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AUTHOR	McGinnis, J. Randy; And Others
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ABSTRACT

This paper describes the use of a valid and reliable instrument, Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science, that measured teacher candidates' attitudes and beliefs. Data was collected from students (N=1,128) in mathematics, science, or pedagogy undergraduate college classes taught in higher education institutions in Maryland. Findings from the data indicate that attitudes toward learning mathematics and science as well as beliefs about mathematics and science did not significantly change during the year in which the survey was administered. The teacher candidates' beliefs about teaching mathematics and science did improve significantly in the second semester while other students' attitudes toward learning to teach mathematics and science dropped in the second semester. In addition to these findings the data assists in constructing a statewide landscape of what undergraduate teacher candidates feel and believe about mathematics and science and the teaching of those disciplines before they enter the methods and student teaching components of their teacher education program. The survey instrument is also included. Contains 38 references. (JRH)

The Assessment of Elementary/Middle Level Teacher Candidates' Attitudes and Beliefs About the Nature of and the Teaching of Mathematics and Science

J. Randy McGinnis
The Science Teaching Center
Department of Curriculum & Instruction
Room 2226K Benjamin
University of Maryland, College Park
College Park, Maryland 20742

Tad Watanabe
Department of Mathematics
Towson University
Towson, Maryland 21204

Gilli Shama
c/o MCTP
2349 Computer & Space Sciences
University of Maryland, College Park
College Park, Maryland 20742

Anna Graeber
The Center for Mathematics Education
Department of Curriculum & Instruction
Room 2226H Benjamin
University of Maryland, College Park
College Park, Maryland 20742

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The Assessment of Elementary/Middle Level Teacher Candidates' Attitudes and Beliefs About the Nature of and the Teaching of Mathematics and Science

Abstract

This session describes the use of a valid and reliable instrument (n =486, α =.76) to measure teacher candidates' attitudes and beliefs about the nature of and the teaching of mathematics and science. The instrument, *Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science* , was developed for the Maryland Collaborative for Teacher Preparation (MCTP), a National Science Foundation funded undergraduate teacher preparation program for specialist mathematics and science elementary/middle level teachers. Sections of the instrument that were verified by factor analysis dealt with beliefs about mathematics and science (α=.7596); attitudes toward mathematics and science (α=.8070); beliefs about teaching mathematics and science (α=.6900); attitudes toward learning to teach mathematics and science (α=.7889); and attitudes toward teaching mathematics and science (α=..6014). Data were obtained (total instrument responses, n=1128; MCTP teacher candidates, n= 323) during the 1995/96 academic year from 38 mathematics, science, or pedagogy undergraduate college classes taught in 8 higher education institutions in Maryland. Findings from the data indicate that attitudes toward learning mathematics and science as well as beliefs about mathematics and science did not significantly change during the year in which the survey was administered. The MCTP teacher candidates' beliefs about teaching mathematics and science did improve significantly in the second semester. Other students' attitudes toward learning to teach mathematics and science dropped in the second semester. The difference between the MCTP teacher candidates' attitudes toward teaching mathematics and science to other college students' attitudes decreased. In addition to these findings, these data assist in constructing a statewide landscape of what undergraduate teacher candidates feel and believe about mathematics and science and the teaching of those disciplines before they enter the methods and student teaching components of their teacher education programs.

The Assessment of Elementary/Middle Level Teacher Candidates' Attitudes and Beliefs About the Nature of and the Teaching of Mathematics and Science

Introduction

This paper describes the factor analysis and the use of a valid and reliable instrument (n =486, α=.76) to measure teacher candidates' attitudes and beliefs about the nature of and the teaching of mathematics and science. The instrument, *Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science* , was developed for the Maryland Collaborative for Teacher Preparation (MCTP), a National Science Foundation (NSF) funded undergraduate teacher preparation program for specialist mathematics and science elementary/middle level teachers.

Context of Study

The MCTP is a NSF funded statewide undergraduate program for students who plan to become specialist mathematics and science upper elementary or middle level teachers. Teacher candidates selected to participate in the MCTP program are, in general, academically representative of all teacher candidates in elementary teacher preparation programs. MCTP teacher candidates are distinctive by expressing an interest in teaching mathematics and science. Recruitment efforts have also attracted many students to the MCTP traditionally underrepresented in the teaching force (23% of those formally admitted come from those groups), most notably African Americans (19%) (MCTP, 1996, p. 3).

Higher education institutions involved in this project include nine of the higher education institutions within the University of Maryland System responsible for teacher preparation. Several community colleges also participate. In addition, several large public school districts are active partners. The goal of the MCTP is to promote the development of professional 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 (University of Maryland System, 1993). This goal is in accord with the educational practice reforms advocated by the major professional mathematics and science education communities (e.g., National Council of Teachers of

Mathematics (NCTM), 1989, 1991; American Association for the Advancement of Science (AAAS) 1989, 1993; National Research Council (NRC) of the National Academy of Sciences, 1989, 1996). Figure 1 contains a program overview of the MCTP.

