Humanistic Mathematics Network Journal

Issue 4 Article 6

12-1-1989

PDP/Academic Excellence Workshops in Mathematics

M. Catharine Hudspeth
California State Polytechnic University, Pomona

PDP/Academic Excellence Workshops in Mathematics

Talk delivered at the Southern California MAA meeting November 11, 1988.

M. Caharine (Kay) Hudspeth
Director, Minority Engineering Program
California State Polytechnic University, Pomona
3801 W. Temple Ave.
Pomona, CA 91768

Let us fantasize for a bit about the characteristics we would like to see in our "ideal" student of mathematics: curious, logically precise, persistent, understands concepts and their applications, communicates effectively in the language of mathematics, and so on. How can we as mathematicians develop these traits in our students?

If at this time we are not satisfied with our students' performance, we must realize that our educational challenge will become even greater as our classrooms reflect the growing cultural diversity of our country as we move to the Twenty-first Century. By the year 2010 in California, for instance, the white non-Hispanic students will be in the minority; for some of our campuses that is already the reality. Thus we mathematicians must not only learn how to teach more effectively the traditional 18 to 21 year-old, middle-class white student, but we also must develop pedagogy that is effective with those from other cultural and educational backgrounds.

Now imagine a group of Black, Hispanic and American Indian students meeting voluntarily 4 hours each week to discuss mathematics. They usually are working in self-selected groups of 3 or 4. As the quarter progresses, they have become quite comfortable with each other and have no hesitancy to move around the room to check on how another group is approaching a problem. Friendly rivalries develop, and they will good-humoredly challenge each other's solutions. To break the routine, the Facilitators will sometimes divide the group into two to four teams. Each team will then compete to solve a "challenge" problem—one that requires a higher degree of sophistication. They will work intensely and with great enthusiasm in hopes of becoming the first team to complete the problem correctly. Many times when the workshop period is over, students remain to complete the solution of a problem or to conclude a discussion of some technical point. Frequently, they will arrange to study together at additional times, especially to review for an examination. Thus the students not only master the material with a higher level of understanding, and learn how to communicate technical material, they also experience the rewards of membership in an academic community. What creates this enthusiasm for learning that we too seldom see? If we can develop strategies that increase the academic performance of minority students, then we will have gained an insight in to how to teach *all* students more effectively.

The workshop model as developed by Prof. Treisman at UC Berkeley and implemented at Cal Poly Pomona is designed to provide a means to develop that academic community for the Black and Hispanic student. These workshops therefore are based on the following premises:

> Students that we see in our freshman calculus are the best from their communities. This is especially true for the Black, Hispanic, and American Indian student since only 60% of Hispanics and 75% of the Blacks that enter high school graduate as compared with 83% for the non-Hispanic white. Of the 18-24 year olds, 28% of the non-Hispanic whites are enrolled in college as compared with 18% of the Hispanics and 20% of the Blacks.
>
> These students are highly motivated; the minority student, especially, is under great pressure to be successful: both from within and from family and community who see this student's success as a reflection of the capabilities of that culture.
>
> The "brightest" minority students (that is, those with higher SAT's) historically have all too often been those least successful in traditional courses.
>
> One of the primary factors that precludes success for such students is the intellectual isolation within which they operate. The Asian and the fraternity/sorority networks are very effective; however, the bulk of our students

have no means by which they may develop their own intellectual community.

These premises may be startling to faculty who have assumed that students come to us either with many of the characteristics of the "ideal" mathematics student or that they do not deserve our time and our resources: that is, our students can "shape up." Some faculty may feel that to assume another posture is to lower our academic standards and let "weak" students through who will be unable to perform in the future.

In the less sophisticated student, this attitude is hostile to the development of those traits we desire in our "ideal" student. We can have an effect on the qualities that we expect and demand. It is not student apathy or perversity that causes the difficulty. Dr. Clarence Stephens' Mathematics Department at SUNY Potsdam, the UC Berkeley PDP workshops, and developing Academic Excellence workshop program at Cal Poly Pomona demonstrate that, first, when we can create an academic community among our students to support their development, and second, when we encourage them to practice learning mathematics in that community, we enable them to develop the ability to synthesize the fundamental principles we so wish them to learn.

Thus, there are two levels of teaching for which we are responsible: the first, which we all recognize is the mathematical content, the second is the process by which students learn mathematics. We give homework for the students to practice their mastery of the content, and we judge this progress through quizzes and tests. We ordinarily, however, provide no structure to guide them to develop their learning strategies, and we test their mastery only indirectly in so far as we test the application of these strategies to the content.

We can more consciously model in detail our problem-solving strategies in our lectures, and we can create a structured opportunity for the students to develop their learning strategies through cooperative learning.

By structuring discussion among students about mathematics, we can help them develop a network of peers and a mode of communication through which they may continue to mature mathematically. In order to thoroughly understand a concept, one must be willing to test that understanding by applying it in a variety of settings and to articulate the distinctions and similarities among them. By sharing insights, by learning whether errors were errors of mechanics or of understanding, by sharing different approaches to the material, all students not only master the content, but they teach each other how to learn mathematics.

