

Toward a Culture of Collaboration, Experimentation, and Deeper Understanding: Response to PMET Initiatives

As we reflect on our college's response to the PMET initiatives, we are tempted to shout, "Look what we have done! Because PMET opened the gate, we have come a long way." At the same time, when we compare the status quo of mathematics education at Union College to the 11 recommendations of the MET Report (The Mathematical Education of Teachers by the Conference Board of the Mathematical Sciences, 2001), we hesitate and whisper, "How are we ever going to get there? What will PMET do to keep us on track?"

The MET report challenged us to dive deeper in developing mathematical understanding. PMET's summer workshop in Potsdam (New York, 2003) opened our eyes to the possibilities of capstone courses, more effective use of technology in the classroom, and cooperative/interactive learning. Before leaving Potsdam, participants were "required" to submit a proposal for their own IYP (intervening year project), on which they would report the next summer in Oswego (New York, 2004). A few weeks later, director Jack Narayan e-mailed participants, urging us to apply for a PMET mini-grant to support our IYP. (Union College gratefully received a mini-grant in December, 2003) The next summer, workshop participants in Oswego stirred each other with reports on their IYPs. They were further inspired to enhance the mathematical education of prospective teachers by the presence of Zalman Usiskin, Richard Askey, Al Cuoco, and Curtis Bennett. In the midst of heated debates about benefits and detriments of technology in the classroom, Steve West called for a balanced approach where graphing calculators would complement in-depth learning of mathematics.

Without a doubt, the IYP expectation and getting the PMET mini-grant have been most beneficial to Union College's program in mathematics education. While the PMET workshops were inspirational and stimulating, the IYP and mini-grant project have driven significant changes on our campus: a growing partnership between the mathematics faculty and education faculty, collaboration with secondary mathematics teachers, and a changing curriculum that will provide prospective teachers with deeper understanding of the mathematics they will teach.

More specifically, what has changed?

First, over the past few years Union's mathematics faculty have been meeting approximately once each month. (Previously, they did not meet as a discipline, but only as part of the Division of Science and Mathematics.) The PMET mini-grant has supported them in planning and providing a workshop for secondary teachers, where mathematics teachers from almost all schools in Union's primary feeder system came together for two days. Jim Lewis (chair of the steering committee for the MET report) and Ruth Heaton, both from the University of Nebraska, were the keynote speakers. At the wrap-up session, the visiting teachers asked that more math workshops be held on the College campus in the near future. Further, they requested inclusion of elementary teachers next time. Ongoing positive feedback from this workshop has led the College to recognize its responsibility to provide similar workshops for a variety of disciplines down the road.

Union's secondary-education faculty have attended several of the meetings with the mathematics faculty. They all worked in partnership to plan the summer workshop for secondary

mathematics teachers. Further, the education and mathematics faculties have worked cooperatively in these meetings to redesign the curriculum for mathematics education majors. Without the PMET mini-grant, the partnering and workshop would not have happened. While the mini-grant was only \$4000, it has motivated significant activity toward the improvement of Union's curriculum and instruction for prospective mathematics teachers.

Second, collaboration between Union's mathematics faculty and school mathematics teachers has moved forward. The summer workshop was the idea of the secondary teachers; it grew out of a survey done under the PMET mini-grant. The survey, sent to the mathematics teachers in the College's major feeder schools, asked: 1) What do you think are the 10 most difficult math topics to teach? 2) What inservice opportunities might the College provide for you?

Principals of the secondary schools became excited about the workshop possibility and consequently were highly supportive. Union's mathematics faculty provided a shorter workshop for these secondary mathematics teachers a year later in conjunction with the NCTM Annual Meeting in Anaheim (April, 2005). Because the PMET mini-grant has run out, it is going to be difficult to provide another summer workshop. Still, there is increased and ongoing communication between these secondary math teachers and Union's mathematics faculty.

Third, our mathematics curriculum has been redesigned and improved to provide prospective teachers with courses that develop a deep understanding of the mathematics they will teach. As Union's mathematics faculty have got together for their monthly meetings, they have given a good deal of thought as to how the mathematics curriculum might be improved. There has been regular give-and-take with the education faculty, who tend to think educational field work and general secondary methods are more important than depth of mathematical understanding in the preparation of teachers.

Accepting recommendations that grew out of these joint meetings of the education and mathematics faculties, and after considerable politicking, the College's Academic Council approved three major changes. Effective in the College Bulletin published this spring (2006), these changes are:

1. Secondary mathematics education majors are required to take a capstone course (Mathematical Connections for Secondary Teachers, MATH 451, 3 hr). History of Mathematics (MATH 360, 3 hr) has been discontinued, with its content spread among several other mathematics courses.
2. Elementary education majors are required to take College Algebra (MATH 111, 3 hr) and Mathematical Concepts for Elementary School Teachers. (MATH 321, 3 hr). Previously, the mathematics requirement for prospective teachers at Union College was only Contemporary Mathematics (MATH 105).
3. The general education requirement at Union College is now MATH 111 (College Algebra) or higher; MATH 221 (Elementary Statistics and Probability) is recommended. Previously, the general education requirement was MATH 105 or higher.