In practice, the MCTP undergraduate classes 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 practice, and to employ a instructional and assessment strategies recommended by the literature to be compatible with the constructivist perspective (i.e., be student-centered, address conceptual change, promote reflection on changes in thinking, and stress logic and fundamental principles as opposed to memorization of unrelated facts) (e.g., Cobb, 1988; Wheatley, 1991; Driver, 1989). Faculty lecture is diminished and student-based problem-solving is emphasized that requires cross-disciplinary mathematical and scientific applications.

Theoretical Underpinnings and Research Questions

A fundamental 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 teacher candidates take throughout their teacher preparation programs (NSF, 1993). A second assumption is that MCTP teacher candidates who take reformed undergraduate mathematics, science, and method classes that are informed by the constructivist epistemology (i.e., learners actively construct knowledge through interaction with their surroundings and experiences, and learners interpret these experiences based on prior knowledge) (von Glasersfeld, 1987, 1989) develop more positive attitudes and beliefs toward mathematics and science and the teaching of those subjects.

Research interests within the MCTP fall within both the hypothesis-testing and hypothesis-generation domains (Brause & Mayher, 1991). In the hypothesis-generation domain, the MCTP Research Group is longitudinally documenting over a five-year period how the MCTP teacher candidates and the MCTP faculty participate in the MCTP program. The goal is to construct some insights that suggest ways of how the MCTP participants are impacted by the program. Describing and interpreting the discourse communities is one aspect of this effort (McGinnis & Watanabe, 1996a, 1996b). Another aspect is the focus on case studies to compelling tell the MCTP story (Roth-McDuffie & McGinnis, 1996). In the hypothesis-testing domain, the focus is on determining what are the MCTP teacher candidates' attitudes and beliefs relevant to mathematics, science, technology and to teaching and comparing them with the beliefs and attitudes of non-MCTP teacher candidates. Specifically, in this domain, these two research questions guide MCTP research:

1. Is there a difference between the MCTP teacher candidates' and the non-MCTP teacher candidates' attitude toward:

(i) mathematics and science?

(ii) the interdisciplinary teaching and learning of mathematics and science?

(iii) the use of technology in teaching and learning mathematics and science?

2. Is there a difference between the MCTP teacher candidates' and the non-MCTP teacher candidates' beliefs toward:

(i) the nature of mathematics and science?

(ii) the interdisciplinary teaching and learning of mathematics and science?

(iii) the use of technology in teaching and learning mathematics and science?

Objectives of the Paper

To obtain data to test the hypothesis-testing research questions, the documentation of the MCTP teacher candidates' and non-MCTP teacher candidates' attitudes and beliefs toward and about the learning of and the teaching of mathematics and science throughout their undergraduate years was recognized as essential to perform. In addition to regularly conducted interviews in which faculty and teacher candidates would be asked about their attitudes and beliefs, it was recognized that the regular use of a survey instrument would be a necessary complementary quantitative research strategy to collect valid and reliable data from a large number of program participants (Jaeger, 1988). The instrument would be administered to the undergraduate students in all the MCTP classes offered throughout the state and would be used to assist in describing their attitudes and beliefs about the nature of and the teaching of mathematics and science. Since the majority of MCTP classes consist of a mixture of teacher candidates and non-teacher candidates, the instrument needed to contain items which all enrolled students gave responses and a section which contained items only appropriate for those intending to teach. A Likert style instrument (Likert, 1967) was considered the most efficient under the external constraint of classroom administration.

A comprehensive review of the mathematics and science education literature revealed no single instrument which would provide information to inform all of the research questions. However, partial information could be provided by existing tools that measure attitudes or beliefs towards mathematics or science and the teaching of mathematics or science (e.g., German, 1988; Jasalavich & Schafer, 1994; Jurdak, 1991; Moreira, 1991; Pehkonen, 1994; Robitalille & Garden, 1989; Schonfeld, 1989; and Underhill, 1988). Therefore, the researchers decided to craft a new instrument, *Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science*. Readers interested in the documentation of the instrument's design (history and procedures) are directed to McGinnis, Shama, Graeber, & Watanabe (1997).

Constructs of the Instrument

Items for the instrument needed to measure constructs within the affective, belief, and epistemological areas to inform the research questions. Items were crafted to measure attitudes toward and beliefs about mathematics and science, interdisciplinary teaching and learning of mathematics and science, and the use of technology to teach and learn mathematics and science.

The notion that teachers' attitudes (or preferences) toward mathematics influence their teaching practice has been suggested by researchers (e.g., Thompson, 1984). Ball (1990b) suggests that teachers' attitudes are part of the way they understand mathematics. Therefore, it is one of the two broad areas in which pre-service mathematics courses must address (Ball, 1990a). Likewise, researchers in science education have recognized the importance of the affective domain in the learning and teaching of science (e.g., Simpson, Koballa, Oliver, & Crawley, 1994). They define attitudes toward science as specific feelings which indicate if a person "likes or dislikes science" (p. 213). The MCTP project's goal is that upon completion of their undergraduate teacher preparation program, the teacher candidates will hold positive attitudes toward the learning and the teaching of mathematics and science. Sample paired attitude items crafted for the survey include:

I like mathematics (science).

