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Characteristics of Mathematics Teacher Preparation Programs in the United States: An Exploratory Study[1]

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Abstract

The purpose of this study was to gather information on current characteristics of mathematics teacher preparation programs in the United States in the context of the recent reform recommendations. A survey, developed and distributed to a sample of mathematics teacher educators, was designed to gather information on several of the prevailing themes of the reform documents and recommendations. Characteristics of mathematics teacher programs reflected in the sample were similar to those in place for the past 75 years. However, several of the institutions mentioned future directions that may result in substantial changes to the practice of mathematics teacher preparation.

Introduction

The *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics (NCTM), 1989) and the more recent *Principles and Standards for School Mathematics* (NCTM, 2000) suggest a vision for school mathematics in the United States that is substantially different from what had been the norm in most precollege classrooms prior to the early 1980's. The documents call for substantial changes in not only *what* mathematics is taught but also *how* it is taught. Both documents have significant implications for teacher education in the United States both at the inservice and preservice level. Subsequent national reports, NCTM's *Professional Standards for Teaching*

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Mathematics (1991) and Mathematical Association of America's (MAA) *A Call for Change* (1991) explicitly discuss these implications and highlight recommendations for teacher preparation based on the *Curriculum Standards* vision of school mathematics. However, it's not clear whether or not and how these recommendations have influenced the characteristics and practices of programs in the nation's postsecondary institutions responsible for mathematics teacher preparation.

This paper reports on an exploratory study of characteristics of mathematics teacher preparation in the United States. The study seeks to gather information on the salient characteristics of mathematics teacher preparation programs in the United States and how these characteristics relate to the practices of teaching mathematics envisioned by the reform documents. The primary source of data for the study is a survey completed by mathematics teacher educators at a sample of US institutions of higher education. The background discussion will be followed by a discussion of the development of the survey, the results, and the interpretation of the results. We conclude with a discussion of next steps and suggestions for further research. We begin with some background information that includes the historical context, a summary of recent recommendations, and a review of related work.

Background

Historical Context

In studying the characteristics of current programs, it is important to look at the historical context, when did such programs begin, what were the characteristics of the early programs, how did the characteristics change over time, and why did they change. This section provides an overview of the early development of mathematics teacher preparation programs and ends with a discussion of events toward the end of the twentieth century that led to the release of several sets of recommendations for school mathematics in the United States. These recommendations have implications for mathematics teacher preparation programs.

Programs to prepare teachers of mathematics in the United States date back to the advent of the normal school in the early 1800's. First to develop were programs for elementary teachers. Secondary teachers were typically college

graduates with a degree in mathematics, or whatever subject they were assigned to teach, and typically had no specific preparation in the methods of teaching. By the early 1900's the normal schools had developed programs for secondary teachers as well.

By 1920, the typical two-year program of the normal school for the preparation of elementary teachers consisted of academic subject matter, professional education, and supervised teaching in a laboratory school. The mathematics portion of the academic subject matter in the training of these early teachers for elementary schools focused on a review of arithmetic with some algebra and geometry. The goal of the program was to see that prospective elementary teachers knew the rules of computation and how to conduct computational drill.

The preparation of mathematics teachers for high schools was a four-year, university program, consisting of a liberal arts major or possibly minor in mathematics and some courses in the teaching of mathematics taken from the new departments or schools of education (Swafford, 1995, pp. 157-158).

From 1920 to the late 1950's several organizations such as the National Council of Teachers of Mathematics (NCTM) and the Mathematical Association of America (MAA) produced recommendations for the preparation of mathematics teachers. These recommendations typically consisted of lists of mathematics courses or mathematical concepts and shorter lists focused on recommended experiences in teaching mathematics. At the end of this time period a typical elementary teacher did not have a mathematics course beyond one year of high school mathematics and a typical secondary mathematics teacher had completed only a minimal college-level mathematics major (Dubish, 1970).

The picture in terms of requirements for mathematics teacher preparation changed dramatically with the launching of Sputnik in 1957 when the nation's attention and resources were focused on improving mathematics and science education at all levels. The United States was concerned about falling behind in the technology race and many felt that key to improving mathematics and science education was improving the mathematics and science background of current and future teachers. The reports released in response to these concerns recommended that elementary teachers should be required to complete two college-level mathematics courses and that secondary teachers should be required to complete a "major in mathematics with a minor in a field using mathematics (Swafford,

1995)." The recommendations of the post-Sputnik era reflect a commitment to deep and broad content knowledge for mathematics teachers. So although the recommended number of college-level mathematics courses increased for both elementary and secondary teachers, the framers of the post-Sputnik recommendations were still only minimally concerned with how individuals develop a knowledge of teaching practice. They felt that a strong background in mathematics content was necessary, if not sufficient, for becoming a strong mathematics teacher. Although the recommendations had only minor impact at the elementary level, most of the secondary recommendations were implemented.

