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ABSTRACT

This report orients the reader to the Maryland Collaborative for Teacher Preparation (MCTP) and gives an overview of the ongoing research activities being conducted within the project. The MCTP is a National Science Foundation funded statewide undergraduate program for students who plan to become specialist mathematics and science upper elementary or middle level teachers. The goal of the MCTP is to promote the development of teachers who are confident teaching mathematics and science, and who can provide an exciting and challenging learning environment for students of diverse backgrounds. Four research studies being conducted within the Research Group focus on the following: (1) statistical examination of data from the college student version of the MCTP "Attitudes and Beliefs About the Nature of and the Teaching of Mathematics and Science" instrument, (2) discourse examination of the mathematics and science MCTP faculty discussing science and mathematics, (3) perception of MCTP teaching faculty on the integration of mathematics and science and on barriers to implementing integration in their classes, and (4) teaching practices of an MCTP mathematics professo . Two appendixes contain college student versions of survey and faculty interview protocols. (Contains 17 references.) (Author/MKR)

Researching The Preparation of Specialized Mathematics and Science Upper Elementary/Middle-Level Teachers: The 2nd Year Report

Abstract

The purpose of this report is to orient the reader to the Maryland Collaborative for Teacher Preparation and to give an overview of the ongoing research activities being conducted within the project. The Maryland Collaborative for Teacher Preparation [MCTP] is a National Science Foundation funded statewide undergraduate program for students who plan to become specialist mathematics and science upper elementary or middle level teachers. The goal of the MCTP is to promote the development of teachers who are confident teaching mathematics and science, and who can provide an exciting and challenging learning environment for students of diverse backgrounds.

Structurally, the paper is divided into two sections: Section One contains an overview of the Maryland Collaborative for Teacher Preparation and the Research Group. Section Two contains summaries of four research studies conducted within the Research Group. Study One focuses on a statistical examination of data from the college student version of the MCTP "Attitudes and Beliefs About The Nature Of And The Teaching Of Mathematics And Science" instrument. Study Two focuses on a discourse examination of the mathematics and science MCTP faculty discussing science and mathematics. Study Three focuses on the perception of MCTP teaching faculty on the integration of mathematics and science and on barriers to implementing integration in their classes. And Study Four focuses on the teaching practices of a MCTP mathematics professor.

Researching The Preparation of Specialized Mathematics and Science Upper Elementary/Middle-Level Teachers: The 2nd Year Report

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Researching The Preparation of Specialized Mathematics and Science Upper Elementary/Middle-Level Teachers: The 2nd Year Report

Introduction

The Maryland Collaborative for Teacher Preparation (MCTP) is a National Science Foundation funded statewide undergraduate program for students who plan to become specialist mathematics and science upper elementary or middle level teachers. The goal of the MCTP is to promote the development of teachers who are confident teaching mathematics and science, and who can provide an exciting and challenging learning environment for students of diverse backgrounds.

The purpose of this report is to orient the reader to the Maryland Collaborative for Teacher Preparation and to give an overview of the on-going research activities being conducted within the project. Structurally, the paper is divided into two sections: Section One contains an overview of the Maryland Collaborative for Teacher Preparation and the Research Group, Section Two contains summaries of four research studies conducted within the Reseach Group.

Interested readers who desire additional information are encouraged to conduct the MCTP Co-Directors of Research: J. Randy McGinnis, jm250@umail.umd.edu, (301) 405-6234 and Tad Watanabe, Tad@midget.towson.edu, (410) 830-3585.

Section One: Overview of the Maryland Collaborative for Teacher Preparation and the Research Group

The MCTP consists of the following:

- Specially designed courses in science and mathematics, taught by instructors committed to a hands-on, minds-on interdisciplinary approach.
- Internship experiences with research opportunities in business, industrial and scientific settings, and with teaching activities in science centers, zoos, and other institutions.
- Field experiences and student teaching situations with mentors devoted to the interdisciplinary approach to mathematics and science.
- Modern technologies as standard tools for planning and assessment, classroom and laboratory work, problem-solving and research
- Placement assistance and sustained support during the induction year in the teaching profession
- Financial support for qualified students.

