DOCUMENT RESUME

ED 421 350		SE 061 547

AUTHOR	McGinnis, J. Randy; Kramer, Steve; Roth-McDuffie, Amy; Watanabe, Tad
TITLE	Charting the Attitude and Belief Journeys of Teacher Candidates in a Reform-Based Mathematics and Science Teacher Preparation Program.
SPONS AGENCY	National Science Foundation, Arlington, VA.
PUB DATE	1998-04-16
NOTE	40p.; Paper presented at the Annual Meeting of the American Educational Research Association (San Diego, CA, April 13-17, 1998). For related document, see SE 061 545.
CONTRACT	DUE-9255745
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*Behavior Rating Scales; Educational Change; Elementary Secondary Education; Junior High Schools; Mathematics Education; *Mathematics Teachers; *Measures (Individuals); Middle Schools; *Preservice Teacher Education; Science Education; *Science Teachers; *Teacher Attitudes
IDENTIFIERS	Maryland; National Science Foundation

ABSTRACT

This study reports the use longitudinally of a valid and reliable instrument to measure teacher candidates' attitudes and beliefs about the nature of and the teaching of mathematics and science. The instrument used, "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. The current analysis reports on how MCTP teacher candidates' attitudes toward and beliefs about mathematics and science evolved over a two-year period. During the Fall 1995 and Spring 1996 semesters the instrument was administered in MCTP classes twice each semester to the study participants (N=104; 100% response). During the Fall 1996 and Spring 1997 semesters the instrument was mailed to the study participants at the end of each semester (N=96; 46% Fall response; 75% Spring response). Since individual responses to the questionnaire were not independent, the unit-of-analysis responses from five institutions participating in the program were used. Survey responses within each institution were aggregated and changes analyzed (repeated-measures t-test design). It was determined that the MCTP appears to affect participating teacher candidates' attitudes toward and beliefs about mathematics and science in the direction intended. In particular, the MCTP teacher candidates' attitudes and beliefs moved in the desired direction on all five subscales of the instrument. Moreover, the magnitude of change was statistically significant at the .01 level for the subscale measuring "Beliefs about the Nature of Mathematics and Science" and for the subscale measuring "Beliefs about Teaching Mathematics and Science". In addition, the magnitude of change for the subscale measuring "Attitudes towards Mathematics and Science" approached statistical significance. These findings make a highly significant contribution to the science and mathematics education research communities interested in charting the attitudinal and belief journeys of teacher candidates participating in a reform-based teacher preparation program. (Contains 6 tables, 5 figures and 31 references.) (Author/NB)

Running head: CHARTING THE ATTITUDE AND BELIEF JOURNEYS OF TEACHER CANDIDATES

Charting The Attitude And Belief Journeys Of Teacher Candidates In A Reform-Based Mathematics And Science Teacher Preparation Program

J. Randy McGinnis
Science Teaching Center
Department of Curriculum & Instruction
Room 2226K Benjamin
University of Maryland, College Park
College Park, Maryland 20742
301-405-6234
jm250@umail.umd.edu

Steve Kramer & Amy Roth-McDuffie
The Center for Mathematics Education
Department of Curriculum & Instruction
Room 2226 Benjamin
University of Maryland, College Park
College Park, Maryland 20742

Tad Watanabe
Department of Mathematics
Towson University
Towson, Maryland 21204

A paper presented at the annual meeting of the American Educational Research Association, San Diego, California, April 13-17, 1998.

The preparation of this manuscript was supported in part by a grant from the National Science Foundation (Cooperative Agreement No. DUE 9255745).

Abstract

This study reports the use longitudinally of a valid and reliable instrument to measure teacher candidates' attitudes and beliefs about the nature of and the teaching of mathematics *and* science. The instrument used, *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. In the current analysis, we report how MCTP teacher candidates' attitudes toward and beliefs about mathematics and science evolved over a two-year period. During the Fall 1995 and Spring 1996 semesters the instrument was administered in MCTP classes twice each semester to the study participants (N=104; 100% response). During the Fall 1996 and Spring 1997 semesters the instrument was mailed to the study participants at the end of each semester (N=96; 46% Fall response; 75% Spring response). Since individual responses to the questionnaire were not independent, we used as the unit-of-analysis responses from five institutions participating in the program. We aggregated survey responses within each institution, and analyzed changes (repeated-measures t-test design). We determined that the MCTP appears to be affecting participating teacher candidates' attitudes towards and beliefs about mathematics and science in the direction intended. In particular, the MCTP teacher candidates' attitudes and beliefs moved in the desired direction on all five subscales of the instrument. Moreover, the magnitude of change was statistically significant at the .01 level for the subscale measuring "Beliefs about the Nature of Mathematics and Science" and for the subscale measuring "Beliefs about Teaching Mathematics and Science". In addition, the magnitude of change for the subscale measuring "Attitudes towards Mathematics and Science" approached statistical significance. These findings make a highly significant contribution to the science and mathematics education research communities interested in charting the attitudinal and belief journeys of teacher candidates participating in a reform-based teacher preparation program.

Charting The Attitude And Belief Journeys Of Teacher Candidates In A Reform-Based Mathematics And Science Teacher Preparation Program

Introduction

This study reports the use longitudinally of a valid and reliable instrument to measure teacher candidates' attitudes and beliefs about the nature of and the teaching of mathematics *and* science. It is not at all common for investigations in the affective domain to focus simultaneously on these two content disciplines. However, there is a urgent need for this type of study as attempts are made to make connections among mathematics and the sciences in both teacher preparation programs and in the schools. 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 (McGinnis, Watanabe, Shama, & Graeber (1997a). Sections of the instrument that were verified by factor analysis dealt with beliefs about mathematics and science (α=.76); attitudes toward mathematics and science (α=.81); beliefs about teaching mathematics and science (α=.69); attitudes toward learning to teach mathematics and science (α=.79); and attitudes toward teaching mathematics and science (α=.60).

Context Of The 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. While teacher candidates selected to participate in the MCTP program in many ways are representative of typical teacher candidates in elementary teacher preparation programs, they are distinctive by expressing an interest in teaching mathematics and/or science by making connections between the two disciplines.

Nine higher education institutions responsible for teacher preparation within the University System of Maryland, including community colleges, participate in the MCTP. 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 within 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 (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, 1996).

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 practices, and to employ instructional and assessment strategies recommended by the literature to be compatible with the constructivist perspective (i.e., address conceptual change, promote reflection on changes in thinking, and stress logic and fundamental principles as opposed to memorization of unrelated facts) (Cobb, 1988; Driver, 1989; Tobin, Tippins, & Gallard, 1994; von Glasersfeld, 1987, 1989). Faculty lecture is diminished and student-based problem-solving is emphasized in cross-disciplinary mathematical and scientific applications.

Theoretical Assumption And Research Question

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). One of the ways reformed undergraduate classes can change teaching practices is by changing the attitudes and beliefs of teacher candidates. The MCTP Research Group is investigating whether enrollment in MCTP classes encourage teacher candidates to adopt more positive attitudes towards mathematics and science, and towards the teaching of these subjects. We also want to determine whether the MCTP fosters beliefs about the nature of mathematics and science, and about the best ways to teach mathematics and science, that are compatible with the program's goals: use of constructivist instructional strategies, emphasis on connections between mathematics and science, appropriate use of technology when teaching mathematics and science, and encouragement of students from diverse backgrounds to participate in challenging and meaningful learning.