The recommendations, stated above, that grew out of the "new math" era of the late 1950's and 1960's represented the status quo in US mathematics teacher preparation until the early 1980's when there was again a growing national concern over the inadequacies of schooling in the United States. Changes and growth in the business and industry sector brought about by an increase access to information and technology were demanding a change in the focus of mathematics education. The "back to basics" movement of the late nineteen sixties and nineteen seventies was not sufficient for meeting new demands in the work place and other areas as the nation moved toward the twenty-first century. The concerns prompted several reports and recommendations such as NCTM's *Agenda for Action* (1980) and the report, *A Nation at Risk* (1983). Key components of NCTM's *Agenda for Action* included a recommendation that problem solving become a focus of school mathematics in the 1980's, that the concept of basic skills be broadened to include more than computational proficiency, that programs take advantage of available technology, and that assessment be broadened to include more than conventional testing. The *Agenda for Action* also contained recommendations for teacher education and teaching practice. The recommendations stated that priority should be given to involving students in meaningful problem-solving activities, that more time should be spent on mathematics in elementary classrooms, that teachers should use a diverse set of instructional strategies, that programs need to be staffed by individuals who are qualified, competent, and current in their field, that teacher preparation institutions need to develop new programs that incorporate an emphasis on problem solving, and that certification standards need to be updated to reflect the new recommendations (Price and Gawronski, 1981).

The *Agenda for Action* served as a blueprint for the *Curriculum and Evaluation Standards for School Mathematics* released by NCTM in 1989 and several other sets of recommendations that followed. These recommendations and

their implications for teacher preparation in the United States are discussed in the next section.

A Summary of Recent Recommendations

As stated previously, the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) presents a vision of mathematics teaching that is supported by the recommendations contained in the *Professional Standards for Teaching Mathematics* released in 1991. We have seen that historically a well-prepared mathematics teacher, particularly at the secondary level, has been primarily thought of as an individual with a solid preparation in mathematics content. The recommendations released in the late nineteen eighties and early nineteen nineties broaden the expectations for mathematics teachers to include such aspects as "knowing mathematics and school mathematics", "knowing students as learners of mathematics", and "knowing mathematical pedagogy". Having a solid background in mathematics is no longer thought of as sufficient.

The above broadened expectations for teacher preparation are consistent with a broadened view of teaching practice that goes beyond a view of teaching that relies heavily on lectures and the teacher as the sole intellectual authority. It is this latter view that was primarily in place at the time that the above recommendations were released. Teachers primarily saw themselves as dispensers of information to passive students. The *Professional Standards for Teaching Mathematics* (NCTM, 1991) attempt to define an alternative vision of teaching practice. For example, the section on "Standards for Teaching Mathematics" presents a view of teaching as a complex decision making process during which a teacher participates in each of the following activities:

- Setting goals and selecting or creating mathematical *tasks* to help students achieve these goals;
- Stimulating and managing classroom *discourse* so that both the students and the teacher are clearer about what is being learned;
- Creating a classroom *environment* to support teaching and learning mathematics;
- *Analyzing* student learning, the mathematical tasks, and the environment in order to make ongoing instructional decisions (NCTM, 1991, p.4).

The broadened expectations are also reflected in the document *A Call for Change: Recommendations for the Mathematical Preparation of Teachers of Mathematics* released by the Mathematical Association of America (MAA) in 1991 to coincide with and complement the release of the *Professional Standards*. The MAA recommendations focus mainly on the "collegiate mathematical experiences that a teacher needs in order to meet [the] vision". Similar to the *Professional Standards*, the MAA document refers to mathematics teaching as a complex task and states that the necessary preparation must go beyond a solid foundation in mathematical content. Specifically,

> To change the teaching and learning of mathematics in the nation's schools, the preparation of teachers must also include developing an understanding of students as learners of mathematics, obtaining appropriate background in mathematical pedagogy, and constructing suitable classroom environments to foster learning by all students (MAA, 1991, p.ii).

Although the document refers to these aspects of a teacher's development as important, it does not give any explicit recommendations in this area and instead refers its readers to the *Professional Standards* document for more details.