History of the MCTP

The National Science Foundation selected Maryland in 1993 as one of the first three states awarded Collaborative Teacher Preparation Grants (spread out over a five-year period) to develop and implement an interdisciplinary program for intending elementary and middle school teachers to become science/mathematics specialists. Higher education institutions involved in this grant include a number of University of Maryland institutions. Public school districts involved include Baltimore County and Prince George's County. The project management team consists of Jim Fey, Project Director, Co-Principal DirectorsGenevieve Knight, Tom O'Haver, and John Layman, and Executive Director Susan Boyer. Various committees working on the MCTP include the Content Teaching Committee, the Pedagogical Committee, and the Research Group. These committees are charged with developing and researching new college-level content and methods courses for recruited teacher candidates who started in the program in the fall of 1994.

What is the history and leadership of the Research Group?

In late July 1994, Fey, MCTP Project Director, asked J. Randy McGinnis (Science Educator), University of Maryland at College Park (UMCP), andTad Watanabe (Mathematics Educator), Towson State University (TSU), to share the leadership of a Research Component of the MCTP. Anna Graeber, University of Maryland at College Park, and Co-Director of the MCTP Methods Group, agreed to act as a mentor to the Research Group. Amy Roth-McDuffie, Mary Ann Huntley, Karen King andSteve Kramer, doctoral mathematics education students at UMCP, have served as graduate research assistants to the Research Group. Gilli Shama, a visiting Israeli mathematics educator, also joined the Research Group in the fall, 1995.

Who constitutes the Research Group?

The leadership of the Research Group identified and recruited Institutional Research Representatives (IRR) who would coordinate research efforts at the participating institutions offering MCTP courses. The individuals who took on this responsibility are Dr. Renny Azzi, Frostburg State University, Dr. Delores Harvey, Coppin State College, Dr. Joan Langdon, Bowie State University, and Dr. Gerry Rossi, Salisbury State University. Dr. Randy McGinnis and Dr. Tad Watanabe also took on this responsibility for their institutions, respectively.

What is the purpose of MCTP research?

In essence, the primary purpose of research in the MCTP is directed at knowledge growth in undergraduate mathematics and science teacher education. The unique elements of the MCTP (particularly the instruction of mathematical and scientific concepts and reasoning methods in undergraduate content *and* methods courses that model the practice of active, interdisciplinary teaching) are being longitudinally documented and interpreted from two foci: the faculty and the teacher candidate perspectives.

What are the guiding research questions addressed in the MCTP research?

The following questions serve as the *a priori* research questions (*a posteriori* questions will emerge throughout the research period):

1. What is the nature of the faculty and teacher candidates' beliefs and attitudes concerning the nature of mathematics and science, the interdisciplinary teaching and learning of mathematics and science to diverse groups (both on the higher education and

upper elementary and middle level), and the use of technology in teaching and learning mathematics and science?

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

Answers to those questions will address the following global research questions driving teacher education research:

1. How do teacher candidates construct the various facets of their knowledge bases?
2. What nature of teacher knowledge is requisite for effective teaching in a variety of contexts?
3. What specific analogies, metaphors, pitfalls, examples, demonstrations, and anecdotes should be taught content/method professors so that teacher candidates have some knowledge to associate with specific content topics?

What data are being collected for MCTP research?

Both numerical and qualitative data are being collected to address the MCTP research questions. Numerical data derive from the administration of two Likkert-type surveys developed by the MCTP Research Group: a college student version and a faculty version of "Attitudes and Beliefs About The Nature Of And The Teaching Of Mathematics And Science". Participating faculty and students in MCTP classes (both MCTP teacher candidates and non-MCTP students) contribute to this data base. Data are analyzed using the software program SPSS.

Qualitative data derive from semi-structured ongoing interviews with participants in MCTP classes, MCTP class observations, participant journals, and MCTP course materials. Standard qualitative analysis techniques (analytic induction, constant comparison, and discourse analysis) assist in he interpretation and presentation of case studies emerging from this rich data set. The software program NUD.IST. facilitates the data analysis.