Specifically, the research question investigated in this study is:

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

Method

Instrumentation

Between September, 1995 and May, 1997 MCTP students have periodically completed a questionnaire, entitled *Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science.* The questionnaire contains 37 statements to which students responded on a Likert scale (Likert, 1967). That is, each item had five possible responses, ranging from "A-strongly agree" to "E-strongly disagree". We used student responses to these 37 items to compute their scores on five subscales intended to measure their attitudes and beliefs.

We originally developed the subscales with the aid of a factor analysis, as described in McGinnis, et al. (1997a). The questionnaire, as well as the subscales used to report its results, was intended for several purposes. We have used it, for example: to compare the attitudes and beliefs of teacher candidates enrolled in the MCTP program to those of teacher candidates not enrolled in the program (McGinnis, Shama, Watanabe, & Graeber, 1997b); to see if students' attitudes and beliefs change between the beginning and end of a single MCTP course; and to identify "outlier" MCTP courses which seemed to have a particularly strong impact on students' attitudes and beliefs.

In the current analysis, we report how MCTP teacher candidates' attitudes toward and beliefs about mathematics and science evolved over a two-year period. In order to do so, we found it necessary to modify one of the five subscales described in McGinnis, et.

al. (1997a). Specifically, one of the subscales, which we had labeled "X_4: Attitudes towards learning to teach mathematics and science" contained two items which we dropped. These items asked teacher candidates to rate their agreement with the statement "I expect that the college courses I take will be helpful to me in teaching mathematics in elementary or middle school," and "I expect that the college courses I take will be helpful to me in teaching science in elementary or middle school". As MCTP students filled out the questionnaire during multiple occasions over a 2-year period, many of them completed a significant portion of their undergraduate classes, and their responses to these two items, instead of measuring the attitudes we had intended, began to reflect their expectation that they did not need to take many more college courses to complete their teacher preparation program. This precipitated a reliability issue. Therefore, we dropped the two items from the "X_4" subscale. The remaining two items on the subscale focused rather narrowly on students' attitudes towards learning to use technologies to teach mathematics and science. Consequently, we have renamed the subscale to more accurately reflect its new emphasis.

Table 1 describes the five subscales in detail. For each subscale, the Cronbach's alpha reported is based on the original sample of students who completed the questionnaire in the fall of 1995. All 535 students enrolled at that time in mathematics and science classes influenced by the MCTP completed the first section of the questionnaire, and their responses were used to compute reliabilities for subscales X_1, X_2, and X_3. Only those of the 535 students who identified themselves as teacher candidates--a total of 313 students--completed the items on the questionnaire contained in subscales X_4 and X_5, so only their responses could be used to compute reliabilities for these two subscales. (Note: in subsequent administrations of the questionnaire reliabilities were generally similar to those reported here.)

Data collection

During the fall semester of the 1995-96 school year, each MCTP course administered the *Attitudes and Beliefs about the Nature of and the Teaching of Mathematics* *and Science* questionnaire twice: once near the beginning of the semester, and once near the end. The same process was repeated during the spring semester of that same (1995-96) school year. The majority of MCTP courses in which the questionnaire was administered were either mathematics or science content courses, containing a mixture of undergraduate teacher candidates enrolled in the MCTP program, teacher candidates who were not enrolled in the MCTP program, and students who did not identify themselves as teacher candidates. The questionnaire was administered in-class to all students present, and we did not collect information that could be used to identify individual students who completed the questionnaire.

In December, 1996 (i.e., the end of the fall semester of the 1996/97 school year) we began to use the questionnaire for a periodic mail-in survey of MCTP students. This mail-in survey strategy was selected in response to instrument administration fatigue voiced by many of the MCTP faculty. We identified 113 students enrolled in the program who had been in the MCTP program for at least a year, and mailed a survey to each of them. The response rate to the December, 1996 survey was lower than for our goals and standards. Of the 113 MCTP students sent surveys, 52 completed and returned them (46% response rate).

In May, 1997 (i.e., during the spring semester of that same academic year) we mailed 104 surveys to those of the original 113 who remained in the MCTP program. To increase the response rate, we used ideas from the "Total Design Method" (Dillman, 1978). These ideas included a follow-up postcard mailed to each survey participant, an additional certified mailing of the instrument to non-respondents, and the possibility of a modest stipend for three randomly selected respondents. Of the 104 MCTP students sent surveys in May, 1997, 76 completed and returned them (71% response rate).

In addition to the larger-scale surveys of MCTP students described above, we have used the questionnaire for several smaller-scale surveys. Each summer, a small number of MCTP students participate in a special internship in the science or business community.

These interns were surveyed by mail at the end of the summer in 1996 and in 1997. In addition, one MCTP professor used the survey during the fall of 1997 to measure the attitudes and beliefs of all students in his Science Pedagogy Methods class.

Data Analysis

In this study, we are investigating how MCTP students' attitudes towards and beliefs about mathematics and science changed over time as they remained in the program. Two years of data are available to us. The simplest question to ask, and the one we address statistically, is "Were MCTP students' attitudes and beliefs different in the spring of 1997 from what they had been in the fall of 1995?"

In addressing this question, a simple t-test with individual surveys as the unit-of-analysis would not make sense. Within each institution of higher learning, individual responses to the questionnaire were not independent. Each of the nine institutions implemented its own unique "flavor" of the MCTP program, depending on the preferences of the faculty and the needs of the student body. Moreover, MCTP students within each institution took courses together and were encouraged to interact with each other extensively. T-tests have been shown to be highly inaccurate unless the data being used for the analysis consists of *independent* observations.

In such a situation, an acceptable solution that preserves statistical accuracy is to use the institution as the unit-of-analysis (Stevens, 1996, pp. 238-241). This is what we did. Of the nine institutions involved in the MCTP, only five participated fully during the period from the fall of 1995 through the spring of 1997. (Three institutions joined the program on a rather small scale later than 1995, and a fourth institution did not implement the MCTP program fully.) Therefore, we aggregated survey responses (i.e., computed the average response) within each of these five institutions, and analyzed changes in these aggregated scores. This enabled us to use a "repeated-measures" t-test design, with each of the five institutions having a repeated measure of its students' responses to the attitudes and beliefs questionnaire.

Because we were using a repeated measures t-test on multiple subscales, we used a Bonferonni adjustment, requiring a significance level of .01 in order to declare differences on a subscale statistically significant. This preserved an overall-experiment type I error rate of 5%. (If we had tested each of the five subscales separately at, for example, the .05 significance level, the probability of making at least one inaccurate rejection of a null hypothesis would have been $(1-(.95)^5) = 22.6\%$.)

In addition to checking for significant differences between MCTP students' attitudes and beliefs at the time of the first survey and their attitudes and beliefs at the time of the last survey, we analyzed the data graphically to get a qualitative impression of how MCTP students' attitudes and beliefs evolved. To remain consistent with our statistical analysis, we prepared the graphs using only data from the five institutions that participated fully throughout the 2-year period covered, and we used data that had been aggregated to the institution level.

Administrations of the Instrument

This study analyzes MCTP students' responses to the questionnaire on six occasions:

1) the "pretest" given in all MCTP classes at the beginning of the fall semester, 1995;
2) the "post test" given in all MCTP classes at the end of the fall semester, 1995;
3) the "pretest" given in all MCTP classes at the beginning of the spring semester, 1996;
4) the "post test" given in all MCTP classes at the end of the spring semester, 1996;
5) the mail-in survey, conducted in December, 1996;
6) the mail-in survey, conducted in May, 1997.