I am not good at mathematics (science) [negative].

I am looking forward to taking more mathematics (science) courses.

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

A second major component of the instrument was on beliefs. Researchers have long noticed that beliefs have an influential impact on the learning and teaching of mathematics and science (e.g., Schoenfeld, 1985; Silver, 1985; Thompson, 1992). The MCTP project's goal is that upon completion of their undergraduate teacher preparation program, the teacher candidates will hold beliefs toward the learning and the teaching of mathematics and science compatible with MCTP principles. These principles support mathematics and science for all, the use of cooperative learning, the use of technology to enhance instruction, the fundamental importance of problem-solving and inquiry, and the view that the disciplines are human endeavors open to revision. Sample paired belief items crafted for the survey include:

Truly understanding mathematics (science) requires special abilities that only some people possess [negative].

The use of computing technologies in mathematics (science) is an aid primarily for slow learners [negative].

A third major construct focused on a philosophical perspective on the learning mathematics and science. The MCTP project is based on a constructivist epistemology. Although there is still an on-going discussion on what a constructivist teaching of mathematics and science is (see Simon, 1995; Steffe & D'Ambrosio, 1995; Tobin, Tippins, & Gallard, 1994), the MCTP promotes the following aspects as three important components of a constructivist mathematics/science classrooms: (a) students should be given opportunities to experience and explore mathematics/science using concrete materials (b) students should be encouraged to think and reflect about their mathematics/science understanding, and (c) students should be given opportunities to exchange their ideas. The MCTP project's goal is that upon completion of their undergraduate teacher preparation program, the teacher candidates will hold beliefs toward the learning and the teaching of mathematics and science compatible with these epistemological perspectives. Sample paired epistemological items crafted for the survey include:

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

Small group activity should be a regular part of the mathematics (science) classroom.

Factor Analysis Of The Instrument

Sample

During the fall, 1995, the survey was administered to all undergraduate students (n= 391) enrolled in 21 non-lecture hall MCTP content courses offered at 8 institutions of higher learning in Maryland. The survey was administered during course time. These courses included introductory science content classes (biology, chemistry, physics, and general science), introductory and intermediate mathematics classes, and one general pedagogy class designed for prospective elementary teachers with a concentration in mathematics or science. In addition, the survey was administered to all students (n=144) enrolled in a large lecture MCTP-influenced content class (biology). Of the students enrolled in the courses, the student response rate was 98%. Most students who indicated they intended to teach were Caucasian women. See Table 1 for detailed information on the sample.

Findings

The instrument includes two groups of items. One group consists of thirty-two items that are to be answered by all students. The other group consists of nine items that are to be answered only by those intending to teach. The pre-planned sub-scales were verified on each group of items separately, using principle-components factor-analysis, with varimax rotation.

In order to execute the factor-analysis, it is recommended that the sample be at least 15 times the number of items, that is at least (32*15) 480 students. The total sample of the first administration (fall 1995 pre-test) was 535 students (391+144). However, 49 respondents did not complete all items. Therefore, the sample size for the factor analysis is 486. A sample of 486 exceeds the minimum sample size factor-analysis requirement for a 32-item instrument.

Two to five factors were extracted from the 486 students' responses to the first group of items, following the scree plot. Three factors were chosen, since they offered the highest reliabilities and theoretically meaningful dimensions. The three identified factors accounted for 32% of the total variance. Their corresponding eigenvalues were 4.61, 2.98 and 2.57. A similar process, on the 331 students' responses to the second group of items, yielded two factors. The two factors account for 50% of the total variance. Their corresponding eigenvalues were 3.04 and 1.43.

The items were classified into sub-groups by the factor on which they were most highly loaded. The classification and loading appear in Table 2. Reliability of each of the five sub-groups was examined by Cronbach's alpha . Four items that lowered their group's reliability were taken out of any further analysis. They included three mathematics items and one general item. All other items were retained to maximize reliability. On each item the scale was converted, so that 5 represents the most desired answered and 1 represents the least desired answer. For each of the five groups, a variable X_i was defined as the mean of scores on items in the group. The five variables that were verified by factor analysis were the following:

- Beliefs about the nature of mathematics and science, variable X_1
- Attitudes towards mathematics and science, variable X_2
- Beliefs about the teaching of mathematics and science, variable X_3
- Attitudes towards learning to teach mathematics and science, variable X_4
- Attitudes towards teaching mathematics and science, variable X_5

Another factor that was extracted from each of the five groups is linked to the classification of most items into pairs. Each pair included two corresponding items, one from the mathematics discipline, and the other from the science discipline. Paired items appear in the same row of Table 2.