Section Two: Summary of Four On-Going Research Studies in the Maryland Collaborative for Teacher Preparation

This section contains summaries of four studies conducted within the Maryland Collaboration for Teacher Preparation. Study One focuses on a statistical examination of data from the college student version of the MCTP "Attitudes and Beliefs About The Nature Of And The Teaching Of Mathematics And Science" instrument. Study Two focuses on a discourse examination of the mathematics and science MCTP faculty discussing science and mathematics. Study Three focuses on the perception of MCTP teaching faculty on the integration of mathematics and science and on barriers to implementing integration in their classes. And Study Four focuses on the teaching practices of a MCTP mathematics professor.

Study One: Statistical Examination Of College Students' Responses On The MCTP College Student Survey

Introduction

During the summer of 1994, the MCTP Research Group developed a Likkert-type instrument to determine the beliefs and attitudes college level students held in MCTP classes. A pilot version of the survey was administered, during the 1994-1995 school year, to hundreds of students enrolled in MCTP classes throughout the state participating in the project. During the summer of 1995, the survey was revised to address concerns made apparent during the pilot administrations. These concerns included wording of some items, placement of demographic data and more explicit directions. Appendix A contains a copy of the revised 48-item college student survey, "Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science."

During the beginning of the fall 1995 semester the survey was administrated to 807 students enrolled in twenty-one mathematics, biology and physics MCTP classes, offered at 7 institutions of higher learning in Maryland, and two large lecture biology classes offered at another institution. Of that sample, 57 were dropped due to various irregularities in instrument administration. The responses from the remaining 750 served for examining the instrument's validity and reliability. Factor analysis was performed on the 32 general items, and separately on 9 items that were for intending teachers only (7 items were on demographics). A pre-designed structure of five subscales was supported. The five subscales, and there estimated reliability by Cronbach's alpha, are:

(a) Beliefs about the nature of mathematics and science (alpha=0.745);

(b) Beliefs about the teaching of mathematics and science (alpha=0.681);

(c) Attitudes toward mathematics and science (alpha=0.801);

(d) Attitudes toward learning to teach mathematics and science (alpha=0.807);

(e) Attitudes toward the teaching of mathematics and science (alpha=0.596).

The estimation of the instrument's reliability is the median of subscales reliabilities, 0.745.

The survey was administrated to all 21 MCTP classes once at the beginning of the fall 1995 semester (pre-test), and once at the end of the same semester (post-test). The responses of the students in the large lecture hall biology class were removed from further analysis since the context of their learning environment was so different from the other small classes. The remaining 391 students who contributed the pre-test were analyzed. Of those respondents, 97 identified themselves as MCTP students, and 216 as non-MCTP pre-service teachers. The responses of 375 students to the post-test were analyzed. Of those respondents, 83 identified themselves as MCTP students, and 176 as non-MCTP prospective teachers.

Summary of Emergent Understandings

Data analysis of the survey results included a comparison of pre-test results to post-test results, and a comparison of responses between MCTP candidates and non-MCTP candidates. Significance of means differences was examined by t-test.

General results indicate that the sample population's pre-test means on the subscales (on a range of 1 to 5, where 5 is positive) were 3.81, 2.97, 2.39, 3.16, and 2.18 respectively. The sample population's post-test means on the subscales were 3.71, 3.05, 2.41, 3.03, and 2.18 respectively. On the positive side, all students' mean on beliefs about the teaching of mathematics and science have significantly increased. This increase was due to an increase in students' mean over items relating to beliefs about the use of technology for teaching mathematics and science. The most unanticipated significant finding from a comparison of the pre-test and post-test results was the significant decline in the students mean in the beliefs about the nature of mathematics and science subscale.

A comparison of pre-test results between the 97 MCTP candidates and the remaining 216 intending teachers students was conducted. It was found that, on each of the subscales, the MCTP candidates' mean was significantly higher then other students' mean. However, the comparsion of post-test results paint a different story. We could not reject the assumptions that MCTP candidates' post-test means are equal to the other intending teachers' mean on the subscale of beliefs about the nature of mathematics and science, on the subscale of beliefs about the teaching of mathematics and science, and on the subscale of attitudes toward the teaching of mathematics and science. In comparing the MCTP candidates' pre-and post-test means on the subscale of attitudes toward the teaching of mathematics and science, it was also found that they have significantly declined from pre-test to post-test.

These findings are from one semester. Future semesters will also be analyzed for changes since this is a longitudinal study. Of particular interest is documentation of changes of MCTP teacher candidates over their entire undergraduate programs of study.