Participants

Only responses from MCTP students at the five institutions which participated in all six surveys are used in this analysis. Table 2 summarizes how many MCTP students from each institution responded to each survey administration.

In the December, 1996 mail-in survey, 104 of the MCTP students who were sent questionnaires attended one of the five universities analyzed in this study. Of those surveyed, 48 returned a completed questionnaire, yielding a 46% response rate. In the May, 1997 mail-in survey, 96 of the MCTP students who remained in the program were sent questionnaires attended one of the five universities analyzed in this study. Of the 96 teacher candidates surveyed, 72 returned a completed questionnaire, yielding a 75% response rate. We attribute the higher response rate in the May administration of our questionnaire to our extensive efforts at that time to ensure surveys were returned, following recommendations made by Dillman (1978).

MCTP teacher candidates generally take at least one MCTP course each semester. Therefore, the data from each of the in-class surveys conducted during the 1995-96 academic year generally reflect the attitudes and beliefs of the majority of teacher candidates enrolled in the MCTP program at that time.

The teacher candidates responding to the two mail-in surveys during the 1996-97 school year were generally from the same group who had completed surveys in-class during the 1995-96 school year. This is because MCTP courses and recruitment during 1995-96 were geared to first-year and second-year undergraduate teacher candidates. (The MCTP planned to develop upper-level courses during the subsequent two years.) Therefore, few MCTP teacher candidates graduated at the end of the 1995-96 school year. Most remained and became part of the cohort whom we began surveying by mail in December, 1996.

In summary, although a few of the MCTP teacher candidates who attended MCTP classes in 1995-96 were not part of the cohort surveyed by mail, and although some of the teacher candidates in the cohort surveyed by mail were new to the program in 1996-97, the majority of those surveyed were in the program throughout the two years investigated by this study. For this reason, our decision to use survey responses to draw conclusions about how MCTP teacher candidates' attitudes and beliefs evolved as they remained in the program over a 2-year period is legitimate statistically.

Results

Figures 1 through 5 display graphically the mean attitude and beliefs scores for MCTP teacher candidates at each of the six administrations of the survey analyzed in this report. The figures were prepared using data aggregated to the institution/college level. Each score is the mean of the college means. (For comparison purposes, we also prepared similar graphs using unaggregated data. The resulting graphs were very similar to those contained in this report.)

In preparing Figures 1 through 5, we marked the vertical scale for each variable in units of approximately one-fourth of a standard deviation. (For this purpose, we used student-level standard deviations. In normally distributed data, a movement of .25 standard deviations is enough to move a student's score from the 50th percentile up or down by 10%. Computing standard deviations on data aggregated to the institution level would have produced an artificially shrunken number, exaggerating the apparent importance of changes in the mean.)

As is apparent in Figures 1 through 5, over the 2 year period during which we administered the survey, MCTP teacher candidates' attitudes and beliefs moved in the desired direction on all five subscales. Moreover, the magnitude of change was statistically significant at the .01 level for the subscale measuring "Beliefs about the Nature of Mathematics and Science" (X_1), and for the subscale measuring "Beliefs about Teaching Mathematics and Science" (X_3). In addition, the magnitude of change for the subscale measuring "Attitudes towards Mathematics and Science" (X_2) approached statistical significance. This can be seen by examining Table 3.

Table 4 demonstrates that the changes in MCTP teacher candidates' attitudes and beliefs have substantive significance. For each subscale, we computed the effect size of the change between the fall of 1995 and May, 1997 in student attitudes or beliefs. "Effect size" is defined as the number of standard deviations the score has changed. In computing effect size, we used the student-level standard deviation among MCTP teacher candidates who took the fall, 1995 pretest survey at the five institutions of higher learning analyzed in this study.

Cohen (1977) has suggested as a rough rule of thumb that an effect size around .20 is small, an effect size around .50 is medium, and an effect size greater than .80 is large. As noted by Stevens (1996, pp. 174-5), most evaluations of social science programs find "small" effect sizes, as defined by Cohen. In contrast, Table 4 shows that effect sizes on four of the five subscales reported in this study achieved the "moderate" level.

To provide the reader a better understanding of the substantive significance of the change we have reported, Table 4 also reports what percentile a student would move to, if they had been at the 50th percentile of all respondees at the time of the Fall, 1995 pretest, and increased their score by the effect size reported. Thus, teacher candidates who had been at the 50th percentile (i.e., exactly average) on "X_1: Beliefs about the nature of Mathematics and Science" would move to the 76th percentile if they increased their score by the typical .70 standard deviations we reported. On "X_2: Attitudes towards Mathematics and Science," the typical increase of .68 standard deviations would move a student from the 50th percentile to the 75th percentile. On "X_3: Beliefs about teaching Mathematics and Science," the typical increase of .63 standard deviations would move a student from the 50th percentile to the 74th percentile. On "X_4: Attitudes towards using technology to teach Mathematics and Science," the typical increase of .27 standard deviations would move a student from the 50th percentile to the 61st percentile. On "X_5: Attitudes towards teaching Mathematics and Science," the typical increase of .51 standard deviations would move a student from the 50th percentile to the 70th percentile.

Alternate explanations.

As noted above, the positive changes in MCTP students' attitudes and beliefs are substantively and statistically significant. The MCTP program appears to be influencing students' attitudes and beliefs in the ways it intended.

However, the timing of students' changed attitudes did raise one possible doubt about this conclusion. As can be seen in Figures 1 through 5, a large positive change occurred on four of the five subscales between when the questionnaire was administered in class at the end of the spring, 1996 semester, and when the questionnaire was first administered as a mail-in survey in December, 1996. On two of the subscales (X_1: Beliefs about the nature of Mathematics and Science and X_2: Attitudes towards Mathematics and Science) average scores on the questionnaire increased more between those two administrations than at any other time. Could the apparent improvement in students' attitudes and beliefs be attributable merely to the difference between how students respond to an in-class survey, and how they respond to a mail-in survey? Perhaps students respond more positively to a questionnaire if the fill it out at home than if they fill it out in a classroom setting. Or, perhaps those who didn't have attitudes and beliefs desired by MCTP were disproportionately among non-respondants to the mail-in questionnaire. Finally, it is possible that the in-class sample of "MCTP students" was contaminated by some non-MCTP students in the same class, who mistakenly identified themselves as being enrolled in the MCTP.

Such an explanation, however, seems fairly unlikely. Even before the switch to a mail-in survey, average scores had increased on four of the five subscales. Moreover, we have data that cast doubt on two of the three mechanisms by which switching to a mail-in survey could have artificially inflated average subscale scores.

