DOCUMENT RESUME

ED 406 201 SE 059 916

AUTHOR McGinnis, J. Randy; And Others
TITLE Development of an Instrument To Measure Teacher Candidates' Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science.
SPONS AGENCY National Science Foundation, Arlington, VA.
PUB DATE 22 Mar 97
CONTRACT DUE-9255745
NOTE 24p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (70th, Oak Brook, IL, March 21-24, 1997).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Attitude Measures; Higher Education; *Mathematics Education; *Preservice Teacher Education; Questionnaires; *Science Education; *Student Attitudes
IDENTIFIERS Nature of Science

ABSTRACT

This paper describes the development 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--Attitudes and Beliefs about the Nature of an the Teaching of Mathematics and Science--was developed for the Maryland Collaborative for Teacher Preparation (MCTP), an undergraduate teacher preparation program for specialist mathematics and science elementary/middle level teachers funded by the National Science Foundation. Sections of the instrument that were verified by factor analysis dealt with beliefs about mathematics and science, attitudes toward mathematics and science, beliefs about teaching mathematics and science, attitudes toward learning to teach mathematics and science, and attitudes toward teaching mathematics and science. It is concluded that the survey instrument has proven useful as one tool in an effort to landscape the attitude and belief paths the MCTP teacher candidates travel during their undergraduate years. The survey instrument is included in the appendix. Contains 37 references. (Author/JRH)

Development Of An Instrument To Measure 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

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

Tad Watanabe
Department of Mathematics
Towson University
Towson, Maryland 21204

A paper presented at the annual meeting of the National Association for Research in Science Teaching, Oak Brook, Chicago, March 21-24, 1997.

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

Development Of An Instrument To Measure Teacher Candidates' Attitudes And Beliefs About The Nature Of And The Teaching Of Mathematics And Science

Abstract

This session describes the development of a valid and reliable instrument ($\underline{n}$ =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; attitudes toward mathematics and science; beliefs about teaching mathematics and science; attitudes toward learning to teach mathematics and science; and attitudes toward teaching mathematics and science.

Development Of An Instrument To Measure Teacher Candidates' Attitudes And Beliefs About The Nature Of And The Teaching Of Mathematics And Science

Introduction

This paper describes the development of a valid and reliable instrument ($\underline{n}$ =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 <u>and</u> 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; Schroeder, 1991; 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,* which is the focus of the remainder of this paper.

Instrument Design and Procedures

History of the instrument

The development of the instrument proceeded in discrete phases. In the first phase, a pool of items which could measure the desired constructs were selected from the identified existing instruments. Particularly useful sources included Pehkonen (1994) and Robitalille & Garden (1989). Constructs not adequately represented required the researchers (representing both mathematics and science education) to craft new items. The resulting 87-item draft instrument was administered to an expert sample of mathematics and science education faculty and graduate students to establish face validity. Adjustments were then made to the instrument to eliminate items that were confusing or uninformative and to improve the remaining items' clarity of language. The goal was to develop a reliable and valid instrument that could be completed within a 15 minutes external time constraint. A 49-item pilot instrument emerged from this phase of the instrument development.

Phase two involved the piloting of the instrument in MCTP classes. During the 1994-1995 school year, the survey was administered to 200 students in the fall and to 210 students enrolled in the spring semester. All enrolled students completed the survey during the first week of class and once again during the last week of the class. During the summer of 1995, a review of the first year's pilot results indicated that some refinements to the instrument were necessary. Several items were either eliminated or reworded. In addition, concerns that became apparent from administering the survey were elicited from a large panel consisting of MCTP participating mathematicians, scientists, and method specialists. Specific concerns included the placement of the demographic data items and the need for more explicit directions. Following factor analysis, the instrument was refined from 49 to 45-items (see Appendix).

<u>Constructs of the Instrument</u>

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 discplines 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%. Four hundred and eighty-six students completed all the items. Most students who indicated they intented to teach were Caucasian female.