Study·Two: University Science and Mathematics Content Professors Talk About The Others' Discipline: An Examination of the Role of Discourse Among Professors Involved in A Collaborative Mathematics/Science Teacher Preparation

Introduction

The notion of 'collaboration' has become an important idea in the field of education. A number of recent studies have investigated the classroom culture with an underlying assumption that learning/teaching is a collaborative effort involving teachers and students (e.g., Cobb. Wood, Yackel, & McNeal, 1992). This development is consistent with the basic premises of the social constructivist perspective of learning/teaching, which has become widely accepted.

Because teacher development is also a process of learning/teaching, and because being a teacher involves a wide range of knowledge (Shulman, 1987), 'collaboration' is crucial. A number of recent reform documents (e.g., AAAS, 1994; NCTM, 1991) call for collaborations among universities/colleges/community colleges, K-12 schools, business, and government agencies in preparing future teachers. Since 1993, the National Science Foundation has awarded several highly funded grants to the projects which aim to reform teacher education programs under the program, Collaborative for Excellence in Teacher Preparation.

Summary or Emerging Understandings

In this research study focus, a discourse analysis is performed on conversations among inter-institutions university mathematicians and scientists participating in reforming content classes for teacher candidates in the Maryland Collaborative for Teacher Preparation (MCTP). Discourse as used in this study is defined as the dynamic interplay of dialogue between individuals that includes the use of rules developed by certain groups of people (Gee, 1990). The focus on discourse in this study is the result of recent theoretical views that stress the importance of the environment in which members of a community communicate (Greeno, 1991; Rogoff, 1990). Conversations or `talk' is recognized as a particularly revealing resource in analyzing social interactions for patterns that can promote sense making of a community (Lemke, 1990; McCarthy, 1994). Talking is a communicative event in which the conversants collaborate in constructing a social text and an academic text simultaneously (Green, Weade, & Graham, 1988). The social text is the agreed upon rules and purposes for the social interactions. The academic text is the content of the discussion.

In this study, content expertise and an interest in reforming content classes for teacher candidates defined membership in either the science teacher preparation speech community or the mathematics teacher preparation speech community. Sharing ideas on the integration of mathematics and science in MCTP undergraduate content classes served as the purpose of the social text. The content of the discussion varied in the two speech communities but one consensus theme emerged: a recognized need to go beyond the connections of each content and to gain insight into the nature of the `others' discipline expertise by direct collaboration with an expert in the others content. "The new vision of the teaching of science and mathematics "(mathematician, conversation 6/10/95) required this. The experience of searching for this assistance among the usual members of the content speech community proved to be deficient in supplying the depth of understanding of the others' content which they felt should distinguish a truly integrated mathematics/science content class. Spurred on by this realization as a result of a newly formed inter-institutional dialogue, pioneers in the separate speech communities boldly made plans to create an intra-institutional dialogue with other pioneers from the other content speech community. A critical implication of this study is the role of dialogue in both inter- and intra-institutional to promote collaboration between mathematics and science content professors involved in teacher preparation.

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Study Three: Integrating Mathematics and Science in Undergraduate Teacher Education Programs: Faculty Voices from Maryland Collaborative for Teacher Preparation

Introduction

The focus of this study is on investigating how university/college instructors who were teaching MCTP mathematics and science courses during the 1994-1995 school year perceived the nature of these disciplines as well as the connections between them. The two primary sources of the data for this analysis were semi-structured interviews with individual instructors conducted during the 1994 - 95 school year and two content area debriefing meetings held during the summer of 1995.

Specifically, the following three questions addressed in this study include:

- What are the perceptions of MCTP faculty about the "other" discipline?
- What are the perceptions of MCTP faculty about the connections between mathematics and science?
- What are some barriers in implementing mathematics and science courses that emphasize connections?

The instructors of MCTP courses were interviewed twice during the semester in which they were teaching MCTP courses. In addition, instructors who were not teaching an MCTP course during the second semester were interviewed once during that semester. The interviews were semi-structured in that there was a set of standard questions that were asked of all participants (see Appendix B). Additional questions were posed reflecting the responses of the participants. To answer the specific questions listed above, we have focused primarily on the participants' responses to the first question in both interview protocols. However, their responses to other questions, for example question 13 in interview 2, also related to the research questions, and participants' responses to other questions were also included as appropriate.