As we noted above, one professor administered the questionnaire in-class to his pedagogy methods students in September, 1997--that is, months later than the most recent mail-in survey for which we have data. Unlike earlier in-class administrations, the

September, 1997 questionnaire obtained student identifications, and we were able to identify six MCTP students who completed the questionnaire in this particular class, and had earlier completed it for one of the mail-in surveys. If students' apparently improved attitudes and beliefs were attributable to the difference between completing a questionnaire in-class and completing a questionnaire by mail, we would expect to see generally lower subscale scores on the in-class questionnaires completed by these six students. Conversely, if improved attitudes and beliefs were attributable to time spent in the MCTP, we would expect to see generally higher subscale scores on the in-class questionnaires completed by these six students. For these six students, we did in fact see improved subscale scores on the later, in-class survey. As shown in Table 5, average in-class scores were higher on 4 of the 5 subscales. On the remaining subscale (X_4: Attitudes towards using technology to teach Mathematics and Science), the six students had already reached the "ceiling" score of 5.0 by May, 1997, and maintained their high score in September. Although not definite proof, the data in Table 5 is consistent with the hypothesis that improved scores were due to time spent in the MCTP program, and not due to a tendency to respond more "positively" to mail-in questionnaires than to in-class questionnaires.

We also tested whether the apparently improved attitudes and beliefs were likely due to the less than 100% response rate for the mail-in surveys. As noted above, the May, 1997 survey which we used for our statistical analysis achieved a 75% response rate. What if the 25% who didn't respond tended to be the MCTP students whose attitudes and beliefs least resembled those desired by the program? To control for this possibility, we modified the pretest Fall, 1995 data to eliminate the 25% lowest responders. We computed the average of the five subscales for each of the 97 students who completed the in-class questionnaire for the Fall pretest, and eliminated the 25% with the lowest average scores. We then aggregated scores for the remaining 73 students to the college level, and repeated our comparison with results of the May, 1997 mail-in survey. As shown in Table 6, the results still indicated a gain on all five subscales, with a statistically significant gain on X_3 and a nearly significant gain on X_1.

We were unable to eliminate the possibility that the sample of students who completed the questionnaire in-class was contaminated by non-MCTP students who incorrectly responded that they were in the MCTP program. MCTP students are special, in that they take a large number of MCTP classes, they have special seminars and internships, special relationships with advisors, etc. In any given MCTP class, however, there were often a number of non-MCTP preservice teachers who may have mistakenly believed that, since they were in an MCTP class, they should call themselves MCTP students. Moreover, our earlier work (McGinnis, et. al., in review) indicates that non-MCTP preservice teachers tend to receive lower scores on our subscales than do preservice teachers in the MCTP. This possible contamination, though it is unlikely to explain our results, should nonetheless be kept in mind when considering our conclusions.

Conclusion

The MCTP appears to be affecting participating teacher candidates' attitudes towards and beliefs about mathematics and science in the direction intended. In particular, it seems that MCTP teacher candidates' beliefs about the nature of the two disciplines, and their beliefs about how one ought to teach them, are becoming more in line with beliefs advocated by current reform efforts in mathematics and science education. This positive result is particularly striking given the fact that, during the period MCTP teacher candidates were surveyed, most of them were completing their MCTP-influenced mathematics and science content courses, and had not yet begun to take their MCTP-influenced pedagogy courses or their MCTP-influenced student teaching.

Many researchers have suggested that a teacher's attitudes towards and beliefs about mathematics and science are key influences on how they teach those subjects. (See, Ball, 1990a, 1990b; Brickhouse, 1989, 1990; Lederman, 1992; Moreiri, 1991; Peterson, Fennema, Carpenter, & Loef, 1989; Schoenfeld, 1985,1989; Silver, 1985; Thompson, 1984, 1992). The MCTP appears to be having a positive affect on the attitudes and beliefs of prospective mathematics and science teachers participating in the program. A complementary study that examines the perspectives of MCTP teacher candidates via extensive analysis of semi-structured interviews (Watanabe, McGinnis, & Roth-McDuffie, 1997) supports this assertion along with documenting how the MCTP teacher candidates come to see the possibility of different ways of teaching mathematics and science. It is hoped that these attitudes, beliefs, and new perspectives of teaching and learning mathematics and science will be maintained and strengthened as the MCTP teacher candidates complete their teacher preparation program. Moreover, one new component of the MCTP program is to assist graduates as they move into actual teaching positions. The emerging literature on the induction of new teachers (see, Huling-Austin,1990) suggests that ongoing support during the first few years of teaching practice will help the MCTP teachers maintain their positive attitudes and beliefs. In the long run, the hope is that, as suggested by the literature, our graduates' attitudes and beliefs will positively affect their teaching and their learning.

Educational Significance Of The Study

There are a dearth of reported longitudinal studies which strive to document longitudinally the struggles teacher candidates and others confront when participating in reform-based, constructivist-informed instruction that attempts to make connections between science and mathematics. The findings from this phase of our study investigating the impact of reform-based undergraduate classes and other professionally enhancing experiences (such as summer internships in science and mathematics rich environments) in science, mathematics, and methods classes directly contributes to this targeted knowledge base. Our instrument, *Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science*, is proving to be useful in providing a "longitudinal topography" of the attitudes and beliefs of MCTP teacher candidates. We believe that we are charting the attitudinal and belief journeys of an identifiable group of mathematics and science teacher candidates throughout their teacher preparation program. The findings from this type of study is a significant contribution to the science and mathematics education research communities interested in understanding all aspects of the impact of implementing reform-based practices in teacher preparation.

References

American Association for the Advancement of Science (1989). Science for all Americans. New York: Oxford University Press.

American Association for the Advancement of Science (1993). Benchmarks for Science Literacy. New York: Oxford University Press.

Ball, Deborah L. (1990a). Breaking with experience in learning to teach mathematics: The role of a preservice methods course. For the Learning of Mathematics, 10(2), 10-16.

Ball, Deborah L. (1990b). The mathematical understandings that prospective teachers bring to teacher education. The Elementary School Journal, 90(4), 10-16.

Brickhouse, N. W. (1989). The teaching of philosophy of science in secondary classrooms: Case studies of teachers' personal theories. International Journal of Science Education, 11(4), 437-449.

Brickhouse, N. W. (1990). Teachers' beliefs about the nature of science and their relationship to classroom practice. Journal of Teacher Education, 41(3), 53-62.

Cobb, P. (1988). The tension between theories of learning and instruction in mathematics education. *Educational Psychologist*, 23(2), 87-103.

Cohen, J. (1977). Statistical power analysis for the behavioral sciences. New York: Academic Press.

Dillman, D. A. (1978). Mail and telephone surveys: The total design method. New York: John Wiley & Sons.

Driver (1989). The construction of scientific knowledge in school classrooms. In R. Miller (Ed.) Doing science: Images of science in science education. London: Falmer Press.

Huling-Austin, L. (1990). Teacher induction programs and internships. In W. R. Houston (Ed.), Handbook of research on teacher education (pp. 535-548). New York: Maxmillan.

Lederman, N.G. (1992). Students' and teachers' conceptions of the nature of science: a review of the research. Journal of Research in Science Teaching, 29(4), 331-359.

Likert, R. (1967). The method of constructing an attitude scale. In M. Fischbein (Ed.), Attitude theory and measurment (pp. 90-95). New York: John Wiley & Sons.

Maryland Collaborative for Teacher Preparation (1996). Remarks for December 9, 1996 NSF Review. Unpublished manuscript. University of Maryland, College Park.

McGinnis, J. R., Watanabe, T., Shama, G., & Graeber, A. (1997, March). Development of an instrument to measure teacher candidates' attitudes and beliefs about a and science. A paper presented at the National Association for Research in Science Teaching, Oak Brook, Illinois. (ERIC Document Reproduction Service No.ED406201).