The view of teaching stated explicitly and implicitly by the NCTM and MAA documents has implications for preservice preparation programs whose goal is to foster a view of teaching and learning consistent with NCTM's 1989 *Curriculum and Evaluation Standards for School Mathematics* and the newly released *Principles and Standards for School Mathematics* (NCTM, 2000). For example, the authors of the *Professional Standard* state some foundational assumptions about mathematics teacher education:

- The *Curriculum and Evaluation Standards for School Mathematics* provides a vision of mathematics education that is the basis for the professional development standards.
- Teachers are influenced by the teaching they see and experience.
- Learning to teach is a process of integration.
- The education of teachers of mathematics is an ongoing process.

- There are level-specific needs for the education of teachers of mathematics (NCTM, 1991, pp. 124-125).

These assumptions suggest that mathematics teacher preparation programs should model teaching consistent with the recommended goals for precollege mathematics teaching, develop experiences that allow prospective teachers to "engage simultaneously in studies of mathematics and mathematics pedagogy", view the preservice experience as only the beginning of a career-long process of professional growth, and develop programs and experiences that reflect the educational goals of the various levels: elementary, middle, and high school. The assumptions formed the basis of a survey developed in the current study and distributed to a sample of mathematics teacher preparation programs in the United States. The survey was designed to gather information about the characteristics of US mathematics teacher preparation programs and how the current characteristics compare to national recommendations. The survey and results will be described following a review of related work.

Review of Related Work

Many states have developed frameworks and recommended changes in state-level certification standards based on the above national recommendations and research in teacher preparation (Coordinating Commission for Post-Secondary Education, 1995; New Hampshire Preservice Education Review Project, 1997; Texas State Systemic Initiative, 1995). Several of these efforts have included documentation of current programs and practices to provide baseline data and determine alignment with the recommendations.

The New Hampshire Preservice Education Review Project (PERP) (Curran, 1999) aimed to develop a *consensus model* for teacher preparation in mathematics and science and to document NH preservice teacher education programs against the model. The *model* resulted from "a two-year extensive review of state and national documents, research, other preservice education nationally, and the advice of stakeholders within the State of New Hampshire (NH PERP, 1997). The model contained a series of proficiency standards that "represent what prospective teachers in New Hampshire should know and be able to do: the knowledge they need about the way students think, learn, and behave; the knowledge they need relative to instruction and technology; and the knowledge they need in the content areas of mathematics and science (NH PERP, 1997, p.1)".

It was hoped that the proficiency standards would serve as the standard on which to revise state level certification standards, to revise teacher preparation programs at state institutions of higher education, and to develop and revise state level accreditation standards and policies. As part of the NH PERP project a study was conducted to research and report on discrepancies that exist between the *consensus model* and current teacher preparation programs in New Hampshire. The discrepancy study consisted of an extensive survey of preservice teachers, recent graduates from NH Institutions of Higher Education, cooperating teachers, Presidential Awardees, and college and university department chairs in mathematics and education. The survey focused on whether New Hampshire's preservice teachers receive adequate preparation in several areas including: mathematical content, grade-level specific mathematical content, pedagogical content, field experiences, working with culturally diverse students, gender issues, and technology. At all grade levels respondents felt that more pedagogical training was necessary, especially earlier and more frequent field experiences. At the elementary and middle school levels, content preparation varied widely and was often weak (Curran, 1999).

Luft and Ebert-May (1999) report on a study in Arizona to examine initial teacher preparation programs in mathematics and science. The goal of the study was to compare components of initial certification programs with state and national level recommendations. Data collected included mission statements, composition of initial certification programs, curriculum, instruction and assessment practices, and profiles of faculty, staff and students for 4 state regents' institutions. Comparisons were made across institutions and across department types, mathematics, science, and education. Results of the Luft and Ebert-May study that are important in the context of the current study are summarized below:

- Although the mission statements from each of the institutions did not specifically address mathematics or science education, several discussed the "importance of preparing knowledgeable educators to meet the communities needs."
- The programs as a whole had no special admission standards for mathematics and science education students.
- Although mathematics and science educators indicated they use a variety of curriculum materials in their courses, the majority (60%) indicated that they use textbooks frequently. Only 22% of all the faculty indicated that

they used the World Wide Web frequently to some of the time in their courses and 37% gave a similar response for computer software. Significant differences between departments occurred in the use of texbooks, K-12 curriculum materials, the Arizona Essential skills, the use of the Internet and the World Wide Web, and the use of manipulatives. For example education faculty utilized K-12 curriculum materials in their courses significantly more than science faculty.