Altogether, forty interviews involving 16 mathematics and science instructors from four institutions were conducted. There were four mathematics instructors attending the mathematics debriefing meeting, while nine science instructors attended the science debriefing meeting. All interviews and group meetings were audio- and/or video-recorded and transcribed for subsequent analysis.

Summary of Emerging Understandings

It appears that the MCTP university/college faculty members have developed a renewed sense of respect and appreciation for each other and each other's discipline. At the same time, they are still struggling with a number of issues. One such issue that is of particular interest to mathematics educators is the nature of mathematics in relationship to science. On the one hand, there is a tendency/desire on the part of mathematics instructors to treat mathematics as a distinct and independent discipline of its own right. This perspective reflected the concern on the part of mathematicians and mathematics educators that science instructors would simply treat mathematics as a tool and "the nature of what mathematics is is very often not explored in science" (mathematics instructor, June, 1995). On the other hand, there is also a perspective that mathematics is a science:

> We've always said that mathematics was the queen of all sciences, and some of us even say that we want to talk about the mathematical sciences. So, I think we ourselves are part of science. (mathematics instructor, June, 1995)

Thus, it appears that participation in the MCTP project has raised a fundamental question among mathematicians and mathematics educators concerning their own discipline, as well as the nature of the relationship between mathematics and science. Most, if not all, mathematics instructors agree that mathematics-science connections are important and useful; however, many appear to be grappling with the nature of these connections. Is there something special about the connections between mathematics and science that are not shared by connections between mathematics and, for example, economics? Tentative findings seem to imply that the answer to this question is yes. On the other hand, the recommendations of the NCTM Standards seem to take a broader perspective of the notion of connections. Thus, the nature of the relationship between mathematics and science appears to be an open question not just among the MCTP project participants. As we continue to gather data from these participants, we hope to be able to document how this issue is considered by these participants.

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Study Four: Modeling Reform-Style Teaching in a College Mathematics Class from the Perspectives of Professor and Students

Introduction

This study focuses on the perceptions of five pre-service teachers and their mathematics professor as participants in a reform-style mathematics classroom. The goal is to promote understanding which can inform future research on the teaching and learning practices of college level mathematics instructors from a constructivist perspective and thus contribute to the preparation of pre-service mathematics teachers.

Mathematics education in the United States is in the midst of reform. The National Council of Teachers of Mathematics [NCTM] (1989, 1991, 1995), the Mathematical Sciences Education Board [MSEB] (1990, 1991, 1995), the Mathematical Association of America [MAA] (Tucker & Leitzel, 1995) and the National Research Council [NRC](1991) have issued documents proposing a framework for change in mathematics education at all levels, elementary through college. The framework is based on the philosophy that students are active learners who construct knowledge through their interpretations of the world around them. The above reform documents present goals for mathematics education which state that all students should: learn to value mathematics, become confident in their ability to do mathematics, become mathematical problem solvers, learn to communicate mathematically, and learn to reason mathematically.

The purpose of this qualitative case study was to provide a description and an interpretation of a MCTP professor and five MCTP students who are attempting to teach and learn in a class consistent with the goals set forth by the reform documents. This study addressed the following a priori research question: Do the instructor and the pre-service teachers perceive the instruction in their mathematics course as modeling the kind of teaching/learning they would like to promote as upper elementary/middle level teachers of mathematics and science? And if so, how?

Several publications directed at college mathematics teachers stress the importance of modeling reform-style teaching to undergraduate students (MAA, 1988; MSEB, 1995; NRC, 1991; National Science Foundation [NSF], 1993; Tucker & Leitzel, 1995). Modeling reform-style teaching at the college level is important for the following reasons. First, since the literature on teacher education posits that teachers tend to teach as they have been taught when they were students (Brown & Borko, 1992; Kennedy, 1991), teachers (including college level teachers) should model the type of teaching that is consistent with the reform documents, (MSEB, 1995). Second, as a consequence of this finding, there are implications specific to college teaching. While all teachers serve as role models for students who want to become teachers, college faculty are the people teaching pre-service teachers as they train for their careers; thus, college faculty should be especially concerned about modeling good teaching. "Unless college and university mathematicians model through their own teaching effective strategies that engage students in their own learning, school teachers will continue to present mathematics as a dry subject to be learned by imitation and memorization" (NRC, 1991, p. 29). Third, the result of modeling good teaching is a better education for all students, not just future teachers (NRC, 1991; NSF, 1993).