McGinnis, J. R., Shama, G., Graeber, A., & Watanabe, T. (1997, March). The assessment of elementary/middle level candidates' attitudes and beliefs about the nature of and the teaching of mathematics and science. A paper presented at the American Educational Research Association, Chicago, Illinois. (ERIC Document Reproduction Service No. ED 407235).

Moreiri, C. (1991). Teachers' attitudes towards mathematics and mathematics teaching: Perspectives across two countries. Presented at and published in Proceedings of PME-15: The Fifteenth Conference of the Psychology of Mathematics Education. Vol. II. Italy, Assisi., 17-24.

National Council of Teachers of Mathematics (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: Author.

National Council of Teachers of Mathematics (1991). Professional standards for teaching mathematics. Reston, VA: Author.

National Research Council (1996). National Science Education Standards. Washington, D. C.: National Academy Press.

National Science Foundation (1993). Proceedings of the National Science Foundation Workshop on the role of faculty from scientific disciplines in the undergraduate education of future science and mathematics teachers. (NSF 93-108). Washington, D.C.: National Science Foundation.

Peterson, P. L., Fennema, E., Carpenter, T. P., and Loef, M. (1989). Teacher's pedagogical content beliefs in mathematics. Cognition and Instruction, 6, 1-40.

Schoenfeld, A. H., (1985). Mathematical problem solving. Orlando, Florida: Academic Press.

Schoenfeld, A. H. (1989). Explorations of students' mathematical beliefs and behavior. Journal for Research in Mathematics Education, 20(40), 338-355.

Silver, E. A. (1985). Research on teaching mathematical problem-solving: Some under represented themes and directions. In E. A. Silver (Ed.), Teaching and learning mathematical problem solving: Multiple research perspectives (pp. 247-266). Hillsdale, New Jersey: Lawrence Erlbaum.

Stevens, J. (1996). Applied multi variate statistics for the social sciences, third edition. Mahwah, New Jersey: Lawrence Erlbaum.

Thompson, A. G. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D. A. Grouws (Ed.), Handbook of research on science teaching and learning (127-146). New York: MacMillan.

Tobin, K., Tippins, D. J., & Gallard, A. J. (1994). Research on instructional strategies for teaching science. In D. White (Ed.), Handbook of research on science teaching and learning (45-93). New York: Macmillan.

University of Maryland System (1993). Special teachers for elementary and middle school science and mathematics: A proposal submitted to the National Science Foundation Teacher Preparation and Enhancement Program. Unpublished manuscript.

von Glasersfeld, E. (1987). Learning as a constructivist activity. In C. Janvier (Ed.) Problems of representation in the teaching and learning of mathematics. Hillsdale, New Jersey: Lawrence Erlbaum.

von Glasersfeld, E. (1989). Cognition, construction of knowledge, and teaching. Synthese, 80 (1), 121-140.

Watanabe, T., McGinnis, J. R., & Roth-McDuffie, A. (1997, March). University faculty "modeling" good instruction in mathematics and science courses for prospective middle grades teachers: Voices from the MCTP. A paper presented at the American Educational Research Association, Chicago, Illinois. (ERIC Document Reproduction Service No.ED406896).

Table 1

The Five Subscales

Description	Cronbach's a
X1. Beliefs about the nature of mathematics and science	**a=.76**

In grades K-9, truly understanding mathematics requires special abilities that only some people possess.[1]
In grades K-9, truly understanding science requires special abilities that only some people possess.
The use of technologies in mathematics is an aid primarily for slow learners.
The use of technologies in science is an aid primarily for slow learners.
Getting the correct answer to a problem in the mathematics classroom is more important than investigating the problem in a mathematical manner.
Getting the correct answer to a problem in the science classroom is more important than investigating the problem in a scientific manner.
The primary reason for learning mathematics is to learn skills for doing science.
The primary reason for learning science is to provide real life examples for learning mathematics.
Mathematics consists of unrelated topics (e.g., algebra, arithmetic, calculus and geometry).
Science consists of unrelated topics like biology, chemistry, geology, and physics.
To understand mathematics, students must solve many problems following example provided.
To understand science, students must solve many problems following example provided.
Theories in science are rarely replaced by other theories.
Science is a constantly expanding field.

X2. Attitudes towards mathematics and science — **a=.81**

I am looking forward to taking more mathematics courses.
I am looking forward to taking more science courses.
I like mathematics.
I like science.
I enjoy learning how to use technologies in mathematics classrooms.
I enjoy learning how to use technologies in science classrooms.

X3. Beliefs about the teaching of mathematics and science — **a=.69**

Using technologies in mathematics lessons will improve students' understanding of mathematics.
Using technologies in science lessons will improve students' understanding of science.Calculators should always be available for students in science classes.
Students should be given regular opportunities to think about what they have learned in the mathematics classroom.
Students should be given regular opportunities to think about what they have learned in the science classroom.
Students should have opportunities to experience manipulating materials in the mathematics classroom before teachers introduce mathematics vocabulary.
Students should have opportunities to experience manipulating materials in the science classroom before teachers introduce science vocabulary.
Small group activity should be a regular part of the mathematics classroom.
Small group activity should be a regular part of the science classroom.

X4. Attitudes towards using technology to teach mathematics and science — **a=.80**

I want to learn how to use technologies to teach mathematics.
I want to learn how to use technologies to teach science.

X5. Attitudes towards teaching mathematics and science a=.60

The idea of teaching mathematics scares me.
The idea of teaching science scares me.
I prefer to teach mathematics and science emphasizing connections between the two disciplines.
I feel prepared to teach mathematics and science emphasizing connections between the two disciplines.

---

1. Note: items in italics have been reversed, so that a response of "strongly agree" is scored as a "1" and a response of "strongly agree" is scored as a "5".

Table 2

Number of Students Participating in Each Survey Administration

Institution	Pretest Fall '95	Post test Fall '95	Pretest Spring '96	Post test Spring '96	Dec '96 Survey	May '97 Survey
A	9	8	3	3	8	15
B	23	13	22	26	5	11
C	10	10	8	10	9	12
D	34	22	18	20	11	18
E	20	8	6	5	15	16
Total	96	61	57	64	48	72

Table 3

Change in MCTP Students' Attitudes and Beliefs over 2 Years: Significance Tests

(Repeated-measures t-test using 5 institutions of higher learning as unit-of-analysis.)

variable	Fall '95 Pretest mean	May '97 Survey mean	SE of mean	t-value	df	95% CI of difference	2-tail significance
X1	3.96	4.31	.072	4.83	4	(.149, .551)	.008**
X2	3.81	4.31	.172	2.94	4	(.028, .985)	.042*
X3	4.11	4.41	.044	6.96	4	(.184, .427)	.002**
X4	4.66	4.83	.099	1.73	4	(-.103, .444)	.159
X5	3.51	3.90	.254	1.57	4	(-.305,1.104)	.191

* significant at the .05 level

** significant at the .01 level

Table 4

Change in MCTP Students' Attitudes and Beliefs over 2 Years: Effect Sizes

(Effect sizes based on student-level standard deviation on Fall, 1995 pretest.)

variable	Fall '95 Pretest mean	May '97 Survey mean	Change	student level sd. dev.	effect size	Student at 50th percentile would move to
X1	3.96	4.31	.35	.50	.70 std. dev.	76th percentile
X2	3.81	4.31	.51	.75	.68 std. dev.	75th percentile
X3	4.11	4.41	.31	.49	.63 std. dev.	74th percentile
X4	4.66	4.83	.17	.62	.27 std. dev.	61st percentile
X5	3.51	3.90	.40	.79	.51 std. dev.	70th percentile

Table 5

Change in 6 MCTP Students' Attitudes and Beliefs between May, 1997 mail-in survey and Sept., 1997 in-class survey.