Limitation of the Survey

The sample of this study included undergraduate students who do not intend to teach. Therefore, the results should be viewed carefully when compared to only teacher candidates' responses.

Results

1. *Beliefs about the nature of mathematics and science*

The variable X_1 measures beliefs about the nature of mathematics and science, in a scale of 1 to 5. The first semester's pre-test X_1 students' mean was 3.81. MCTP students' mean was 3.98. The responses to the variable X_1, reported by administration, by semester, and by MCTP membership, are given in Table 3.

The hypothesis that MCTP students' mean is equal to the mean of the other students was rejected using a t test, in each administration and in each semester (see two Tail significance, in Table 3). The MCTP students' mean was higher than the other students' mean. Considering both administrations and both tests, the difference between MCTP student's mean to other students' mean is 0.24.

A significant difference between pre-test mean to post-test mean was found only on the Fall semester for the total sample. The 95% confidence interval for this difference is 0.11 to 0.10. Therefore the drop in mean from pre-test to post-test was limited in scope, small and did not include MCTP students.

2. *Attitudes towards mathematics and science*

The variable X_2 measures attitudes towards mathematics and science, in a scale of 1 to 5. First semester's pre-test X_2 mean of all students' was 3.39. The MCTP students' mean was 3.83. The responses to the variable X_2, reported by administration, by semester, and by MCTP membership, are given in Table 4.

The hypothesis that MCTP students' mean is equal to the mean of the other students was rejected using a t test, in each administration and in each semester (see two-Tail significance, in Table 4). The MCTP students' mean was higher than the other students' mean. Considering both administrations and both tests, the difference between MCTP student's mean to other students' mean is 0.44.

The hypothesis that MCTP students' variance is equal to the variance of the other students was rejected using a Levene's test, in fall semester. The group of MCTP students is much more homogenous in its response than the group of non-MCTP students.

The hypothesis that pre test's mean is equal to post test's mean was not rejected using a t test, in each group of students and in each semester (see two-Tail significance, in Table 4).

3. *Beliefs about the teaching of mathematics and science*

The variable X_3 measures beliefs about the teaching of mathematics and science, in a scale of 1 to 5. First semester's pre-test X_3 mean of all students' was 3.99. MCTP students' mean was 4.11. The responses to the variable X_3, reported by administration, by semester, and by MCTP membership, are given in Table 5.

The MCTP teacher candidates' mean was higher than the other students' mean, in each semester and administration. The difference between MCTP students' mean to other students' mean was not significant in the post test of fall semester, and in the pre test of spring semester (see two-Tail significance, in Table 5). Considering both administrations and both tests, the difference between MCTP student's mean to other students' mean is only 0.15.

In the first semester, post test's mean was non-significantly higher than pre test's mean, in each group of students. In the second semester, MCTP students' mean significantly improved from pre test to post test (see two-Tail significance, in Table 5).

4. *Attitudes towards learning to teach mathematics and science*

The variable X_4 measures attitudes towards learning to teach mathematics and science, in a scale of 1 to 5. The first semester's pre-test X_4 mean of all students' was 4.16. The MCTP students' mean was 4.59. The responses to the variable X_4, reported by administration, by semester, and by MCTP membership, are given in Table 6.

The hypothesis that MCTP students' mean is equal to the mean of the other students was rejected using a t test, in each administration and in each semester (see two-Tail significance, in Table 6). The MCTP students' mean was higher than the other students' mean. Considering both administrations and both tests, the difference between MCTP student's mean to other students' mean is 0.52.

The hypothesis that MCTP students' variance is equal to the variance of the other students was rejected using a Levene's test, in both semesters and in both administrations. Standard derivations of the group of MCTP students are from 0.54 to 0.70. Standard derivations of the group of non-MCTP students are above 0.85. These facts point out that the group of MCTP students is much more homogenous in its response than the group of non-MCTP students.

The hypothesis that pre test's mean is equal to post test's mean was rejected using a t test, for non-MCTP students in the spring semester (see two-Tail significance, in Table 6). Considering both semesters, the mean of non-MCTP students dropped significantly from 4.02 to 3.82. The mean of MCTP students, which was originally very high, dropped slightly and insignificantly (see Table 6).

5. *Attitudes towards teaching mathematics and science*

The fifth variable X_5 measures attitudes towards teaching mathematics and science, in a scale of 1 to 5. First semester's pre-test X_5 mean of all students' was 3.18. The MCTP students' mean was 3.51. The responses to the variable X_5, reported by administration, by semester, and by MCTP membership, are given in Table 7.

The MCTP students' mean was higher than the other students' mean, in all administrations and in all semesters. Considering both administrations and both tests, the difference between MCTP student's mean to other students' mean is 0.36.