- Mathematics and science education faculty reported that they frequently emphasized and understanding of basic concepts and the use of higher order thinking skills in their courses. However, significant differences existed between institutions and departments in terms of what the content was focused on (advanced concepts in mathematics and science versus theories of teaching and learning), time spent modeling effective instruction, time spent on professional development, and time spent of classroom management. For example, education faculty reported spending more time modeling effective instruction than did science faculty or joint appointments.
- Mathematics and science education faculty reported utilizing a variety of traditional and more reform-oriented assessments. However, education faculty used products of student work (research papers or models) and performance checklists significantly more than science faculty.
- Overall the requirements for an individual seeking general elementary certification is one or two mathematics content courses and one mathematics methods course, for an individual seeking elementary certification with a specialization in mathematics the requirement if 2-4 lower division courses for a total of 18 semester hours, the requirements for a secondary mathematics majors is several content courses and 2 or 3 pedagogical courses.
- All programs had a field experience competent and all programs tried to identify exemplary teachers to serve as cooperating teachers although no details were provided as to how this was accomplished. A variety of individuals serves as supervisors for the field experience including retired educators, graduate students, full and part-time faculty, and education specialists, but no discipline-based faculty.

Overall the study reported that many faculty and staff at the surveyed institutions were not using the practices and materials envisioned by the *Professional Teaching Standards* or in the *National Science Education Standards* (1996). The report stresses the need in for more coordination between institutions in Arizona, the need for a guiding framework of teacher preparation programs in mathematics and science, the need to attract and retain qualified students, the need to emphasize the utilization of reform-based practices in faculty and staff evaluations, and the need to recruit and retain faculty who are specialists in mathematics and science education.

Additional studies have been conducted on a more national level to determine teacher education program effectiveness (Andrew, 1990; Loadman et.al., 1999). Typically these studies have involved "follow-up surveys" of program graduates who are currently teaching as well as those that might have left the profession. Some of these "follow-up" studies have attempted to compare structural aspects, such as the difference between a four-year undergraduate model to teacher preparation and a five-year integrated graduate and undergraduate experience (Andrew, 1990). Other "follow-up" studies have collected and analyzed data relating to career satisfaction, quality of general attributes of preservice programs, and demographic information (Loadman et. al., 1999). Few have compared the structure of content-specific programs on a national level, examining the common themes, components, and practices across programs, and how they compare to national recommendations.

More specifically in the area of mathematics teacher education efforts have also focused on describing innovative programs or practices in order to provide information for individuals or institutions that are interested in exploring change. For example, Fisher and Leitzel (1996) edited a document entitled, *Making Change – Pioneering Attempts in Implementing Reform in Mathematics Teacher Preparation*. The document was intended for college and university faculty interested in initiating change in the preparation of teacher of mathematics. The project was funded by the National Science Foundation and the document was compiled from a series of summer workshops and implementation efforts by participating institutions. The document contains institutional reports that provide a description of each institution's focus, a description of demographic and mathematics teacher preparation course information, and a description of the concerns addressed and acted on as part of participation in the project. Specific institutions were targeted to share insights on key issues in the preparation of mathematics teachers such as the role of technology, varieties of instructional style,

characteristics of mathematics teacher education might prove useful as an initial step in determining common preservice experiences nationwide and finding how these experiences compare with the expectations for classroom practice, K-12 as stated in the NCTM recommendations, *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) and *Principles and Standards for School Mathematics* (NCTM, 2000). If the characteristics of mathematics teacher preparation programs are inconsistent with the recommendations, then there may be little hope of changing classroom practice.

The current study sought to address the lack of information at the national level by gathering and analyzing information on mathematics teacher preparation program characteristics from a sample of US institutions of higher education. The survey instrument, results, and analysis are presented in subsequent sections of this paper. The discussion is followed by a description of recommendations for future work.

Description of Survey

The purpose of this study is to gather preliminary information on characteristics of mathematics teacher preparation across the United States in the context of recent national recommendations for mathematics teacher preparation (*Professional Standards for Teaching Mathematic* (NCTM, 1991) and *A Call for Change: Recommendations for the Mathematical Preparation of Teachers of Mathematics* (MAA, 1991)) and the effort to improve precollege mathematics teaching as envisioned by recent reports (*Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) and *Principles and Standards for School Mathematics* (NCTM, 2000)).