The PMET initiatives have spurred other improvements in the preparation of mathematics teachers at Union. There has been steady progress toward a departmental culture that values

collaboration, experimentation, and deeper understanding. Four books, made available at PMET's summer workshops, have guided Union's move toward this culture:

1. *The Mathematical Education of Teachers* by the Conference Board of Mathematical Sciences.
2. *Knowing and Teaching Elementary Mathematics* by Liping Ma.
3. *Mathematics for High School Teachers: An Advanced Perspective* by Usiskin, Peressini, Marchisotto, and Stanley.
4. *Cooperative Learning in Undergraduate Mathematics* by participants in Project CLUME, edited by Rogers, Reynolds, Davidson, and Thomas.

The Potsdam workshop emphasized cooperative learning as a promising means for gaining deeper understanding of mathematics. While the seed for cooperative learning was planted in Potsdam, it did not sprout until summer faculty scholarships were made available at Union College in 2004. Through these scholarships, a few faculty were encouraged to experiment in redesigning a course for enhanced learning. Based largely on ideas presented in the book, *Cooperative Learning in Undergraduate Mathematics*, MATH 121 (Precalculus) was redesigned for students to work in teams of four in cooperative learning. Students had mixed reactions to the cooperative learning approach as implemented in the fall semester. Overall, however, their reactions were positive. So the experiment continues in MATH 121. Further, both the new capstone course for secondary math majors and the new concepts course for elementary teachers are being developed around the cooperative learning model.

The Oswego workshop emphasized the use of graphing calculators in our mathematics classrooms—as a means of achieving deeper understanding of the mathematics involved, but not at the expense of sluffing fundamentals that are basic to mathematical comprehension. While we have believed in the advantages of graphing calculators for years and have regularly encouraged the use of TI-83s in class and on exams, the Oswego workshop convinced us that certain basics must be learned and performed without the use of calculators. This led to further experimentation in testing, sometimes with the use of a calculator and other times without. The result is that exams in a number of our mathematics classes now have part 1 without the use of calculators and part 2 with calculators and books.

Additional evidence of a budding culture of collaboration, experimentation, and deeper understanding is how students in our mathematics methods class are involved in teaching the College's intermediate algebra course several days during the semester. Before making a day's presentation to the intermediate algebra class, the student teacher does a "dry run" to the methods class. Fellow students and the methods teacher take time to reflect on the "dry run" and to make suggestions that will optimize understanding on the part of the intermediate algebra students in the next day's delivery. On the day after delivering a lesson to the intermediate algebra students, the student teacher, fellow classmates, and the methods teacher review the presentation, looking for how it might be improved for deeper student understanding another time. The collaborative involvement of both the methods teacher and the intermediate algebra teacher is critical to the success of this experiment. (They both are there when the student teachers present the lesson to the intermediate algebra class.) Fortunately, the spirit of cooperation has already been nurtured through the regular meetings of the mathematics teachers in the project made possible by the PMET mini-grant.

It should be noted that student teachers in the methods class gave high ratings to the intermediate algebra experiment this semester. Similarly, the methods students gave high ratings to the opportunity provided them to attend the NCTM Annual Meeting in St. Louis in April. They feel strongly that both experiences have led them into deeper understanding of the mathematics they will soon be teaching.

The book *Mathematics for High School Teachers: An Advanced Perspective* will be used for our new capstone course, Mathematical Connections for Secondary Teachers (MATH 451). We were introduced to this book in Potsdam, where workshop participants were assigned to groups for collaboration in designing a capstone course and syllabus. The book and the PMET workshop experience have given us solid direction for developing our own capstone course at Union College.

As we began developing our new course for elementary teachers, MATH 320, we used the Internet to search for potential textbooks. We were glad to quickly find a book by Parker and Baldrige, *Elementary Mathematics for Teachers*, 2004. It appears to be a perfect fit. When we found references to the work of Askey and Ma in the book, we were pleased. When we found that the book is based on guidelines laid down in Liping Ma's *Knowing and Teaching Elementary Mathematics*, we became more certain. When we found this college textbook is coordinated with SingaporeMath.com's primary school textbook series (and sold as a package), we made our decision. Our PMET connections guided the selection process.

We could mention how PMET introduced us to Texas Instrument's Voyage 200 and TI-84—in fact, gave us discounted prices; how we began using Geometer's Sketchpad and Cabri Jr.; how our Modern College Geometry course is being modified as a result; how we are dreaming that some book company will see light in helping colleges put a quality set of high school mathematics books in the office of each math professor to help them connect their college courses with the mathematics our prospective teachers will be teaching; ...

The bottom line is that PMET thinking is permeating our mathematics department. We want to continue toward a culture of collaboration, experimentation, and deeper understanding.

Obstacles to sustaining this culture are the proverbial constraints of time and money. During the years of the PMET mini-grant project, we have had an additional mathematics professor on staff, one who moved from administration back into teaching. This move allowed one faculty member to have released time to work on our PMET project. Unfortunately, that professor is retiring and will likely be replaced with only limited contract teaching. In addition, the PMET mini-grant is now depleted. The grant had enabled us to pay our mathematics professors for some of the extra time they put into the project--resulting in greater effort and more production. With the mini-grant all used up and the professor's imminent retirement, we will be struggling to maintain the culture. PMET, where can we turn for more help?

Submitted at the PMET Regional Conference (June 11-13, 2006)

Asilomar Conference Grounds, Pacific Grove, California

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