The research was conducted from a perspective which combines ideas of interactionism and constructivism. This perspective is consistent with the philosophy toward teaching and learning that underlies the framework for reform in mathematics education and with the philosophy of the Maryland Collaborative for Teacher Preparation [MCTP] which is described above. First, according to the perspective of interactionism, people invent symbols to communicate meaning and interpret experiences (Alasuutari, 1995; Blumer, 1986); moreover, people create and sustain social life through interactions and patterns of conduct including discourse (Alasuutari, 1995; Gee, 1990; Hicks, 1995; Lave & Wenger, 1991). Furthermore, this position is in accordance with the constructivist perspective of learning in that individuals develop understandings based on their experiences and knowledge as it is socially constructed (Ernest, 1991).

Cobb and Bauersfeld (1995) discuss the social aspects of learning and knowledge by advocating viewing mathematics education through the perspectives of interactionism and constructivism. Incorporating the interactionist perspective with constructivism, Cobb and Bauersfeld (1995) state that,

> They draw on von Glasersfeld's (1987) characterization of students as active creators of their ways of mathematical knowing, and on the interactionist view that learning involves the interactive constitution of mathematical meanings in a (classroom) culture. Further, the authors assume that this culture is brought forth jointly (by teachers and students), and the process of negotiating meanings mediates between cognition and culture (p. 1).

As part of this case study, the professor and the students engaged in on-going interviews and observations throughout the semester to obtain data regarding their perceptions and actions of toward teaching and learning and the extent to which the instruction modeled the kind of teaching and learning appropriate for grades 4 through 8. The data were collected and analyzed through the use of the qualitative techniques of analytic induction, constant comparison, and discourse analysis for patterns of similarities and differences between the professor's and students' perceptions (Bogdan & Biklen, 1992; Gee, 1990; Goetz & LeCompte, 1984).

Summary of Emerging Understandings

An analysis of the data indicated that Dr. Taylor and the students perceived significant differences between "traditional instruction" and the teaching and learning "this way" as modeled by Dr. Taylor. Moreover, both Dr. Taylor and the students expressed a clear image of what they thought teaching in grades 4 through 8 should be. This image of ideal teaching was quite consistent with the teaching and learning that they experienced in Dr. Taylor's class. The experiences of these students and this professor has implications for teacher education programs interested in preparing pre-service teachers to achieve the standards for teaching and learning set forth in the reform documents.

A major implication gained from this qualitative study is that the college students who experienced a reform-style mathematics classroom completed a first step in achieving the vision for reform of mathematics education: constructing an initial model of mathematics teaching and learning which embraces the ideals of the reform movement. However, this initial experience as a student in a reform-style mathematics classroom is not enough for preparing pre-service teachers. In accordance with the findings of Borko, Eisenhart, and colleagues (Borko, et al., 1992; Eisenhart, et al., 1993), the students in Dr. Taylor's class believed that further educational coursework and field experiences would be necessary before they would be prepared to "do the things that [Dr. Taylor is] doing now" (Beth, Interview, 12/8/94) in their own teaching. This finding suggests that while one content course taught from a constructivist perspective is not sufficient in preparing pre-service teachers to meet the goals for reform, it is necessary to begin the process of preparing pre-service teachers to incorporate reform-based practices into their future mathematics teaching.

Another implication for the preparation of pre-service teachers rests in what was not discussed or taught in Dr. Taylor's class. In observing the classes and talking to the participants, the researcher never heard overt talk about how the students' experiences in Dr. Taylor's class might translate to the students' future practice as elementary/middle school teachers unless they were specifically asked to discuss this by the researcher. It seems that discussions of pedagogical issues relevant to pre-service teachers were considered to be inappropriate discourse.