The hypothesis that MCTP students' mean is equal to the mean of the other students was not rejected using a t test, in second administration of fall semester (see two-Tail significance, in Table 7). A significant difference between pre-test mean to post-test mean was found only on the fall semester for the MCTP students. The MCTP students' mean dropped significantly. In the same semester non-MCTP students' average increased slightly. Therefore, the significant difference that was between MCTP students to other students, in the beginning of the semester, disappeared. The average of all students in both semesters grew insignificantly from pre-test to post-test (see first line of Table number 7).

Discussion

There are a dearth of longitudinal studies which strive to document the struggles teacher candidates and others confront when participating in constructivist-based instruction that attempts to make connections between mathematics and science. Findings from this phase of a longitudinal study focusing on this issue is limited. The impact of one or two courses taken during one academic year on students' beliefs and attitudes cannot be expected in all cases to initiate dramatic positive changes. However, the instrument proved to be useful in providing a global picture of both MCTP teacher candidates and non-MCTP teacher candidates. As we continue to follow the MCTP teacher candidates throughout their college experiences with this instrument, we should be able to test whether or not the program has any impact on their beliefs and attitudes about mathematics and science.

In general, MCTP teacher candidates appeared to have started out with very positive attitudes and beliefs toward mathematics and science. The fact that MCTP teacher candidates had significantly better means on all variables may be a reflection of the fact that students with more mathematics and science background were actively recruited.

There are, however, some troubling trends (from the project's standpoint) in the results reported here. For example, the means for variables X_1 (beliefs about the nature of math and science) significantly dropped in the Fall semester for non-MCTP students. Also, the means for X_4 (attitudes toward learning to teach math and science) declined significantly for non-MCTP students and dropped slightly for MCTP students in the MCTP courses. One possible explanation for these "negative" results is that the MCTP courses were indeed taught differently, with different emphases, compared to traditional mathematics and science courses that these participants had experienced. In some cases, students might have to struggle to get grades they were so accustomed to getting in the past since the instruction and assessment emphasized conceptual change over rote memorization. For some students, this experience may have had a negative impact on their attitude toward the subject matter. This struggle in turn, even if the students realized that this form of instruction was superior to the ones they had experienced themselves as students, might have led some students to realize the challenge that lay ahead as they try to learn how to teach math and science. Individual interviews, as well as classroom observation data, will inform this hypothesis in more detail.

Although statistically not significant, there were some promising trends in the results. In general, the means for MCTP teacher candidates from Spring semester indicate general shift in the direction the project is aiming. All variables show slight (although not statistically significant) improvement except X_2, which remained constant. As we continue our study of MCTP teacher candidates' development, we will be able to examine the effects of MCTP courses more carefully.

Overall, the survey instrument has proven to be useful as we attempt to landscape the paths these teacher candidates will travel during their undergraduate years. We plan to continue surveying the MCTP teacher candidates regularly for next three years to document the attitudinal and belief journeys they take. The issues raised during the first semester administrations will be addressed as we continue our study.

Conclusion

Within the MCTP, the survey instrument has proven useful as one tool in our effort to landscape the attitudinal and belief paths the MCTP teacher candidates travel during their undergraduate years. We plan to continue administering the survey to the MCTP teacher candidates regularly as they proceed through their undergraduate programs and begin their first years of teaching practice. However, we are not focusing all of our attention solely on this strategy to inform us on this important aspect of teacher preparation. In addition to the regular administration of the survey, we are also using complementary research strategies such as in-depth interviews and longitudinal case studies of faculty and teacher candidates. Between these quantitative data obtained from the survey instrument and the qualitative date from the case studies and interviews, we believe that we will be able to vigorously document the attitudinal and belief progression of MCTP teacher candidates (and a comparable sample of non-MTCP teacher candidates). These findings are anticipated to contribute to the crucial need to better understand the impact of reform practices in undergraduate science and mathematics teacher preparation.

Outside the MCTP, the survey instrument is offered as a valid and reliable tool to measure teacher candidates' attitudes and beliefs about the nature of and the teaching of mathematics and science.

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Interested readers are invited to browse the MCTP worldwide web homepage to access additional information concerning the project and the Research Group's efforts (http://www.wam.umd.edu/~toh/MCTP.html).

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Appendix caption
Appendix: Survey Instrument