Based on the work that two of the researchers had done in connection with the NH Preservice Education Review Project (NH PERP, 1997), the historical context, and recent recommendations, a survey was developed and distributed to a group of 28 mathematics teacher educators at 28 institutions throughout the United States. The categories and sub questions contained in the survey represent themes based on the recent recommendations and related research discussed in a previous section. The themes include the notion that teacher education should be viewed as a coherent process, that content as well as methods are important to a preservice teacher's development, that both experiences should be integrated throughout the preparation program, and that preservice teachers should have opportunities to explore mathematics and the teaching of mathematics in ways consistent with the

national recommendations for classroom practice (NRC, 1996). With these themes and the recommendations in mind, the survey was developed to solicit information in several broad categories:

- General information on the location of mathematics education programs within the institution and the distribution of content and methods courses within the program.
- The role of mathematics education within the respective departments and the institution.
- The programs approaches to the development of preservice mathematics teachers (what types of instructional and assessment practices are included and what is the role of technology).
- The place and nature of field experiences.
- Future directions.

The institutions surveyed included colleges and universities and covered the major geographic regions (northeast, southeast, Midwest, and west coast) of the United States. Completed surveys were received from 13 individuals/institutions and program descriptions were included with the returned survey for 9 individuals/institutions. This paper will concentrate on a preliminary analysis of the survey portion of the data. The preliminary analysis sought to determine the commonalities and differences across institutions with respect to the general categories listed above. In addition, the results were interpreted and discussed in the context of recommendations for teacher preparation as outlined in recent reports such as the *Professional Standards for Teaching Mathematics* (NCTM, 1991) as well as the characteristics of the programs and practices in place prior to the reforms of the 1980's and 1990's.

Information gained from the data collected as a result of this study provides insights about what the program values in terms of what prospective mathematics teachers should know and be able to do. The information begins to provide a piece of the national picture of the status of mathematics teacher preparation and will be used to develop a larger quantitative study involving more institutions and a more qualitative study that investigates selected programs in more detail.

Survey Results and Discussion

The results of the study will be discussed in terms of several broad categories each representing a subset of the questions from the original survey. The categories include general information, the role of mathematics education, the role of the standards documents, and field experiences. Each of these categories and associated results will be presented in the following subsections followed by a summary and suggestions for further study.

General Information

Survey questions 1-4 asked respondents for general background information about the location of mathematics education faculty and courses within their respective institutions. Responses provide an indication of who has primary responsibility for the mathematics education of prospective teachers within a given institution and what might be emphasized content or pedagogical methods in a particular program.

Ten of the thirteen faculty responding to the survey list their primary faculty appointment as mathematics. In related program information the responding institutions are fairly consistent on the location of methods courses and mathematics content courses for teachers (see Figure 1). In 8 of the 13 responding institutions, methods for preservice teachers at the elementary level taught in education departments, while methods for preservice secondary teachers are taught in the mathematics departments in 10 of the 13 institutions. Methods for preservice middle school teachers are split fairly evenly between education and mathematics departments; 6 of the responding institutions indicated that methods at the middle school level are taught in the education department and 7 of the institutions indicated that these courses are taught in the mathematics department. A different picture exists relative to the mathematics content courses for teachers, no matter what the level, these courses are primarily taught in each institution's mathematics department (see Figure 1).

Figure 1

Question 2:

Courses offered by	Elementary level	Middle school level	Secondary level
Math dept	5	7	10
Edu dept	8	6	3
TOTAL	13	13	13

Question 3:

Content courses in	Elementary level	Middle school level	Secondary level
Math dept	11	11	13
Edu dept	2	2	1
TOTAL	13	13#	14*

(Note: "#" one respondent indicated that there is no M-S math education program in his/her institution, but another respondent indicated that math content courses for M-S mathematics teachers are offered at both C&I dept and Math dept in his/her institution.

"*" one respondent indicated that math content courses for secondary mathematics teachers are offered at both C&I dept and Math dept in his/her institution.)

The balance of content versus methods course requirements at all of the institutions is weighted heavily in favor of content, particularly at the secondary level. At the middle school and elementary level the distribution is more equal at least in terms of mathematics content versus mathematics methods. We suspect that the balance between overall content requirements and overall methods requirements would exhibit a ratio similar to secondary mathematics if all course work, not just course work in the area of mathematics was surveyed.

Some preliminary observations can be made about methods and content courses. First, mathematics methods courses and mathematics content courses appear to have two different homes particularly at the elementary level. Many of the responding institutions identified this as a disadvantage in the way that mathematics education is structured at their institutions. The following comments are representative of the type of comments received regarding this separation between where mathematics content and methods courses are housed:

- The split between COE [College of Education] and math department requires close communication between the two departments to minimize redundancy and maximize appropriate preparation. This doesn't happen.
- The biggest advantage of having all mathematics education specialists in Mathematics is that both mathematics content (at least course use specifically in the major) and mathematics methodologies are under the control of these specialists. We can make program updates and modifications much easier than if content and methods were handled in separate colleges. The biggest disadvantage is that we have no mathematics education specialists involved in the field experience components of our students' programs.
- I think the fact that we offer all math ed courses from the math dept is a strong advantage. The major weakness is that elementary teachers belong in a different department, thus we don't have much to say on programmatic issues.
- I think it is unfortunate that our content and methods courses are taught in 2 different places.