(Effect sizes based on standard deviation of these 6 students on the mail-in survey.)

variable	earlier mail-in mean	later in-class mean	Change	mail-in std. dev. for these 6 students	effect size	Student at 50th percentile would move to
X1	4.43	4.67	.25	.40	.63 std. dev.	74th percentile
X2	4.64	4.78	.14	.37	.38 std. dev.	65th percentile
X3	4.57	4.80	.22	.33	.67 std. dev.	75th percentile
X4	5.0	5.0	-	-	-	-
X5	3.45	3.88	.13	.63	.21 std. dev.	58th percentile

Table 6

Significance Tests with lowest-scoring 25% thrown out from Fall pretest.

(Repeated-measures t-test using 5 institutions of higher learning as unit-of-analysis.)

variable	Fall '95 Pretest mean	May '97 Survey mean	SE of mean	t-value	df	95% CI of difference	2-tail significance
X1	4.07	4.31	.055	4.30	4	(.085, .393)	.013*
X2	4.09	4.31	.114	1.92	4	(-.098, .537)	.127
X3	4.27	4.41	.014	9.52	4	(.097, .177)	.001**
X4	4.82	4.83	.039	0.11	4	(-.104, .112)	.915
X5	3.69	3.90	.225	.96	4	(-.408, .841)	.390

* significant at the .05 level

** significant at the .01 level

Figure Caption

Figure 1. Change over time in mean beliefs about the nature of mathematics and science.

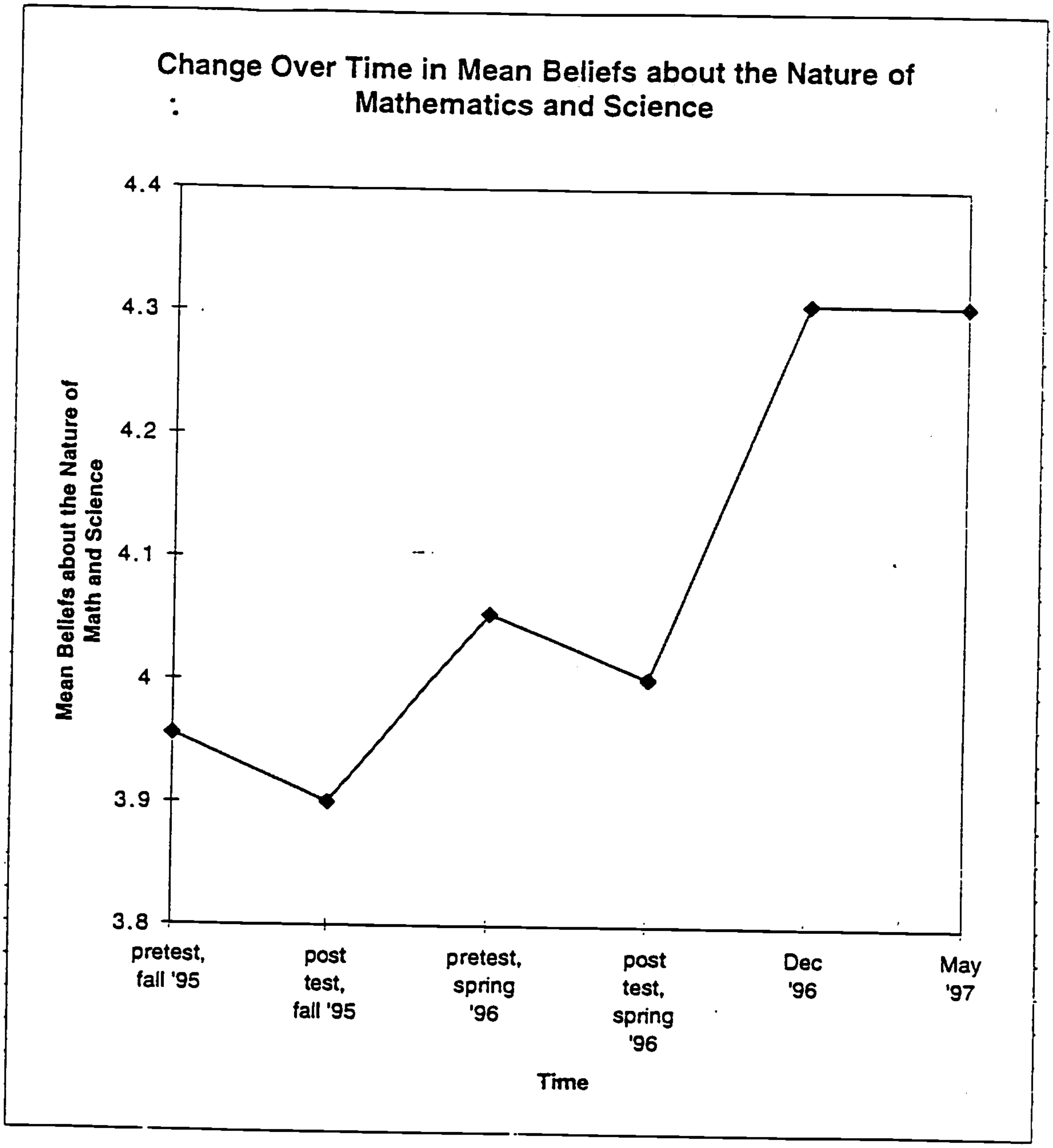

Change Over Time in Mean Beliefs about the Nature of Mathematics and Science
4.4
4.3
4.2
4.1
4
3.9
3.8
Mean Beliefs about the Nature of Math and Science
pretest, fall '95
post test, fall '95
pretest, spring '96
post test, spring '96
Dec '96
May '97
Time

Figure Caption

Figure 2. Change over time in mean attitudes towards mathematics and science.

