

The Mathematical Education of Teachers: One University's Approach

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Abstract

This study focused the collaborative efforts between the Curriculum and Instruction and Mathematics departments at the University of Alabama. These efforts resulted in the development of following courses: 1) numbers and operations, 2) geometry and measurement, and 3) algebra, data analysis, statistics, and probability. The purpose of these courses is to provide the content knowledge needed for teaching elementary mathematics. Survey data informed the departments of the following: a) the number of students taking one or more of these courses at the UA, b) which courses the students were taking, and c) how they felt about the courses in terms of preparation for mathematics in the elementary classroom. The findings suggest that large numbers of the students were taking these courses on-campus and that the courses were indeed helpful in their preparation of becoming a teacher. The implications for this study support the collaborative efforts of the two departments.

In recent years there has been renewed interest in the mathematical preparation of pre-service elementary school teachers. In 2000, The Conference Board of the Mathematical Sciences issued a report entitled *The Mathematical Education of Teachers* (often referred to as the MET report). The report was a response to the growing recognition by mathematicians and mathematics education researchers of “the special nature of the mathematical knowledge needed for K-12 teaching and its implications for the mathematical preparation of teachers”. In addition, many states increased the content course requirements for pre-service teachers in response to the No Child Left Behind legislation. In 2003, the University of Alabama’s Department of Mathematics, College of Arts and Sciences, and Department of Curriculum and Instruction,

School of Education, began a collaboration to design a sequence of three mathematics content courses for pre-service elementary school teachers. When we started our work, there was only one math content “grab-bag” course specifically for elementary school mathematics. Based on results from research available and recommendations of national organizations (such as NCTM and the CBMS Mathematical Education of Teachers report [2000]), we developed curriculum materials for three mathematics courses designed specifically for pre-service elementary teachers.

The framework for the development of these courses is based on the primary recommendation of the MET report that “prospective teachers need mathematics courses that develop a deep understanding of the mathematics they will teach”, further informed by two big ideas--profound understanding of fundamental mathematics as described by Ma (1999) and mathematical knowledge for teaching as described by Ball & Bass (2000). Ma’s definition of *profound understanding* of fundamental mathematics includes four components (1999):

- 1) Connectedness: a teacher with profound understanding has a general intention to make connections among mathematical concepts and procedures
- 2) Multiple Perspectives: those who have achieved profound understanding appreciate and can provide mathematical explanations for different facets of an idea and various approaches to a solution, as well as their advantages and disadvantages
- 3) Basic Ideas: teachers with profound understanding revisit and reinforce ‘simple but powerful basic concepts and principles of mathematics’
- 4) Longitudinal Coherence: teachers with profound understanding are ready at any time to exploit an opportunity to review crucial concepts that students have studied previously and are able to take opportunities to lay the proper foundation for what students will study later.

In order to determine *mathematical knowledge for teaching*, i.e. pedagogically useful mathematical understanding, Ball and Bass (2000) describe an analysis of core activities of mathematics teaching. Core activities of teachers include such things as “figuring out what students know; choosing and managing representations of mathematical ideas; appraising, selecting, and modifying textbooks; deciding among alternative courses of action; and steering a productive discussion.”

How such courses are taught is just as integral to the design of these courses as the topics chosen on which to focus. The content courses are not methods courses but we wish to model the kind of learning environment we want elementary school teachers to create for their students. The MET report recommends that “mathematics courses for prospective teachers should develop the habits of mind of a mathematical thinker and demonstrate flexible, interactive styles of teaching”. The courses are **activity based**. The activities engage students in thinking and problem solving and not just applying procedures. They are designed to allow students to

develop or discover concepts and make connections, building on knowledge they already possess. Interaction with students while working on activities allows the instructor to get a sense of students' prior knowledge, understanding and misconceptions. This models what we want elementary school teachers to be able to do with their students. The courses have a focus on **multiple representations and strategies**. These often arise naturally from students' own work in the activities. From this base the instructor can encourage students to compare and contrast and make connections among strategies and representations. Understanding is promoted by **reflection and communication**. Students are encouraged to share their strategies and thinking with the instructor, with their peers in small groups, and in whole class discussions. Explanations of the why, not just the how, are emphasized at all times. Throughout, the instructor models good classroom discourse while encouraging students as they engage in activities and facilitating whole classroom discussions to bring out understandings developed by the activities.

