transformative science content courses, science method courses, field-based placements in informal after school science internships, and professional development schools. The standards-based curricular and instructional strategy used is focused on data management and analysis. The teacher preparation programs under study represent examples from an Historically Black College/University (HBCU) and a Predominantly White College/University (PWCU). The instrument reported in this study, "MCTP Teachers' Actions and Beliefs of Mathematics and Science" was used to develop an improved and more generic instrument to measure the same constructs. The new instrument is entitled, "New Teachers' Actions and Beliefs of Mathematics and Science." ■

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Appendix A

MCTP Teachers' Actions and Beliefs of Mathematics and Science

Directions: Please select the letter response that best represents your actions and beliefs.

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**

Mathematics

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 an 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 representation 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.

Science

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 an 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]?

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

In Mathematics

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?

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

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.
(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

Appendix B
Background of MCTP Graduates at Time of Survey Response

Sample Size		Number	Percent
Total		68	100%
Number of years teaching			
	In beginning year	46	69.7%
	1 to 2 years	18	27.3%
	3 to 4 years	2	3.0%
	More than 4 years	0	0.0%
Instructional level			
	1^{st} or 2^{nd} grade	6	10.2%
	3^{rd} or 4^{th} grade	10	16.9%
	5^{th} or 6^{th} grade	19	32.2%
	7^{th} or 8^{th} grade	19	32.2%
	Other	5	8.5%
Specialized teacher (by content)			
	Yes	40	66.7%
	No	20	33.3%
Main subject area taught			
	Mathematics	13	31.0%
	Science	16	38.1%
	Both mathematics and science	8	19.0%
	Other	5	11.9%
Employed elementary or middle school teacher		61	100%
	Elementary	29	47.5%
	Middle school	32	52.4%
	Middle school (mathematics)	14	23.0%
	Middle school (science)	9	14.8%
	Middle school (math and science)	9	14.8%