

## Revising and Assessing Content Courses for Elementary Teachers

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Revising mathematics courses for elementary teachers involves much more than drafting new syllabi; it involves researching current standards that impact elementary mathematics teaching, reviewing studies and literature on the depth of the mathematics required for teaching, and providing professional development that lead to the utilization of best practices. Much of these goals have been accomplished recently at Columbus State University, with the support of a PMET Mini-grant and the dedication of the mathematics department to improving the mathematical knowledge of elementary teachers.

The two year project was designed to review and revise the courses we offered in the mathematics department to inservice elementary teachers and to establish an ongoing assessment system.

### Project Background

In the 1999, Columbus State University developed a series of four courses that were designed to improve the mathematical content knowledge of future teachers and to meet the requirements of our state board of regents. These courses included:

- Nature and Use of Numbers 1—an exploration of basic concepts and operations of rational numbers and generalizations to algebra.
- Nature and Use of Numbers 2—an exploration of basic concepts and operations of real numbers and generalizations to algebra.
- Data Analysis, Statistics and Probability—an exploration of data collection, data representation, data analysis, and probability.
- Exploring Geometry and Measurement—an exploration of geometry and measurement topics through the use of a variety of tools. Topics include formal definitions, elementary constructions, ratio and proportion, and area and volume.

These courses were first offered in the fall semester of 2000 and were required for all graduates of our early childhood education majors. Subsequent to the development of our mathematics coursework, national organizations have produced standards clarifying the content knowledge preparation of mathematics teachers including the *Mathematical Education of Teachers* (Conference Board of the Mathematical Sciences, 2001) and the *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics, 2000). In addition, the state of Georgia has revised the mathematics content standards for K-12 schools, the *Georgia Performance Standards*, which is

already impacting the mathematical content knowledge requirements of our preservice teachers.

With the development of these standards, our department was concerned that we were not providing the level of depth required in these courses and applied to the PMET mini-grant to support the assessment and revision of these courses.

### The Revision Process

Prior to engaging in a review of these courses, we invited a colloquium speaker, Dr. Sybilla Beckman-Kazez, to participate in a cornerstone event that would promote discussions of the need to revise our coursework. Dr. Beckmann-Kazez is a research mathematician that has been actively involved in the Center for Proficiency in Teaching Mathematics and is the author of the text, "Mathematics for Elementary Teachers." Her talk was attended by all but two of the mathematics department faculty, resource middle grades and elementary teachers from the campus' Mathematics Collaborative, colleagues from the College of Education, and the deans from the Colleges of Education and Science. Dr. Beckmann-Kazez's presentation of the research related to mathematical knowledge required for teachers lead to subsequent discussion of the importance of revising these courses and the establishment of a committee to revise the syllabi that were currently in use.

Over the following summer, four committee members consisting of two mathematics faculty and two college of education faculty met to revise the syllabi. These syllabi were reviewed by all the principal investigators, which included Dr. Muse, a mathematician, Dr. Henning, a mathematics education, and Ms Hope Phillips, a local teacher, to examine their alignment with current Georgia Standards.

In sum, eight course syllabi were designed to improve the mathematical knowledge of both preservice and inservice teachers. Inservice teachers were considered due to the implementation of a new state curriculum, which requires them to have a much deeper knowledge of the mathematics they are teaching, and to provide coursework for them that could lead to a mathematics endorsement on their teaching certificate. Therefore, we wanted to provide not only four revised courses for our preservice elementary teachers, but add four courses for inservice elementary teachers to deepen their knowledge of mathematics.

The foundational mathematical topics for the courses for both inservice and preservice teachers would need to be the same, however, they would need to be differentiated based upon the professional development level of the particular populations. Though our department felt strongly that the courses be differentiated in some manner, we were equally adamant that preservice teachers would greatly benefit from having inservice teachers in the same course, providing insights into elementary classroom learning. After meeting with colleagues in the college of education and consulting with local teachers, we decided to provide separate foundational courses that established learning norms for each population, based upon the topic of Numbers and Operations. Subsequent courses

would be offered concurrently. These courses, based on Algebra & Proportionality, Data Analysis & Probability, and Geometry & Measurement, are offered at the same time to allow preservice and inservice teachers to interact, but have distinctly different requirements for inservice teachers

#### Understanding Numbers and Operations (for Pre-Service Teachers)

Designed as the first course in the sequence, it establishes problem solving methods, emphasizing the use of multiple strategies, as a vehicle for learning mathematics that is integrated into all four courses. Within this framework, students study the development of number systems, including whole numbers, integers, rational numbers (fractions) and real numbers, and examine the relationships between these systems. A significant portion of the course is also devoted to understanding operations and analyzing a variety of algorithms used in elementary schools.

#### Understanding Numbers and Operations (for Inservice Teachers)

Many of the mathematical topics overlap with the previous course, however this course is also designed to establish deep connections between these topics and the mathematics inservice teachers observe in their elementary classrooms. Inservice teachers in the course will analyze video-taped interviews of elementary students learning mathematics to learn to conduct independent action research projects related to mathematical topics in subsequent courses.

Understanding Algebra and Proportionality (Taught concurrently). This course begins by extending the concept of fraction to examine proportional relationships which leads to a deep examination of algebra topics that are relevant for elementary school teaching. Number theory, functions, pattern recognition and elementary mathematical modeling using technology, are all examined during the course through a variety of problem solving activities. Preservice and inservice teachers learn these topics together, but inservice teachers are required to complete independent projects that involve observing their students learning about algebra and proportionality.

Understanding Data Analysis and Probability (Taught concurrently). . Students taking this course will learn how to make decisions and predictions through collecting, representing, processing, summarizing, analyzing, and transforming data taken from real-world scenarios. In addition, the course is designed to develop students' understanding of basic probability concepts. Both the statistical and probabilistic topics are shown to be embedded within the elementary curriculum and can be used to connect mathematics to other curricular topics through data collection in sciences and social sciences. Again, preservice and inservice teachers learn these topics together, but inservice teachers are required to complete independent projects that involve observing their elementary students collecting and analyzing data.

Understanding Geometry and Measurement (Taught concurrently). . This course is designed to broaden student understandings of fundamental concepts of

geometry and measurement. Particular attention is given to developing multiple methods of solving geometry problems using transformations, projections, coordinates, or other pure deductive reasoning methods, and using manipulative objects or technological tools such as Geometer's Sketchpad to develop definitions and conjectures. Preservice and inservice teachers learn these topics together, but inservice teachers are required to complete independent projects that involve observing their elementary students learning geometric concepts.

The topics of these courses were developed using the *Mathematical Education of Teachers*, produced by the Conference Board of Mathematical Sciences (2001), as a guide. However, during the development of the syllabi, our discussions also recognized the importance of how those topics would be delivered to best achieve deep mathematical understandings and help student connect the mathematics they were learning to the content they would one day teach. These discussions were heavily influenced by many of our faculty who attended a local conference sponsored by TEAM Math (Transforming East Alabama Mathematics), a project funded by the National Science Foundation. At this conference Dr. Deborah Ball presented her work related to the mathematics elementary teachers must know to teach the subject.

In a related article, Ball, Bass and Hill (2004) defined what they term as *Mathematical Knowledge for Teaching*, a specialized knowledge teachers encounter during instruction. Through focused observations of elementary classrooms, the researchers identified explicit mathematical activities in which teachers engaged, including:

- Articulating explanations that are mathematically accurate and useable for students;
- Creating and evaluating mathematical definitions;
- Using multiple representations for problem solving and mapping between representations;
- Interpreting and evaluating students' mathematical work;
- Responding productively to questions and mathematical curiosity;
- Appraising the quality of instructional materials and making necessary modifications; and
- Posing rich mathematical problems or questions.

(Ball, Bass and Hill, 2004)

While this work influenced the development of the syllabi, we also found that articulating topics or objectives that promote these particular notions was challenging.

#### Establishing An Assessment System

Clearly, the syllabi will continually need to be reviewed and revised to incorporate current research in the field of mathematics education, so our final accomplishment was to establish an assessment program that can provide insights into the impact of the new courses that were developed. With the support of the PMET mini-grant, we were able to acquire and received training on an instrument designed to measure the mathematical knowledge of elementary teachers, developed by the Center for Proficiency in Teaching Mathematics, located in Dearborn, Michigan. Beginning in January 2006, when the first

of the new courses were implemented, all students in the Understanding Numbers and Operations course were administered the instrument. Subsequent administrations were also completed at the end of the Algebra & Proportionality and Geometry & Measurement courses. Analysis of this data has not yet been completed as of the date of this report; however we are hopeful that the new courses will reveal positive results.

In the upcoming semester, which is the final semester of the grant, we also plan to engage a focus group of recent graduates and inservice teachers to receive additional feedback about the mathematical preparation of elementary teachers. We are hopeful that these teachers may provide insights into the pedagogical methods used in the courses as well as the topics and level of depth that are addressed in the courses.

The PMET Mini-Grant provided not only the funds to support the review and revision of our courses, but also the opportunity to structure and focus on the courses during the period of the grant. However, with the establishment of the assessment program, the grant has helped to develop a framework for continual evaluation and revision of our courses that should persist after its conclusion.