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

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.*

	M	SD	N
1. I am looking forward to taking more mathematics courses.	3.12	1.36	1126
2. I enjoy learning how to use technologies (e.g., calculators, computers, etc.) in mathematics classrooms.	2.06	1.12	1127
3. I like mathematics.	2.65	1.32	1128
4. In grades K-9, truly understanding mathematics in schools requires special abilities that only some people possess.	3.79	1.22	1127
5. The use of technologies (e. g., calculators, computers, etc.) in mathematics is an aid primarily for slow learners.	4.36	.99	1124
6. Mathematics consists of unrelated topics (e.g., algebra, arithmetic, calculus and geometry).	3.91	1.25	1127
7. To understand mathematics, students must solve many problems following examples provided.	2.49	1.22	1123
8. Students should have opportunities to experience manipulating materials in the mathematics classroom before teachers introduce mathematics vocabulary.	2.33	1.05	1125
9. Getting the correct answer to a problem in the mathematics classroom is more important than investigating the problem in a mathematical manner.	4.08	1.08	1124
10. Students should be given regular opportunities to think about what they have learned in the mathematics classroom.	1.64	.83	1127
11. Using technologies (e.g., calculators, computers, etc.) in mathematics lessons will improve students' understanding of mathematics.	2.26	1.10	1127
12. The primary reason for learning mathematics is to learn skills for doing science.	3.32	1.11	1126
13. Small group activity should be a regular part of the ...classroom.	1.71	.90	1128
14. I am looking forward to taking more science courses.	2.97	1.39	1127
15. Using technologies (e.g., calculators, computers, etc.) in science lessons will improve students' understanding of science.	2.26	1.10	1127
16. Getting the correct answer to a problem in the science classroom is more important than investigating the problem in a scientific manner.	4.17	1.01	1123

17. In grades K-9, truly understanding science in the science classroom requires special abilities that only some people possess.	3.94	1.18	1123
18. Students should be given regular opportunities to think about what they have learned. in the science classroom	1.54	.75	1126
19. Science is a constantly expanding field.	1.33	.69	1124
20. Theories in science are rarely replaced by other theories.	3.67	1.14	1122
21. To understand science, students must solve many problems following examples provided.	2.75	1.18	1122
22. I like science.	2.46	1.29	1124
23. I enjoy learning how to use technologies (e.g., calculators, computers, etc.) in science.	2.04	1.10	1121
24. The use of technologies (e. g., calculators, computers, etc.) in science is an aid primarily for slow learners.	4.26	1.05	1121
25. Students should have opportunities to experience manipulating materials in the science classroom before teachers introduce scientific vocabulary.	2.31	1.13	1125
26. Science consists of unrelated topics like biology, chemistry, geology, and physics.	3.82	1.30	1120
27. Calculators should always be available for students in science classes.	2.15	1.09	1122
28. The primary reason for learning science is to provide real life examples for learning mathematics.	3.15	1.11	1115
29. Small group activity should be a regular part of the science classroom.	1.51	.80	1113

THE FOLLOWING ITEMS ARE FOR ONLY THOSE INTENDING TO TEACH

	M	SD	N
1. I expect that the college mathematics courses I take will be helpful to me in teaching mathematics in elementary or middle school.	1.86	1.12	922
2. I want to learn how to use technologies (e.g., calculators, computers, etc.) to teach mathematics.	1.72	1.05	941
3. The idea of teaching science scares me.	3.25	1.31	916
4. I expect that the college science courses I take will be helpful to me in teaching science in elementary or middle school.	2.04	1.14	919
5. I prefer to teach mathematics and science emphasizing connections between the two disciplines.	2.66	1.16	915
6. The idea of teaching mathematics scares me.	3.28	1.38	920
7. I want to learn how to use technologies (e.g., calculators, computers, etc.) to teach science.	1.88	1.05	916
8. I feel prepared to teach mathematics and science emphasizing connections between the two disciplines.	3.04	1.18	913

Table 1
The sample

Description		Total sample	MCTP students
Gender:	Male	24.8%	13.6%
	Female	75.2%	86.4%
Ethnicity:	African-American	24.5%	15.2%
	Asian/Pacific Islander	4.4%	3.0%
	Caucasian	65.0%	79.1%
	Hispanic	2.0%	0.9%
	Other	4.1%	1.8%
Number of complete college credits:	0-30	32.1%	40.5%
	31-60	31.2%	29.3%
	61-90	19.4%	17.8%
	91+	15.0%	10.3%
	post-baccalaureate	2.3%	2.1%
Major area of concentration:	Education / Mathematics	6.8%	8.2%
	Education / Science	6.5%	6.9%
	Education / Math & Science	13.4%	39.6%
	Education / Other subject(s)	45.8%	43.8%
	Not in teacher certification program	27.5%	1.5%
Area of teaching certification:	elementary (grades 1-8)	75.5%[1]	91.2%
	secondary mathematics (5-12)	4.7%	4.0%
	secondary science (5-12)	1.8%	0.0%
	other	17.0%	4.6%
Intending to teach grades:	K-3	39.6%	38.9%
	4-8	88.1%	51.2%
	9-12	5.1%	1.5%
	post-secondary	1.4%	0.6%
	undecided	15.8%	7.8%
Administration	Fall 1995, Pre-test	391	97
	Fall 1995, Post-test	293	74
	Spring 1996, Pre-test	242	84
	Spring 1996, Post-test	202	68
Total		1128	323

[1] Percentages from those intending to teach, N=922.