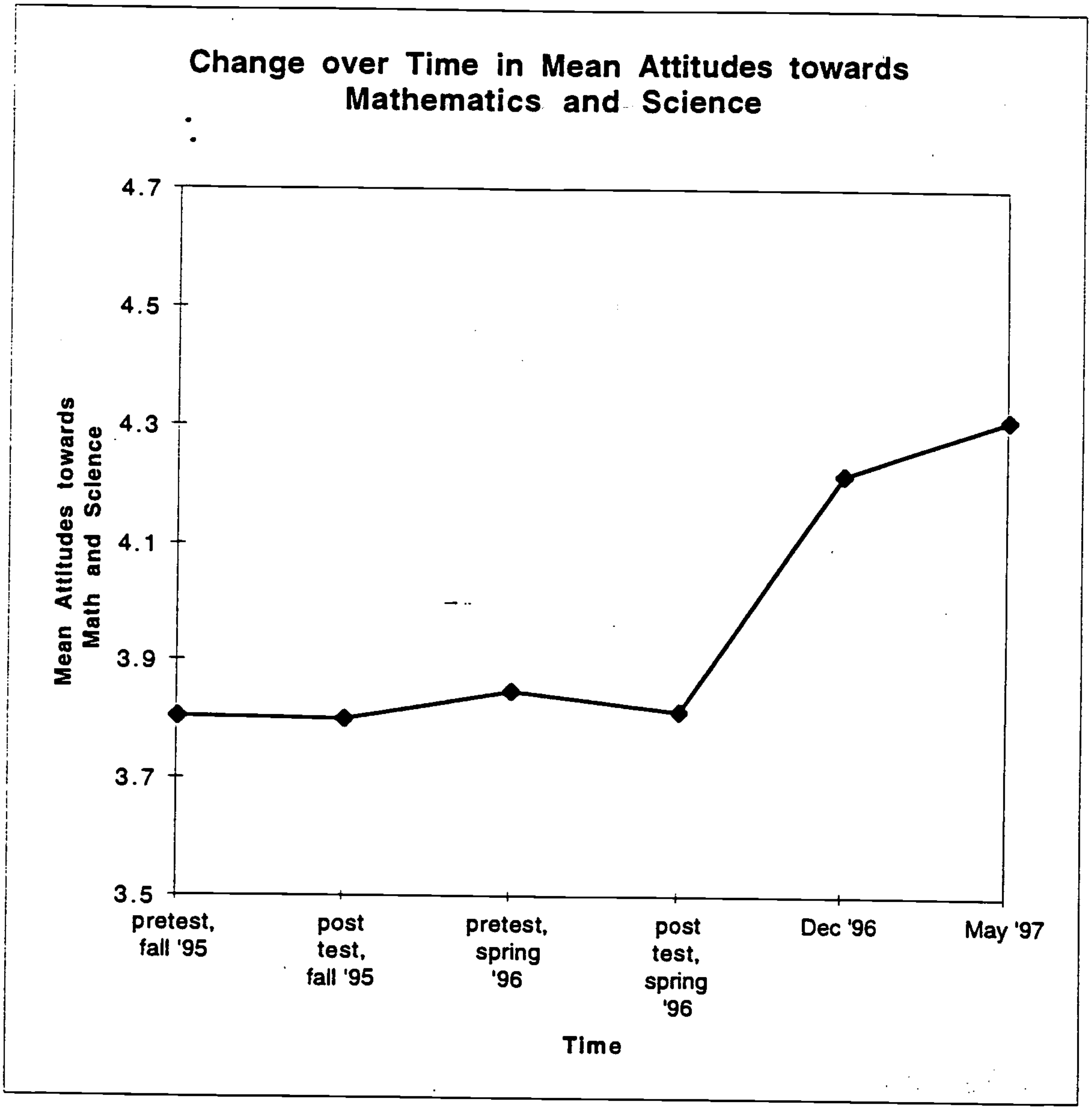

Change over Time in Mean Attitudes towards Mathematics and Science
Mean Attitudes towards Math and Science
4.7
4.5
4.3
4.1
3.9
3.7
3.5
pretest, fall '95
post test, fall '95
pretest, spring '96
post test, spring '96
Dec '96
May '97
Time

Figure Caption

Figure 3. Change over time in mean beliefs about the teaching mathematics and science.

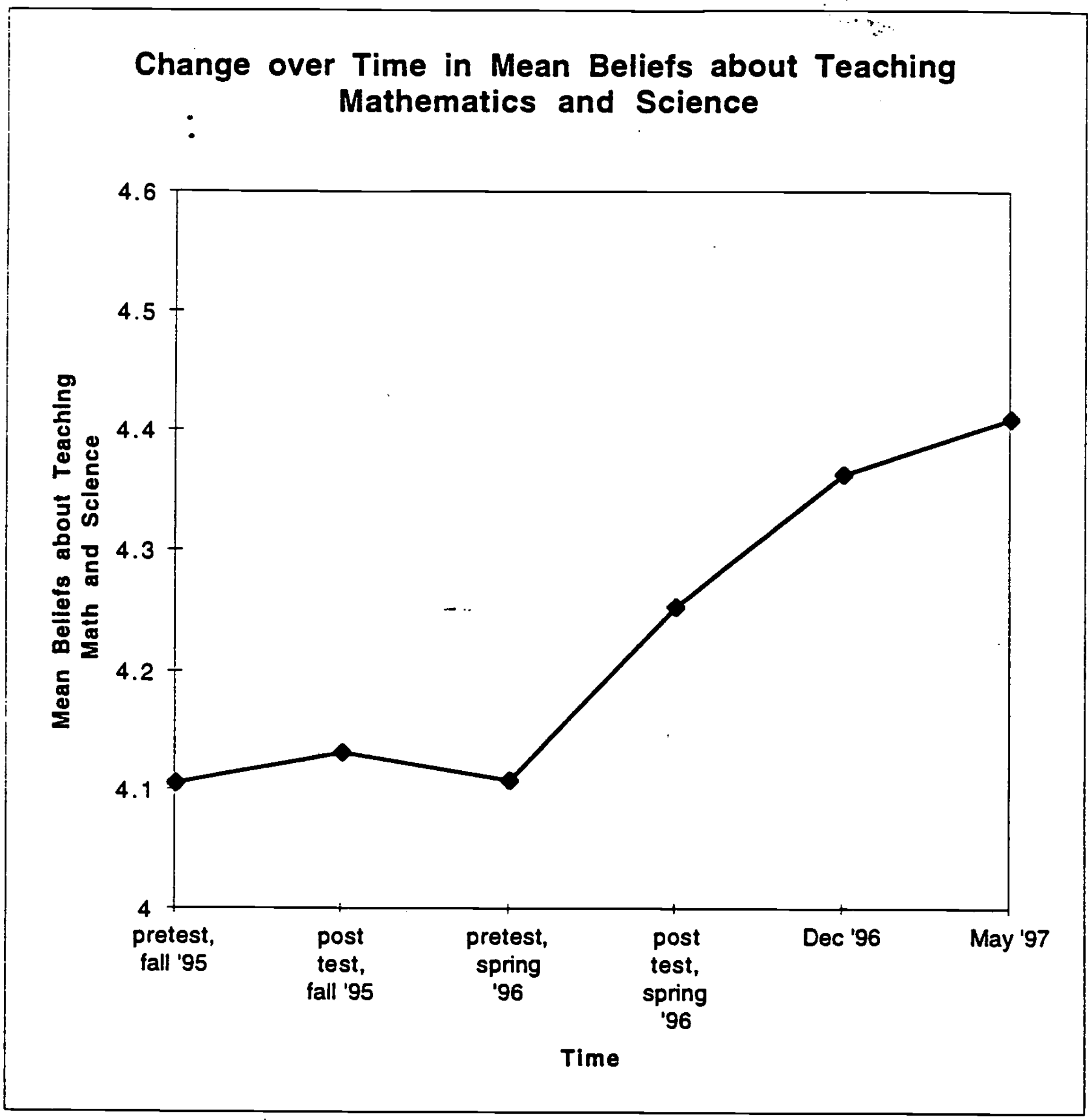

Change over Time in Mean Beliefs about Teaching Mathematics and Science
Mean Beliefs about Teaching Math and Science
4.6
4.5
4.4
4.3
4.2
4.1
4
pretest, fall '95
post test, fall '95
pretest, spring '96
post test, spring '96
Dec '96
May '97
Time

Figure Caption

Figure 4. Change over time in mean attitudes toward using technology to teach mathematics and science.