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 1. Reliability of each of the five sub-groups was examined by Cronbach's alpha (see bolded results in Table 1). 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 1.

<u>Limitation of the Survey</u>

In the validation and reliability process three items that were constructed for mathematics were dropped whereas all the science items were retained. This points to the non-total-equivalence between the disciplines in the analysis.

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.

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 indepth 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, this 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.

Author Note

The researchers within the MCTP research team would like to acknowledge the ongoing support given to them by the MCTP Principal Investigators, Jim Fey, Genevieve Knight, John Layman, Tom O'Haver, and Jack Taylor, and the MCTP Executive Director, Susan Boyer. We also are very appreciative of the participation of the many faculty, teacher candidates, and cooperating classroom teacher participants in the MCTP research program. We would also like to acknowledge the support to the MCTP Research Group provided by some talented and hardworking doctoral students in mathematics education: Amy Roth-McDuffie, Steve Kramer, Mary Ann Huntley, and Karen King.

Interested readers are invited to visit 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).

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

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 learningto teach mathematics: The role of a preservice methods course. *For the Learning of Mathematics*, 10(2), 10-16.

Ball, D.L. (1990b). The mathematical understandings thatprospective teachers bring to teacher education. *The Elementary School Journal*, 90(4), 449-466.

Brause, R., & Mayher, J. (Eds.). (1991). *Search and re-search: What the inquiring teacher needs to know*. London: Falmer Press.

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

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

Germann, P. J. (1988). Development of the attitude toward science in school assessment and its use to investigate the relationship between science achievement and attitude toward science in school. *Journal of Research in Science Teaching*, 25(8), 689-703.

Jaeger, R. M. (Ed.). (1988). Survey research methods in education. In Richard M. Jaeger, *Compementary methods for research in education*, pp. 303-330.Washington, D.C.: American Educational Research Association.

Jasalavich, S. M., & Schafer, L. (1994, March). An instrument to assess preservice elementary teachers' beliefs about science teaching and learning. A paper presented at the annual meeting of the National Association for Research in Science Teaching, Anaheim, CA.

Jurdak (1991). Teachers' conceptions of math education and the foundations of mathematics. (remainder of citation unknown)

Likert, R. (1967). The method of constructing an attitude scale. In M.Fishbein (Ed.), *Attitude theory and measurement* (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. (1996a, March). Higher education science teaching faculty talk about science and mathematics: An examination of the role of discourse in a middle-level teacher preparation program. A contributed paper presented at the annual meeting of the National Association of Research in Science Teaching, St. Louis, Missouri.

McGinnis, J. R., & Watanabe, T. (1996b, April). University scientists and mathematicians talk about the others' discipline: An examination of the role of discourse among professors involved in a collaborative mathematics/science teacher preparation. A contributed paper presented at the annual meeting of the American Educational Research Association, New York City, New York.

McDuffie, A., & McGinnis, J. R. (1996, April). Modeling reform- style teaching in a college mathematics class from the perspectives of professor and students. A contributed paper presented at the annual meeting of the American Educational Research Association, New York City, New York.

Moreiri, C. (1991). Teachers' attitudes towards mathematics and mathematics teaching: Perspectives across two countries. (remainder of citation unknown)

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.

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 (1991). *National Science Education Standards*. Washington, D. C. : National Academy Press.

Pehkonen, E. (1994). On differences in pupils' conceptions about mathematics teaching. *The Mathematics Educator*, 5(1), 3-10.

Robitaille, D. F., & Garden, R. A. (Eds) (1989). *The IEA study of mathematics II: contexts and outcomes of school mathematics* (V. 2). New York: Pergamon Press.

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

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

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

Simon, M.A. (1995a). Reconstructing mathematics pedagogy from a constructivist perspective. *Journal for Research in Mathematics Education*, 26, 114-145.

Simon, M.A. (1995b). Elaborating models of mathematics teaching: A response to Steffe and D'Ambrosio. *Journal of Research in Mathematics Education*, 26, 160-162.