At the University of Alabama, we currently offer each semester three sections of the Number and Operations course (Math 208), two sections of the Geometry and Measurement course (Math 209), and one section of the Algebra, Probability, and Data Analysis course (Math 210). Each course is fully enrolled at 32 students per section. The courses are taught in a specially-designed classroom with tables seating four students per table in order to facilitate group work on activities. The classroom is a multimedia classroom that is also equipped with a variety of manipulatives (such as base ten blocks, interlocking cubes, centimeter/gram cubes, balance scales, and so forth) The courses have been mostly taught by tenured mathematics faculty; we are now beginning to involve full time instructors in teaching these courses.

An important note in this study is that the Math 208, 209, or 210 courses are not required by the elementary education program. There is a strong recommendation that the students take these courses but the choice remains up to the student. Another program note is that there is only one math methods course that covers content and pedagogy Kindergarten through Sixth grade. Due to the limited amount of instruction for pedagogy, it is important for us to understand the impact of the content mathematics courses for elementary education majors. Therefore, we decided to investigate what courses the students were taking and where they were taking them to help evaluate our collaborative effort. In this paper we discuss some measures of impact of our effort to better prepare elementary education majors to teach math in the schools.

Participants

The elementary education program at the University of Alabama has had a consistent increase in enrollment over the past few years. Table 1 demonstrates the growth of the program since fall 2005. During the 2007-08 school year, the pre-service elementary education majors taking the math methods course were given a survey about their mathematics backgrounds and the courses they have taken during their college experience. There were a total of 132 respondents to the survey.

Table 1. Enrollment of Elementary Education Majors at UA

Semester	Enrollment
Fall 2005	23
Spring 2006	39
Fall 2006	33
Spring 2007	61
Fall 2007	44
Spring 2008	88

Survey

A survey was administered to find out more about the mathematical backgrounds of our current elementary education majors. The survey asked the following three questions:

- 1) List all the math courses have you taken.
- 2) Did you take 208,209, or 210? List which ones and where you took the courses.
- 3) Do you feel that 208, 209 or 210 help prepare you for the math methods course?
How?

The purpose of the survey was to determine several things. First, how many of the students were taking the math courses for elementary education majors at the University of Alabama.

Secondly, which courses were they taking? Lastly, how did they feel about the math courses in terms of preparation for the elementary math methods course? The data was collected and basic analysis was conducted looking at frequency and themes in the responses.

Findings

There were several interesting findings from the survey data. The first finding was that 85% of the elementary education majors had taken at least one math course designed for elementary education majors. This finding is significant because, while these courses are not required by the elementary education program, our students are electing to take 208, 209 or 210.

After determining how many students took at least one of these courses, we further investigated which courses they took. Table 2 demonstrates what percentage of our students took each course. These findings suggest that our students predominately take the Number and Operation course. One reason for this may be due to the fact that many students only need one more math course to complete their mathematics requirement.

Table 2. Percentage of students taking each math course

208- Number and Operation	84.3 %
209- Geometry and Measurement	74.7%
210-Data Analysis, Probability, & Algebra	53.9%

The data was further analyzed to determine how many courses the students were taking at the University of Alabama. This analysis found that 85% of the students took at least one of the three courses at UA. 67% of the students took two of the three courses at UA. Only 29% of the respondents took all three courses at the University of Alabama. Knowing that 67% of the students were taking two courses at UA, we further investigated what combination of courses the students were taking. Table 3 displays the percentage of the two-course combinations the students elected to take.

Table 3. Percentage of students taking the various combinations of two courses.

208 & 209	60%
208 & 210	23%
209 & 210	17%

The findings from the survey data provided us a picture of what courses students are taking to prepare themselves to be elementary school teachers. This is only one piece of the findings from this survey.

The responses to the final question of the survey provided a qualitative insight into how elementary education majors perceived 208, 209, and 210 to be helpful in preparing them for the math methods course. In terms of a yes response to this question, 95% of the respondents reported that these math courses for elementary education majors were helpful in their preparation for the math methods course. Three themes emerged from the survey data. The first theme that emerged was that the students began to think about conceptual understanding of mathematics. Second, the students described how the math courses for elementary education majors helped them to begin thinking like teachers. Lastly, the theme of children's thinking was important to the students. These key ideas provide insight and support for our efforts.