Such a segregation and lack of communication as indicated above would seem to work against any effort to establish a view of mathematics teacher preparation as a coherent process. In addition, the division may to foster a perspective that methods are unrelated to content or that content is more important than methods. One department is okay for one and not the other. A more integrated approach would appear appropriate and consistent with the national recommendations but did not seem to be the norm in the group of institutions responding to the survey.

Role of Mathematics Education

Survey question 6 asked the respondents to discuss how the mathematics education program was viewed within their department, e.g. was it seen as a vital part of the department's mission, as a service to the state, or as a burden to the department. Responses to this question begin to shape a perspective about mathematics education that could influence programmatic decisions within a department. This questions seems particularly important within departments of

mathematics where mathematics education may be one of several subdisciplines competing for resources, faculty, and students.

Not surprisingly, mathematics education is seen as playing a vital role in most of the departments/institutions that responded to the survey. "It is a very active and important group", "Vital, in the sense of being the largest sub-group of mathematics majors", and "The mathematics education program in our department is definitely vital to the department's mission and the mission of the university. It is one of the best programs in the state so the state definitely counts on us to prepare excellent mathematics teachers." are examples of some of the common responses. However, despite the vital role, several categories of departmental struggles were reported. One struggle is that a typical mathematics for elementary teachers course is not a popular course to teach. Another is that mathematics faculty sometimes consider mathematics education students and sometimes faculty as second-class citizens. The final type of struggle identified involves a conflict that sometimes develops between the research and public service mission of the institution; e.g. "The University and College are waging an all out campaign for higher ratings in the research institution arena, so the press for research productivity vs. the state's expectations that a land-grant institution provide service (more teachers, faster) will remain a tension.

Another indication of the vitality of a mathematics education program within an institution is the percentage of undergraduate majors who are preservice teachers. Among the individuals reporting from mathematics departments, the percentage of undergraduate majors who are preservice secondary teachers ranged from 5% to greater than 70% (see Figure 2). An interesting question to pursue is whether there is a relationship between the number of majors and the influence of mathematics education in the department. For example, do mathematics departments with a high number of preservice mathematics teachers structure their regular departmental mathematics courses differently. If so, in what ways are they different.

Question 5:

(1) Based on responses available to this question, there is no clear indication for the percentage of the undergrads majoring in pre-service mathematics teachers at elementary level. This may partially due to the fact that most respondents have their primary faculty appointments in the Math dept.

(2) Only one respondent indicated clearly that about 20% of the undergrads in his/her department majoring in math education at the middle school level.

(3) Responses to the percentage of the undergrads majoring in pre-service mathematics teachers at secondary level vary dramatically. The following table summarizes the frequency of responses that indicated specific percentage of the undergrads enrolled in the program.

Figure 2

% of the undergrads in secondary math edu	Frequency of responses
5%	1
15%-20%	2
< 50%	1
50%	1
60%	1
70%	2
100%	1
Largest program in the dept	1

Program Approaches

Survey questions 9-11 asked respondents to describe the types of instruction formats, technology, and assessment formats used in content and methods courses for preservice mathematics teachers. Information about each program's approach in these three areas provides evidence about the nature of the preserve teacher's experience as a learner of mathematics and mathematics teaching at each of the responding institutions. In addition, such information provides preliminary evidence on whether or not the programs have incorporated the recommendations outlined in the national documents.

Responses from each institution to survey questions 9 and 10 were used to place the institution in one of two categories, 'traditional-orientated and reform-orientated', with respect to the practices used in content and methods courses. A summary of the categorization is provided in Figure 3. As the summary indicates

more institutions were categorized as 'reform-orientated' relative to methods courses than with content courses.

Figure 3

Questions 9-11:

Instructional practices	Content courses	Methods courses
Traditional-oriented	6	
Reform-oriented	4	10
Not sure/vary	3	2

Examining each of the three areas (instructional format, technology, and assessment) more specifically yield that the primary type of instructional format experienced by preservice mathematics teachers in mathematics content courses is the lecture format and that the assessment formats in these courses are primarily tests and quizzes. The following are representative of the responses in this area:

- Content courses in Math Ed Program – small cooperative groups 40%, whole class discussion and activities 40%, lecture 20%. Content courses in Math Dept – lectures and recitation 100%

- For the most part these [mathematics content courses for preservice teachers] are traditionally-taught classes (35 students, max). However, some of the classes taken mostly by teachers (Foundations of Geometry, History of Math) have had their formats broadened to include problem investigations in groups, presentations, discourse in which professor facilitates.