Simpson, R.D., Koballa, T.R., Jr., & Oliver, J. S., & Crawley, F. E., III (1994). Research on the affective dimension of science learning. In D. White (Ed.), *Handbook of research on science teaching and learning* (pp. 211- 235). New York: Macmillan Publishing Company.

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* (pp.'45-93 New York: Macmillan Publishing Company.

Thompson, A.G. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D.A. Grouws (Ed.), *Handbook of research on mathematics Teaching and Learning* (127-146). New York: Macmillan.

Thompson, A.G. (1984). The relationship of teachers' conceptions of mathematics and mathematics teaching to instructional practice. *ESM*, 15, 105-127.

Underhill, R. (1988). Mathematics learners' beliefs: A review. *Focus on learning problems in mathematics* , 10(1), 55-69.

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*. Hillslade, NJ: Lawrence Erlbaum

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

Wheatley, G. (1991). *Constructivist perspectives on science and mathematics learning. Science Education*, 75 (1), 9-21.

Table 1
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.

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

Active Learning

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

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.

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
DUE # 9255745

Appendix

MCTP Survey Instrument: Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science

Section One: Background Information

1. Gender:
   a. Male b. Female

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

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

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

Section Two: Attitudes and Beliefs

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

Your choices are:

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

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

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

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

7. I like mathematics.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

24. Science is a constantly expanding field.

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

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

27. I like science.

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

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

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

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

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

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

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

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

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

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

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

37. The idea of teaching science scares me.

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

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

40. The idea of teaching mathematics scares me.

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

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

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

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

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

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

SE059916

ERIC

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement (OERI)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Development of an instrument to measure teacher candidates' Attitudes and Beliefs About the Nature of and the Teaching of Mathematics and Science	
Author(s): J. Randy McGinnis, Gilli Shama, Anna Graeber, Tad Watanabe	
Corporate Source:	~~Publication~~ Presentation Date: March 22, 1997

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/optical media, and sold through the ERIC Document Reproduction Service (EDRS) or other ERIC vendors. 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 the identified document, please CHECK ONE of the following options and sign the release below.

[X] **Check here** Permitting microfiche (4"x 6" film), paper copy, electronic, and optical media reproduction	Sample sticker to be affixed to document: "PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY ____ Sample ____ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)." Level 1	Sample sticker to be affixed to document: "PERMISSION TO REPRODUCE THIS MATERIAL IN OTHER THAN PAPER COPY HAS BEEN GRANTED BY ____ Sample ____ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)." Level 2	[ ] **or here** Permitting reproduction in other than paper copy.

Sign Here, Please

Documents will be processed as indicated provided reproduction quality permits. If permission to reproduce is granted, but neither box is checked, documents will be processed at Level 1.

"I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce this document as indicated above. Reproduction from the ERIC microfiche or electronic/optical 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."

Signature: J. Randy McGinnis	Position: Assistant Professor
Printed Name: J. Randy McGinnis	Organization: University of Maryland, College Park
Address: Science Teaching Center, Rm 2226 Benjamin, UMCP, College Park, MD 20742	Telephone Number: (301) 405-6234
	Date: April 3, 1997

OVER

III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC , *or*, if you wish ERIC to cite the availability of this document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents which cannot be made available through EDRS).

Publisher/Distributor:	
Address:	
Price Per Copy:	Quantity Price:

IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

Name and address of current copyright/reproduction rights holder:

Name

Address:

X

V. WHERE TO SEND THIS FORM:

Send this form to the following ERIC Clearinghouse:

Science, Mathematics and Environmental Education (SE)
OHIO State University
1929 Kenny Road
Columbus, OH 43210 - 1080

If you are making an unsolicited contribution to ERIC, you may return this form (and the document being contributed) to:

ERIC Facility
1301 Piccard Drive, Suite 300
Rockville, Maryland 20850-4305
Telephone: (301) 258-5500