Conceptual understanding of mathematics is vital when teaching elementary mathematics. "The concepts taught in 208 and 209 are different than any other math class I have taken before." This was a common statement from many students. Students also frequently mentioned that "I learned how to write my thoughts and processes in Math 208 and 209." By having the students learn how to articulate their thinking, the courses help to solidify conceptual understanding of elementary mathematics. One student clearly stated the purpose and intent of our collaborative efforts. "Math 208 and 209 deal with conceptual understanding and 380 [the methods course] demonstrates how to teach math."

Preparing teachers is our duty. The theme that the math courses for elementary education major helps prepare them to be a teacher is answering the call that we have been charged with. "The math classes focused our perspective as future teachers." Students found that learning mathematics as set forth in 208, 208, and 210 helps them to begin to think about teaching. "These courses are good at teaching concepts. The other math classes I have taken at Alabama only taught the procedures. Elementary education majors NEED these courses because they have

to know how to explain mathematics to kids.” This idea was reiterated by many students in the survey sample.

Lastly, the data suggests that Math 208, 209, and 210 helped prepare the students to think about how children view mathematics. One student stated it very succinctly, “These classes helped me to think about how children think about math.” The students’ comments suggested that many of them felt the same way about the courses. “I now realize there are many ways to think about mathematics and that is important for children to understand as well. There may be kids in my class that don’t think like I do and I have to understand that as a teacher.” Children’s thinking about mathematics can be varied and this data suggests that math content courses are helping future teachers to start thinking about this prior to their arrival in the classroom.

The development of conceptual understanding, helping to prepare future teachers, and investigating children’s thinking of mathematics were the three themes that emerged from this survey. One student’s response validates our collaborative efforts, “Before those classes I never thought about the WHY of math. I just DID the math.” This shift in thinking is our goal as mathematics educators.

Implications

There are two major implications from this study. First, the collaboration between the Mathematics and Education Departments has had positive benefits for the elementary education majors at the University of Alabama. Secondly, elementary education majors are ready to learn elementary mathematics pedagogy as a result of the math course that reinforces the mathematics content necessary to understand various instructional approaches.

The collaborative effort of the Mathematics and Education Departments has been a fruitful effort. Through the development of 208 (Number and Operation), 209 (Geometry and Measurement, and 210 (Data Analysis, Probability, and Algebra) courses, the students are better prepared in the mathematical content they are expected to teach in the elementary classroom. This collaboration has addressed many of the needs of the pre-service teachers. The qualitative data from the survey suggests that our students feel that these courses help to develop their conceptual understanding of the mathematics that they will teach. The students also stated that the math courses for elementary education majors helped them feel more prepared to be a teacher. The collaborative efforts between the departments not only demonstrate effective teaching methods but also reinforce essential mathematical principles that are necessary for elementary teachers.

One of the strongest outcomes of the development of these courses is that students have the ability to really think about mathematical processes which are a critical element of mathematics instruction. Given that such a large percentage of the elementary education majors are taking the Number and Operation course, we note that we are helping to prepare them to really think about the majority of the mathematics they will be teaching. This is a win-win situation. Thus the students are provided the content background for teaching mathematics in the elementary classroom. By using similar activities in the mathematics courses and the methods course, the students in the methods course can now focus on the “how” of teaching mathematics

since there is a basic understanding of the mathematics concepts involved. Responses from the students in the survey data support that the students recognize and appreciate this. In the math methods course, more time can be spent emphasizing pedagogy and less time spent on backfilling content knowledge. This allows the students to be better prepared to teach math in the elementary classroom.

The collaborative efforts between the mathematics and education departments at the University of Alabama have begun to provide a strong foundation for elementary education majors. These efforts should and must continue for the sake of not only the college students but for children in classroom across the state of Alabama.

References

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Dr. Julie Herron is a new assistant professor of elementary mathematics in the curriculum and instruction department at the University of Alabama. Her research interests include early childhood mathematics, culture and mathematics as well as technology and mathematics instruction with pre-service teachers. She also is interested in continuing the collaborative efforts between the Mathematics and Curriculum & Instruction departments at the University of Alabama.

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