As indicated in the last quote, several of the surveys state that if the mathematics content courses are primarily for teachers, the approaches might include more variety but that lectures, tests and quizzes are still the predominant approaches. The situation in the mathematics methods course appears to be radically different. A variety of approaches (individual and group tests, journals, projects, portfolios) are listed in both the areas of instruction and assessment. Although lecture, tests, and quizzes still appear as approaches they are not the predominant approach.

In the area of technology there does not seem to be as much of a distinction between the two types of courses, methods and content. Most of the

responding institutions indicate that technology is used in both the methods and content courses. The distinction may be in the types of technology used and in how the technology is applied in each situation; to explore content as a learner of mathematics, or to explore what technology is available at the precollege level and how it can be implemented in the classroom.

The commonalties in approaches to instruction, assessment, and technology across the responding institutions in this study provide preliminary evidence on the nature of preservice teacher education throughout the United States. For the most part the programs could be classified as 'traditional-orientated' particularly with respect to the mathematics content courses. Additional research would be necessary to determine if this sample is representative of the whole. We suspect the answer is "yes".

The dichotomy between the instructional and assessment approaches in mathematics content versus methods courses might be explained in several ways. First, the nature of the content in each of the courses could influence the approach. For example, a predominant belief that school mathematics is a system of predetermined skills and related concepts may make it "easier" to lecture. On the other hand, the content of a methods course, exploring teaching principles, may be naturally more conducive to discussion and expressing opinion. A second explanation could be that the instructors of the methods courses are more aware of and in agreement with the national recommendations and are modeling the types of experiences supported by those recommendations. In reality it may be some combination of the two. More information is needed.

The dichotomy is also interesting in light of research that suggests that there is a strong relationship between a teacher's subject matter understanding and his/her pedagogical decisions and practices (McDiarmid, Ball, and Anderson, 1989). In addition, research and the reform recommendations for teacher education suggest that prospective teachers need to experience mathematics as learners in a way consistent with how they will be expected to organize instruction as classroom teachers (Ball, 1996; NRC, 1996). The survey results indicate these types of experiences may not be occurring to any great extent; prospective mathematics teachers are not getting consistent experiences in courses where they are learners of mathematics. As a result prospective teachers are receiving mixed messages, a particular approach to teaching and learning is modeled in mathematics education courses but the students are typically not experiencing this approach in mathematics content courses. The approach is valued an advocated in one setting

and not in another. Further research is needed to determine the effect of these differences on the development of the preservice teacher and how these differences in approaches can be mediated.

The Role of the Standards Documents

All of the respondents reported that students in their programs have exposure to one of the standards documents with the *Curriculum and Evaluation Standards* (1989) being referred to most often. Comments indicate a range of experiences and exposure to the documents; "C&E [*Curriculum and Evaluation Standards*], PTS [*Professional Teaching Standards*], and HS Addenda [NCTM High School Addenda Series] are texts for methods", "read and discussed in all methods courses", "students in methods evaluate sample portfolio questions and responses", "at secondary level they are required reading, basis for curriculum selection project, frameworks guide our assessment of clinical experiences, INTASC [*Interstate New Teacher Assessment and Support Consortium*] framework used as portfolio framework", "foundation of topics in methods courses, topics investigated in detail", "all receive copies", "standards used to structure courses", "bring in experts to discuss", "We have at least two lessons focused on discussing state and national curriculum frameworks and standards. At least one expert will be invited to speak on either state curriculum frameworks or national standards."

Responses to the question of what additional efforts might be in place to incorporate/implement the NCTM *Standards* in developing preservice teacher education programs are again varied in both the level and type of experience. Most institutions reported no additional efforts to the ones stated above that involve some familiarity and reading of the document. Several indicated that the pedagogy implied by the standards documents is modeled in the methods courses for preservice teachers. Only one indicated that "the pedagogy of the standards is modeled in all methods and content courses".

In summary, it appears that although students are gaining exposure to the state and national level recommendations they may not be experiencing those recommendations as learners. This in turn may have implications for whether or not they are able to apply the recommendations when developing their own classroom practice.