Change over Time in Mean Attitudes toward Using Technology to Teach Mathematics and Science

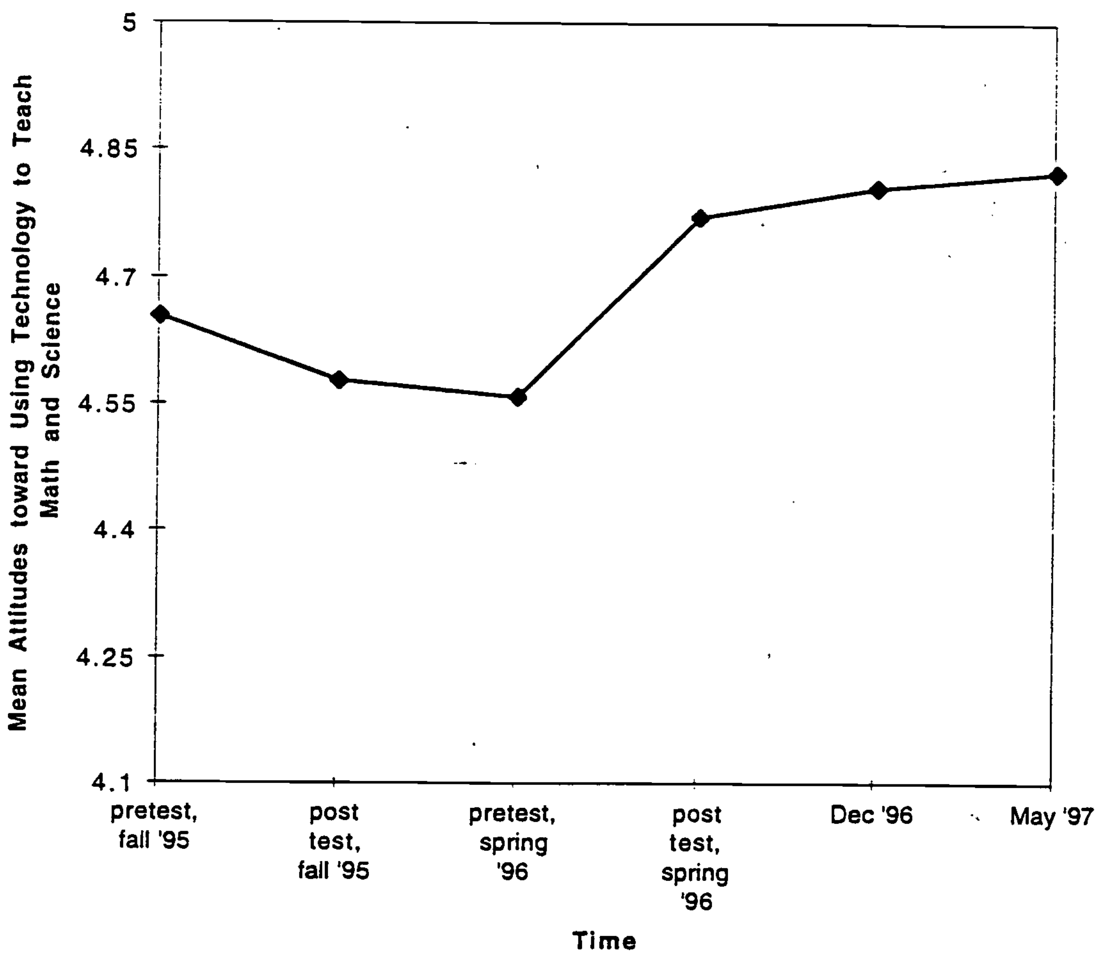
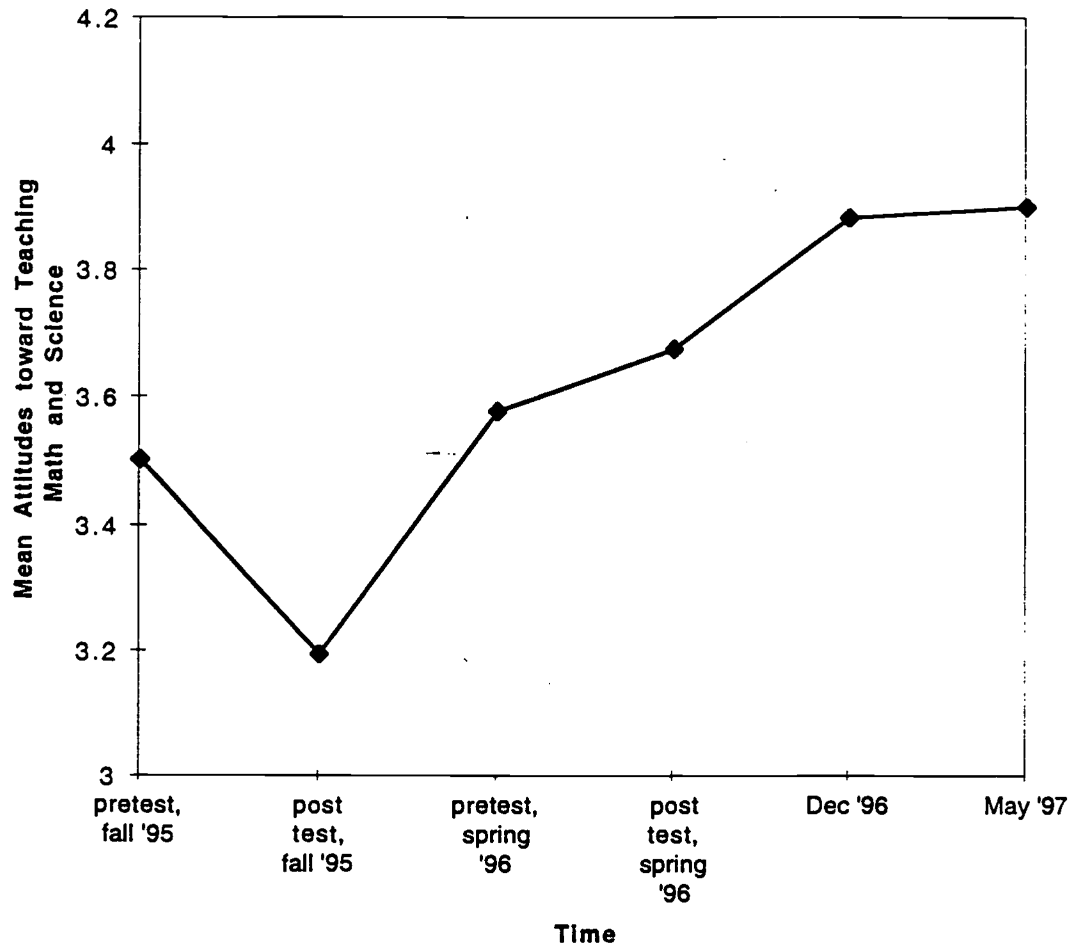


Figure Caption

Figure 5. Change over time in mean attitudes towards teaching mathematics and science.

Change over Time in Mean Attitudes toward Teaching Mathematics and Science



SE061547

ERIC®

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Charting the Attitude and Belief Journeys of Teacher Candidates in a Reform-Based Mathematics and Science Teacher Preparation Program

Author(s): J. Randy McGinnis, Steve Kramer, Amy Roth-McDuffie, TAA

Corporate Source: National Science Foundation No. DUE 9255745

Publication Date: Presented April 16, 1998

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1 ☑	Level 2A ☐	Level 2B ☐
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) and paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, → please

Signature:	Printed Name/Position/Title:	
Organization/Address:	Telephone:	FAX:
	E-Mail Address:	Date: