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**The Preparation of Elementary Teachers  
at Austin Peay State University**

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Abstract

The mathematics education faculty at Austin Peay State University (APSU) has an unusually cooperative and collegial relationship with the rest of the mathematics department. This relationship springs from mutual respect for the role that each faculty member plays in the department, and it makes possible a number of productive collaborations that ultimately benefit all students. Some of these collaborations are discussed. Finally, the elementary education program at APSU is described. This program is the result of cooperative planning, effective use of resources, and strategies that help students examine their own mathematical thinking as well as the thinking of children. Based on this knowledge, students learn to plan significant mathematical experiences for children as they deepen their own understanding of mathematics.

It is mid-September and the mathematics department of Austin Peay State University (APSU) is preparing to host the annual conference of the Tennessee Mathematics Teachers Association (TMTA). One professor is arranging for the printing and placement of signs for the meeting. Another is arranging for parking. Another is planning food for a reception. The chair of the department is working with another faculty member to set up the registration site. These faculty members are not mathematics education faculty, yet they have volunteered their time to make this a successful event. This is the attitude with which the mathematics department approaches every task – cooperation, congeniality, and collegiality.

The mathematics education program is housed in the mathematics department at APSU. There are four full-time faculty members, Mary Lou Witherspoon, Jackie Vogel, Andy Wilson, and myself. However, other mathematics faculty members usually teach some mathematics education courses. For example, David Cochener, an algebraist, usually teaches one to three mathematics education classes during an academic year. In turn, the mathematics education faculty teaches some courses for non-education majors. Led by Mary Lou Witherspoon, the mathematics education faculty works within the mathematics department and the greater university, as well as with local school districts, to improve the mathematics education of all students. In addition, they have worked extensively on statewide efforts to improve teacher

education. Without the unique collegial atmosphere in the mathematics department, much of this work could not easily be accomplished.

There are probably a number of reasons why this unusual collegiality exists among the 21 full-time mathematics faculty. The chair of the department has a background in mathematics education, for example. It might simply spring from a southern tradition of politeness and courtesy. However, the most compelling reason seems to be an extraordinary depth of mutual respect for the role that each faculty member plays in the department.

### Statewide, University, and Mathematics Department Initiatives

The importance, as well as the challenges, of the mathematical preparation of elementary teachers is well-documented (Conference Board of the Mathematical Sciences, 2001). At APSU, many students come to mathematics education courses lacking even a working knowledge of high school mathematics. This is an ongoing challenge in planning curriculum. The need is even greater in light of the impending implementation of new Tennessee K-12 curriculum standards. These standards require that teachers engage students more deeply in the process of learning mathematics. University mathematics educators across the state are working to help teachers understand this role.

The APSU mathematics education faculty has taken a leadership role in this effort. The theme of the TMTA conference hosted by APSU was *Rolling on the River of Mathematics: Anchored in the Standards*. The new curriculum standards provided the major focus of the conference. As noted earlier, mathematics faculty worked together to make this conference a success, several making presentations at the conference. In addition, the conference pre-session was a meeting of the Tennessee Association of Mathematics Teacher Educators of which Mary Lou Witherspoon is the president. In this session, mathematics and education faculty from across the state came together to discuss how they could help with the implementation of the curriculum standards.

At APSU, there is a strong emphasis on addressing student needs early on through an early alert system to target struggling students and through university-wide emphasis on student retention. Since APSU has a freshman retention rate of 73 percent, the lowest in the state, this is a matter of critical importance. Since mathematics is one area in which students often struggle, the mathematics department is working cooperatively to address gaps in students' knowledge of basic mathematics. Clearly, strengthening the overall mathematics program will strengthen the mathematics education program as well.

Historically, one way to address student mathematical deficiencies has been the teaching of developmental mathematics classes. The current effort of the Tennessee Board of Regents (TBR) is to offer developmental courses in community colleges or in classes offered through the Regents Online Degree Programs. Universities are left to find alternatives to serve those students who are enrolled in the university but clearly have deficiencies that need to be addressed. To help universities deal with this problem, TBR awarded grants to six post-

secondary institutions. APSU received one of these grants to re-design the curriculum to meet the needs of students with mathematical deficiencies.

The first step by the APSU administration was to essentially eliminate most developmental mathematics courses and to re-assign that faculty to other university positions. These courses were replaced by enhanced courses (E-courses). The mathematics department was charged with developing and teaching mathematics E-courses with Nell Rayburn leading this effort.

E-courses are designed to serve students with ACT mathematics scores of 18 or below. Two existing courses have been targeted to develop enhanced versions. These courses are MATH 1010, Mathematical Thought and Practice, a project-based course, and MATH 1530, Elements of Statistics. Essentially, the course instructors teach these courses as they normally would. However, students enrolled in MATH 1010E and MATH 1530E must also attend two hours of mathematics laboratory weekly. Pre-tests are used to determine students' mathematical deficiencies. Regular laboratory attendance is mandatory, and the target grade for the class is "C." At the end of each course, students take a post-test to determine if deficiencies have been eliminated.

Laboratories are led by students who have a good knowledge of mathematics and who have been trained to organize laboratories around lesson plans with targeted objectives. In addition to organizing laboratory experiences, these leaders attend all regular class meetings, meet with the course professor weekly, and provide assistance with specific course objectives as well as with deficiencies.

This effort involves most of the mathematics faculty. Both mathematics faculty and mathematics education faculty teach these courses. Because the enhanced courses have only been offered for three semesters, there is no clear data with respect to their effectiveness. If the effort is successful, there should be a positive effect on the mathematical preparation of elementary teachers since elementary education majors must take MATH 1530 and since many of these students have significant gaps in their knowledge of mathematics.

The development of the enhanced courses has been a long, detailed effort and a great deal of work for all involved. However, even if these courses are successful, there are still students who have needs that should be addressed.

In the spring of 2008, Dr. Witherspoon and Dr. Rayburn researched the success of students in mathematics courses compared to their ACT mathematics scores. For example, based on historical data, they concluded that students with ACT scores of 22 or 23 have only a 50 percent chance of success in calculus. Therefore, it makes sense to recommend that students enroll in this class only if they have a minimum ACT of 23. The research indicated that students with ACT scores between 19 and 22 had pass rates of 50 percent or less for all freshman level mathematics courses except MATH 1010 and MATH 1410 – MATH 1420, Structure of Mathematical Systems. A committee consisting of mathematics faculty and mathematics education faculty proposed the development of a problem solving class that would address the needs of those students with ACT scores between 19 and 22.

In response to this proposal, Dr. Witherspoon designed MATH 1110, Algebraic Problem Solving. This is an activity-based problem solving course for students who need college algebra skills for their majors or who need to improve their algebra skills in order to take higher level mathematics courses required for science or mathematics majors. The philosophy guiding the course is that students learn in different ways and that it is more important to understand how algebra works than to just memorize rules. Through data collection, students explore a variety of functions and represent these functions in tables, graphically, and algebraically, using technology when appropriate. Dr. Witherspoon and Dr. Vogel taught the first sections of the course in the fall of 2008. MATH 1110 is presently considered a pilot course, but it has been approved as a core option beginning in the fall of 2009.

Considering the results of their research, Dr. Witherspoon and Dr. Rayburn developed a comprehensive advising sheet for all freshman level mathematics courses. Based on their advisees' ACT scores and on requirements for their majors, advisors can make specific recommendations to students. For example, if a student is required to take precalculus and has an ACT score of 23 or better, she should enroll in precalculus. If her ACT score is between 19 and 22, she should enroll in MATH 1110 and take precalculus after that. If her ACT score is 18 or below, she should enroll in an E-course, then MATH 1110, and then precalculus.

The successful implementation of MATH 1110 exemplifies the benefits of cooperation and collaboration between mathematicians and mathematics educators. A similar collaboration has recently begun with respect to the possible re-design of Elements of Statistics.

At APSU, students seeking K–6 licensure take the following courses.

- MATH 1410 – MATH 1420: Structure of Mathematical Systems (6 hours)
- MATH 1530: Elements of Statistics (3 hours)
- MATH 4100: Teaching Mathematics in Grades K–3 (3 hours)
- MATH 4150: Teaching Mathematics in Grades 4–6 (3 hours)

Among mathematics educators across the state of Tennessee, there has been an ongoing concern about how to best structure MATH 1410 and MATH 1420. In response to this issue, in 2004 the APSU mathematics education faculty organized and hosted the first *MATH 1410 – MATH 1420 Conference*. The goal was to begin a statewide dialogue on the challenges of teaching these important first courses in preparing K–6 teachers. This conference has become an annual event at which mathematics educators from across the state meet to share teaching strategies, textbook selection, and other resources. At these conferences, members of the APSU mathematics faculty have presented several of the unique aspects of their program.

### Structure of Mathematical Systems

One important factor in designing a course is textbook and resource selection. For several years the pre-publication editions and the preliminary edition of *Reconceptualizing Mathematics* by J. Sowder, L. Sowder, and Nickerson (2008) have been the textbooks used for MATH 1410 and MATH 1420.

According to Judy Sowder (2007), development of these materials is based on three underlying assumptions.

1. Teachers must have a deep, profound knowledge of the mathematics they will teach. They need to know the mathematics they teach in a way that allows them to hold conversations about mathematical ideas and mathematical thinking with their students.
2. Such knowledge is best developed through reasoning, conjecturing, discussing, and explaining mathematics. A persistent pursuit of explanation is a hallmark of a classroom in which learning is taking place.
3. This development is more likely to happen in classes and professional development during which good pedagogy is modeled. Prospective teachers are unlikely to demonstrate flexible, interactive styles of teaching unless they have experienced mathematics taught this way.

Through these materials, including videos of elementary students doing mathematics, pre-service teachers examine mathematics content, their own thinking about mathematics, and the thinking of children about mathematics. The study of these research-based materials provides elementary education majors with their first experiences in mathematics education. This is a key component of the mathematics education curriculum at APSU.

Another key component of the MATH 1410 curriculum is Cartoon Math, a two-week unit developed by Dr. Witherspoon. In this unit, students are immersed in base-eight mathematics. For these two weeks, they are not allowed to use base-ten mathematics or to use the language of base-ten mathematics. They count, “One, two, three, four, five, six, seven, oney, oney-one, oney-two, oney-three...”

Students begin to understand what it is like to be introduced to an unfamiliar system, much like elementary students as they first learn about the base-ten system. In Cartoon Math, students explore the meaning of place value. They learn to add, subtract, multiply, and divide in the base-eight system. They become so familiar with this environment that they start to memorize addition and multiplication facts. They develop more efficient methods for carrying out operations. For example, they learn to use an area model for multiplication. They solve contextual problems like the following.

On Planet Cartoon, dynamite is packaged 12 (oney-two) sticks in a box. The coyote has 14 (oney-four) full boxes and 3 more sticks left over from his last failed attempt to catch the roadrunner. How many sticks of dynamite does the coyote have?

Years after taking MATH 1410, practicing teachers comment on their experiences with Cartoon Math and the feelings they had as they struggled to master the system.

Another unique aspect of the MATH 1410 – MATH 1420 curriculum is the use of “feedbacks” to prepare students for testing. Before each test, students download a test review called a feedback. Each student is expected to complete the work and bring it to class, where it is collected at the beginning of class. This work is graded for effort only.

Students are then put in groups of three or four students. Each group is given a shortened version of the feedback. Students are expected to work together to complete the feedback during the class session. If any students have difficulty, the other members of the group are expected to explain or to ask the instructor for help. The group work is graded for accuracy and is returned to students in the next class session.