Field Experiences

Survey questions 12-14 relate to the field experiences for preservice teachers which have traditionally been a significant part of the preparation of teachers. Although research on the significance and value of such experiences is mixed, it is important to examine these practices given recent emphasis on learning through teaching practice and the emphasis being placed on the first several years of teaching (MSEB, 1996). The number of weeks for a student teaching or internship experience at this sample of institutions ranged from 8 weeks to 25 weeks. Most respondents reported that students participate in other types of field experience prior to a more formal concentrated student teaching or internship experience.

Research studies indicate that interns/student teachers perceive their cooperating teachers as having the most significant influence during their field experience. However, the most of the responding institutions indicated that they do not have formal criteria for selecting cooperating teachers. Several institutions mentioned that cooperating teachers must take a course, others listed some criteria such as "acknowledged leader, involved in curriculum reform projects, experienced mentor" but it is unclear how these were evaluated. Several mentioned that it was an education department program and they did not know how the selection process occurred. So, it is interesting to note that despite the importance of this individual in the development of a prospective teacher mathematics teacher educators may typically have little, if anything, to say about who is selected and the nature of the field experiences.

The assessment of the student teaching or internship experience is by its nature performance-based. Traditionally this assessment has been more informal, the cooperating teacher and/or college supervisor observe, evaluate, and make a recommendation. The surveys provide evidence that this process is becoming more formal at several of the institutions. Several of the institutions mentioned that they are developing performance-based assessment methods and more explicit guidelines or rubrics. The following is a sample of responses to a question asking respondents to describe how prospective teachers are assessed:

- Formative and summative assessment, portfolios, performance assessment, and 3-way evaluations involving the supervisor, mentor, and student.

- Cooperating teacher and college supervisor (hired and supported by math dept) each evaluates using a form developed by teacher education. Math dept currently working to develop an approach that will set standards for performance of pre-service teachers, then assess against these standards.

- Secondary level – INTASC & other frameworks are used for performance-based assessment. We have developed an attribute list and rubric to be used during observations of student teachers, as well as mid-term and final evaluations.

Summary and Next Steps

The information presented in this paper is preliminary and based on data collected from a small number of institutions. However, some commonalties are evident in terms of program requirements and curriculum, and use of reform-oriented practices. For example, most of the institutions responded that the mathematical preparation of the elementary teachers was limited to one or two content courses and a methods course. Middle school programs are still being developed at several institutions and even when they exist they appear to be a combination of the secondary and elementary experiences. At the secondary level a focus on learning mathematics content predominates. At all levels, there appears to be a dichotomy in the instructional and assessment approaches used in the content and methods courses. The approaches in the methods courses appear to be more consistent with the reform recommendations. The lack of more standards-based experiences in mathematics content courses may act as a hindrance to the national and state level recommendations for change in the teaching and learning of K-12 mathematics.

The description of mathematics teacher preparation programs represented here, at least on the surface, appears fairly traditional in terms curriculum structure and program requirements. In fact, the current structures are similar to the ones that have been in place for at least the last 75 years. Components of this structure include courses in subject matter preparation, courses in professional education, at most two courses in subject matter specific methodology, and a supervised field experience. So, on the surface the reforms in teacher preparation may appear to have had no effect. However, the data collected as part of this study indicate that there may be changes that are not evident by just looking at the structure of the programs. The changes may be occurring initially in what types of approaches to content and methods preservice mathematics teachers are experiencing within their

courses and within their field experiences. Several of the institutions mentioned future directions that may lead to more substantial changes in the preparation of mathematics teachers than is evident from the data collected in this study. Examples of these future directions include:

- Tie secondary methods course to a co-requisite of working as a peer tutor in the basic math program. This would facilitate discussion of students' difficulty with content.
- Working on revising math dept courses to better reflect *Standards*, increasing communication with Department of Education.
- Piloting new field experiences at secondary level – early field experiences and give us more say in final placements.
- Revamping secondary program and restructuring methods and content, adding and enhancing clinical experiences, and revising performance-based assessment of students.
- Separate middle school program and explore distance education and technology.

The types of activities mentioned here, restructuring methods and content courses, increasing communication, examining performance-based methods, are supported by current recommendations and could lead to programs that are more coherent and consistent.

Further research is needed to determine if the sample responding to the initial survey is representative of the national state of mathematics teacher preparation and what are the implications for the future. This preliminary information could be used to survey a larger sample of institutions in order to examine a broader array of program and course requirements. More qualitative information on selected programs could be collected to provide further details and confirming evidence. This might include site visits, an examination of curriculum materials and assessments used in the courses, observations of field experiences, and interviews with faculty, students, cooperating teachers, and program graduates. Further research is also needed to explore in more detail the relationship between a preservice teacher's learning experience in preparation programs and their classroom teaching practice.

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