Table 2
Factor Analysis

Description	Item index		Avg. load
X1. Beliefs about the nature of mathematics and science			**α=.7596***
In grades K-9, truly understanding... requires special abilities that only some people possess.	10	24	.57
The use of technologies in ... is an aid primarily for slow learners.	12	31	.56
Getting the correct answer to a problem in the ...classroom is more important than investigating the problem in a ... manner.	16	23	.55
The primary reason for learning ... is to ... for learning ...	19	35	.53
... consists of unrelated topics like ...	13	33	.48
To understand ..., students must solve many problems following examples provided.	14	28	.33
Theories in science are rarely replaced by other theories.		27	.41
Science is constantly expanding field.		26^{-}	.30
X2. Attitudes towards mathematics and science			**α=.8070**
I am looking forward to taking more ... courses.	5^{-}	21^{-}	.73
I like ...	7^{-}	29^{-}	.69
I enjoy learning how to use technologies in ... classrooms.	6^{-}	30^{-}	.68
X3. Beliefs about the teaching of mathematics and science			**α=.6900**
Using technologies in ... lessons will improve students' understanding of ...	18^{-}	22^{-}	.55
Calculators should always be available for students in science classes		34^{-}	.51
Students should be given regular opportunities to think about what they have learned in the ... classroom	17^{-}	25^{-}	.48
Students should have opportunities to experience manipulating materials in the ... classroom before teachers introduce ... vocabulary	15^{-}	32^{-}	.51
Small group activity should be a regular part of the ... classroom.	20^{-}	36^{-}	.47
X4. Attitudes towards learning to teach mathematics and science			**α=.7889**
I want to learn how to use technologies to teach ...	38^{-}	44^{-}	.80
I expect that the college courses I take will be helpful to me in teaching in elementary or middle school.	37^{-}	41^{-}	.74
X5. Attitudes towards teaching mathematics and science			**α=.6014**
The idea of teaching scares me.	43	40	.69
I prefer (feel prepared) to teach mathematics and science emphasizing connections between the two disciplines.	42^{-}	45^{-}	.56

$^{-}$ Item is reversed.

Table 3
Means, Standard Derivations and t-tests for independent samples of variable X_1 that measures beliefs about the nature of Mathematics and Science.

	Both administrations			Pre-test			Post-test			2-Tail
	n	M	SD	n	M	SD	n	M	SD	sig
Both semesters										
All students	1128	3.74	.59	633	3.77	.56	495	3.70	.62	.083
MCTP students	332	3.91	.54	181	3.92	.51	142	3.89	.59	.686
Non-MCTP	805	3.67	.59	452	3.70	.57	353	3.63	.61	.070
2-Tail sig			.000[2]			.000			.000	
Fall semester										
All students	684	3.76	.58	391	3.81	.55	293	3.70	.61	.009
MCTP students	171	3.93	.55	97	3.98	.50	74	3.86	.61	.188
Non-MCTP	513	3.71	.58	294	3.76	.56	219	3.64	.60	.018
2-Tail sig			.000			.001			.006	
Spring semester										
All students	444	3.70	.60	242	3.69	.57	202	3.72	.63	.599
MCTP students	152	3.89	.54	84	3.85	.52	68	3.93	.57	.405
Non-MCTP	292	3.60	.61	158	3.60	.58	134	3.61	.63	.868
2-Tail Sig			.000			.001			.001	

Equalities of means that are rejected by t-test are bolded.

[2] T-test for unequal variances was performed, since equality of variances was rejected by Levene's test.

Table 4
Means, Standard Derivations and t-tests for independent samples of variable X_2 that measures attitudes towards Mathematics and Science.

	Both administrations			Pre-test			Post-test			2-Tail
	n	M	SD	n	M	SD	n	M	SD	sig
Both semesters										
All students	1128	3.45	.90	633	3.45	.91	495	3.48	.87	.570
MCTP students	332	3.78	.76	181	3.78	.79	142	3.78	.74	.924
Non-MCTP	805	3.34	.91	452	3.32	.92	353	3.37	.89	.483
2-Tail sig			.000[3]			.000*			.000*	
Fall semester										
All students	684	3.40	.92	391	3.39	.93	293	3.46	.89	.369
MCTP students	171	3.82	.72	97	3.83	.75	74	3.82	.70	.969
Non-MCTP	513	3.29	.94	294	3.25	.93	219	3.33	.91	.317
2-Tail sig			.000*			.000*			.000*	
Spring semester										
All students	444	3.54	.86	242	3.55	.88	202	3.52	.84	.743
MCTP students	152	3.73	.80	84	3.73	.83	68	3.73	.77	.943
Non-MCTP	292	3.44	.88	158	3.45	.89	134	3.42	.86	.761
2-Tail Sig			.001			.016			.014	

Equalities of means that are rejected by t-test are bolded.

[3] T-test for unequal variances was performed, since equality of variances was rejected by Levene's test.

Table 5
Means, Standard Derivations and t-tests for independent samples of variable X_3 that measures beliefs about the teaching of Mathematics and Science.