Why is it significant that pedagogy was not discussed in a mathematics course? Shulman (1986) brought the notion of pedagogical content knowledge to the forefront of teacher education. He defines pedagogical content knowledge as going "beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching " (Shulman, 1986, p. 9) Included in the category of pedagogical content knowledge are: "the ways for representing and formulating the subject that make it comprehensible to others, [and] . . . an understanding of what makes the learning of specific topics easy or difficult" (Shulman, 1986, p. 9). Shulman (1986) calls for teacher education programs which offer instruction focusing on content that includes "knowledge of the structures of one's subject, pedagogical knowledge of the general and specific topics of the domain, and specialized curricular knowledge" (p. 13). In other words, pre-service teachers need to learn about the pedagogical issues in the context of subject matter knowledge. This need is also stated in the reform documents (e.g., NCTM, 1991).

The need for pedagogical content knowledge has implications for classes like Dr. Taylor's. Dr. Taylor seems to have sound reasons for focusing on content at the near exclusion of pedagogical discussions, and many other mathematics and mathematics education faculty probably agree with his reasons. However, does this mean that pedagogical discussions must be delayed until pre-professional education courses? It seems that to delay would be missing a significant opportunity for the development of pedagogical content knowledge. If professors are unwilling or unable to include pedagogical discussions in mathematics content courses, then perhaps providing opportunities such as the MCTP seminar (a seminar which focuses on pedagogical issues as they relate to the students' content courses) is important for pre-service teachers. In other words, if conversations which promote reflecting on and making connections between the pre-service teachers' learning experiences in a mathematics course and their future teaching are not taking place in mathematics classrooms, then teacher education programs should consider initiating forums where this type of conversation can take place in order to enhance pedagogical content knowledge.

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Appendix A: College Level MCTP Survey Instrument

Maryland Collaborative For Teaching Preparation

ATTITUDES AND BELIEFS ABOUT THE NATURE OF AND THE TEACHING OF MATHEMATICS AND SCIENCE

COLLEGE STUDENT VERSION

Directions:

Do not mark on these question sheets. Mark only on the answer sheet.

This survey is being used for research purposes only; your identity will remain confidential.

Thank you for your participation.

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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.

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

9. Mathematics is a constantly expanding field

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

11. Before students spend much time solving mathematical problems, they should practice computational procedures.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

26. Science is a constantly expanding field.

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

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

29. I like science.

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

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

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

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

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

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

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

ITEMS 37--46 ARE FOR ONLY THOSE INTENDING TO TEACH

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

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

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

39. I anticipate/believe that there is very little to learn about teaching at the elementary or middle school level by observing and reflecting on the way the instructor in this class teaches.

40. The idea of teaching science scares me.

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

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

43. The idea of teaching mathematics scares me.

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

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

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

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

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

Appendix B: Faculty Interview Protocols

Interview 1

1. To what extent is the instruction in your class planned to highlight connections between mathematics and science?

2. To what extent will this class involve the application of technology, such as e-mail, CDs, computers, calculators, etc.?

3. To what extent will you make significant attempts to access your students' prior knowledge of a topic before instruction? What techniques will you use?

4. To what extent do the tests and exams stress reasoning, logic, and understanding over the memorization of facts and procedures?

5. In what ways do you think your teaching models the type of teaching that you believe should be done in grades four through nine?

6. To what extent will you explicitly encourage your students to reflect on changes in their ideas about topics in your class?

Interview 2

Reflecting over this semester's MCTP class, what new thoughts do you have on these areas (Question 1-6):

1. Instruction planned to highlight connection among math and the science?

2. Instruction involving the application of technologies?

3. Need to access students' prior knowledge of a topic before instruction?

4. Use of assessment techniques that stress reasoning, logic and understanding as opposed to memorization of facts and procedures?

5. Modelling the type of teaching that you believe should be done in grades 4-9?

6. Need to explicitly encourage your students to reflect on changes in their ideas in the class?

7. Reflecting back, have you seen what you have learned and experienced with MCTP courses and experiences come through in any other professional areas?

8. Reflecting over your course, what are the pieces unique to MCTP that stand out in your mind that worked well or that you might change?

9. Projecting into the future, do you have plans to teach another MCTP course?

10. How do you feel about teaching another MCTP course?

11. Has your involvement with MCTP enabled you to make connections with other MCTP faculty?

12. What kinds of things that have been part of the MCTP project have provided support to you or have contributed to your wanting to continue in the project?

13. What constraints?