Questions on the feedbacks are not usually traditional problems. Students are required to use nontraditional methods, to determine if answers are reasonable, or to explain their work in detail. For example, the following problem appeared on a MATH 1410 feedback.

Use the traditional pencil and paper method to calculate  $6,051 - 815$ . Explain what the 1 you wrote beside the 0 means and where it came from. (Use the candy store, money, or some other context to explain in a way that would make sense to a fourth-grade student. Do not simply recite the rules.)

Students seem to enjoy doing the feedbacks together, and they are more willing to ask questions than in the whole class setting. Each student gets more individual attention than would be possible in a traditional test review.

### Teaching Mathematics

Beginning with MATH 1410 and throughout the mathematics education curriculum, the faculty plans the courses cooperatively. This is particularly important in MATH 4100 and MATH 4150, Teaching Mathematics. Faculty cooperatively plan in-class activities, assignments, and field placement assignments. These experiences are focused on key ideas that can be used in a variety of problem solving situations and mathematical contexts. Counting, place value, proportional reasoning, spatial reasoning, pattern recognition, and representation are areas of focus.

Publications of the National Council of Teachers of Mathematics (NCTM) provide a rich source of curriculum materials. NCTM materials used in courses at APSU include *Principles and Standards for School Mathematics* (2000), the *Navigations* series, and yearbooks. Students use these resources for planning lessons, to learn teaching strategies, and to deepen their own knowledge of mathematics.

In Teaching Mathematics, pre-service teachers need to see examples of good teaching. They need to see how students respond when they are engaged in interesting and challenging problems. Opportunities to see this type of teaching are provided through video studies where teachers use Cognitively Guided Instruction and through the *Learning Mathematics* video series from Annenberg Media (2008). In particular, *Patterning and Partitioning* and *Investigations in Teaching Geometry*, video studies developed at the Vanderbilt University Learning Sciences Institute, provide opportunities for in-depth study of lessons that support student learning (Tyler, Cobb, & Dean, 2002). Although some resources are available online, Dr. Wilson assists with technology issues that sometimes occur when resources are on a variety of different media such as videotapes, CDs, etc.

However, simply watching the videos is not enough to help students understand the importance of using these methods. Students are asked to analyze these materials, to write about what they see, and sometimes, using the videos as a guide, to write plans for lessons that they actually teach in local classrooms. Recently, for example, students in Teaching Mathematics K – 3 were required to watch the *Patterning and Partitioning* videos, to write three lesson plans based on the videos, and to teach these lessons to kindergarten or first-grade students in local schools.

Although students teach some whole class lessons in their field experiences, greater emphasis is placed on working with small groups. In Teaching Mathematics, students are required to read research articles that emphasize the importance of developing counting strategies. After extensive discussion of these strategies, each student administers a counting inventory, a set of counting tasks, to a small group of kindergarten or first grade students and then analyzes the results in light of what she has learned about counting.

In both MATH 4100 and MATH 4150, students are required to teach a unit on a topic that coordinates with the local school district curriculum map. These units are developed in class and are taught in local elementary schools. They incorporate engaging activities as well as formative and summative assessment. Activities are drawn from a variety of research-based sources, including the NCTM *Navigations* series. Based on the ideas developed in class, students must write their own lesson plans and prepare materials. Each student is only required to teach the unit to a small group of four or five children. This gives the student an opportunity to consider deeply the work of individual children and to adjust his teaching based on this assessment. Because all students are teaching the same unit, classroom discussions are similar to those that might take place in a lesson study.

Throughout the mathematics education curriculum, course instructors model the teaching strategies they expect their students to acquire. Students engage in exploration, work together in cooperative groups, engage in conversation about mathematics, and explain their thinking. In field experiences, they engage in extensive analysis of student thinking. All of these experiences are aimed at helping them to become teachers who understand mathematics, understand the thinking of children, and are capable of providing opportunities for their own students to engage in significant mathematics.

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