	Both administrations			Pre-test			Post-test			2-Tail
	n	M	SD	n	M	SD	n	M	SD	sig
Both semesters										
All students	1128	4.03	.52	633	4.01	.51	495	4.04	.53	.270
MCTP students	323	4.13	.48	181	4.09	.48	142	4.18	.47	.063
Non-MCTP	805	3.98	.53	452	3.97	.52	353	3.98	.54	.825
2-Tail sig			.000[4]			.013			.000	
Fall semester										
All students	684	4.02	.54	391	3.99	.54	293	4.02	.54	.573
MCTP students	171	4.10	.48	97	4.11	.49	74	4.10	.47	.894
Non-MCTP	513	3.97	.55	294	3.96	.55	219	4.00	.57	.495
2-Tail sig			.006			.018			.153	
Spring semester										
All students	444	4.05	.49	242	4.03	.47	202	4.07	.51	.299
MCTP students	152	4.16	.47	84	4.06	.47	68	4.28	.45	.004
Non-MCTP	292	3.99	.49	158	4.01	.47	134	3.97	.51	.518
2-Tail Sig			.000			.377			.000	

Equalities of means that are rejected by t-test are bolded.

[4] T-test for unequal variances was performed, since equality of variances was rejected by Levene's test.

Table 6
Means, Standard Derivations and t-tests for independent samples of variable X_4 that measures attitudes toward learning to teach Mathematics and Science.

	Both administrations			Pre-test			Post-test			2-Tail
	n	M	SD	n	M	SD	n	M	SD	sig
Both semesters										
All students	892	4.11	.88	511	4.18	.85	381	4.05	.87	.025
MCTP students	323	4.46	.61	181	4.48	.64	142	4.43	.56	.387
Non-MCTP	569	3.94	.92	330	4.02	.90	239	3.83	.95	.0788
2-Tail sig			.000[5]			.000*			.000*	
Fall semester										
All students	548	4.10	.90	320	4.16	.88	228	4.06	.88	.199
MCTP students	171	4.52	.57	97	4.59	.56	74	4.43	.58	.064
Non-MCTP	377	3.93	.96	223	3.97	.92	154	3.88	.95	.379
2-Tail sig			.000*			.000*			.000*	
Spring semester										
All students	344	4.15	.82	191	4.23	.79	153	4.05	.86	.039
MCTP students	152	4.39	.63	84	4.36	.70	68	4.43	.54	.541
Non-MCTP	192	3.96	.91	107	4.13	.85	85	3.74	.94	.003
2-Tail Sig			.000*			.042			.000*	

Equalities of means that are rejected by t-test are bolded.

[5] T-test for unequal variances was performed, since equality of variances was rejected by Levene's test.

Table 7
Means, Standard Derivations and t-tests for independent samples of variable X_5 that measures attitudes toward teaching Mathematics and Science.

	Both administrations			Pre-test			Post-test			2-Tail
	n	M	SD	n	M	SD	n	M	SD	sig
Both semesters										
All students	888	3.21	.84	507	3.19	.85	381	3.24	.82	.394
MCTP students	323	3.44	.79	181	3.44	.78	142	3.45	.80	.868
Non-MCTP	565	3.08	.83	326	3.06	.85	239	3.12	.81	.408
2-Tail sig			.000			.000			.000	
Fall semester										
All students	543	3.18	.85	315	3.18	.87	228	3.19	.82	.825
MCTP students	171	3.44	.80	97	3.51	.79	74	3.34	.82	.190
Non-MCTP	372	3.07	.84	218	3.03	.86	154	3.12	.81	.306
2-Tail sig			.000			.000			.055	
Spring semester										
All students	345	3.26	.81	192	3.22	.81	153	3.32	.82	.290
MCTP students	152	3.45	.77	84	3.36	.76	68	3.57	.77	.090
Non-MCTP	193	3.11	.82	108	3.12	.84	85	3.11	.80	.967
2-Tail Sig			.000			.040			.000	

Equalities of means that are rejected by t-test are bolded.

Figure Caption

Figure 1. Program overview of the Maryland Collaborative for Teacher Preparation.

Maryland Collaborative for Teacher Preparation

Program Overview

New Content Courses

- integrated science and mathematics content
- smaller classes taught by experienced faculty
- teachers model instruction where students form concepts by actively engaging in experimentation and analysis of data

New Methods Courses

- integrated science and mathematics pedagogy
- use technology in science and mathematics teaching

Internships

- science and mathematics in informal setttings, such as museums and zoos
- real world experience using mathematics and science
- exposure to rich ideas about science and mathematics for use in their own classrooms.

Active Learning

NEW TEACHER

... who understands the connections between science and mathematics and creates an exciting interactive learning environment for all students

Field Experiences

- collaboration with experienced upper elementary and middle school science and mathematics teachers, who are committed to the interdisciplinary approach
- special student teaching experiences

Sustained Professional Support

- placement assistance
- access to a support network of experienced professionals

This program is funded by a grant from the National Science Foundation
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