The greatest increase in understanding occurs when we explore new approaches, employ different techniques, and reflect on the results. That is, in order to learn the most, we must increase the risk of being wrong, then analyze the outcome. A woman or minority student may not be willing to take those risks if he/she does not feel the support of a community of learners or have the audience within which to refine his/her thinking. The women, Hispanic, and Black students in engineering or science, may view themselves as standard bearers for their group. Many feel that their performance is the basis upon which their sex/ethnic group will be judged. No student will risk appearing incompetent in a group to which he/she feels excluded.

The isolation of minority and women students is further compounded: not only are they likely NOT to feel a sense of belonging on our campuses, they may feel isolated from the cultural community from which they come because of their goals. Therefore, we need diverse ways to nurture and mould an effective academic community for those who are highly motivated yet who in the past have not had such an opportunity. Thus we strive to foster cooperative learning among Workshop students so that they may learn in the same way that we continue to learn—from our peers.

Specifically, then, we assume that the traits of an "ideal" mathematics student can be developed in those less experienced, and further, we assume it is our responsibility to do so. The professor is the one who establishes the atmosphere of inclusion or exclusion for the students.

Let us now examine one way to create that community in which students "learn to learn." In the fall of 1986, Cal Poly Pomona's Minority Engineering Program adapted Berkeley's PDP model and began its Academic Excellence Workshops in mathematics. The Workshops are now jointly sponsored by the Minority Engineering Program and The Science Educational Enhancement Services (SEES), and encompass 11 courses in college algebra, calculus, chemistry, physics, statistics and dynamics. Each quarter about 5 workshops have a total of approximately 75 enrollees.

The students who have participated have earned on the average at least 0.5 grade point above the remainder of the class. Frequently it is a full grade point higher. The norm is that 60% of the participants earn A's and B's; the usual expectation for these Black, Hispanics, and American Indian youth is that 60% would be earning D's and F's. Several faculty who have taught the lecture for the Workshop students have noted a sharp change in their classroom: more students participate, the questions are more sophisticated, and test performance is better—not only for Workshop participants, but for the class as a whole. In particular, one professor (who supports, but has been naturally cautious about the workshops) was surprised to find that a subsequent class without Workshop students was a much weaker class overall. He found that the performance of this non-workshop section was a full letter grade below that of one with workshop participants. Not only had Workshop students earned higher grades, but they had brought the entire group to a higher level of understanding.

What is the process by which a Workshop enlivens learning so that students are more able to understand the basic concepts and their applications? Students who elect to participate in a Workshop enroll in one of the designated lectures where they constitute from 10% to 30% of the enrollment. This group of 8 to 25 students agree to regularly attend two 2-hour workshops per week where they will work problems above and beyond homework. They are expected to work on their homework and to read assignments before the workshop session. These sessions are NOT homework sessions, nor tutorials, nor reviews of the lecture.

The Facilitators, upper-division undergraduates, prepare a worksheet of problems in consultation with the lecture professor, and facilitates the discussion and solution of the problems among the students. Since the sessions are designed to coach the students in learning how to learn mathematics, the Facilitator, when ever possible, does not directly answer a student's question; either the student is asked another question to guide him/her to greater insight or the student is referred to another student. The Facilitator models the behavior of our "ideal" student, by asking those questions which a superior students would ask of him/herself. Thus the Facilitator needs not only to be a strong student of mathematics, but needs to understand the conceptual challenges of the material from the participants' perspective. Only when several students are unable to resolve the question does the Facilitator step in. The following questions characterize the Facilitators' primary involvement:

"Why did you do that?"

"Is this problem similar to any others you have worked? How?"

"What do you have in your class notes that might relate to this problem?"

"What makes this problem different?"

"How do you know your answer/procedure is correct?"

"What do you think?"

"Is there another way to do this?"

"How are these problems related, or are they?"

"What other versions are there of this type of problem?"

The environment that the Facilitator strives to create is one of mutual support and friendly competitiveness. The students move from problems similar to the homework to those much more challenging—more difficult that they are likely to encounter on tests. The problems selected for the Worksheet are deliberately chosen to require the student to synthesize from homework and class and to apply that knowledge in a new setting. Through this graded structure of the worksheet, the best student is challenged while those less quick have the support of others to clarify concepts and with whom they may test their understanding. Thus the difficulty of the problems force students to collaborate. For some students this is the first time that cooperative learning has been encouraged and rewarded.

The students are challenged to articulate exactly WHAT the underlying structure is and how to apply it. The students thus are forced to engage in ACTIVE learning, rather than memorizing an algorithm to apply by rote. The students are encouraged to debate among themselves about tactics, procedures, and results. They learn from each other when there are several methods available and discuss how they know when each is appropriate. No student is permitted, no matter how strong (or weak) to avoid this dialogue with others. The student who finishes a problem quickly is encouraged to explain his/her approach to those with questions. All must engage in discussions about mathematics. They learn to use the technical vocabulary and to correct each other's errors. When they examine each other's work, they learn that the process of working out a problem on paper is a form of communication: that there *is* a standard grammar for mathematics.

The title "Academic Excellence Workshops" conveys the level of activity expected. Too frequently the student who has been among the top of his/her high-school class finds that the pace in college is much faster, that the course more rigorous, and that the support of faculty and peers is sparse. Such students, particularly if they are minorities, will avoid at all costs any tutoring or other assistance that may be perceived of as "remedial." If they go at all, it is after the situation if hopeless. For this reason, the commitments, the expectations of the workshop, and the rewards (greater likelihood of A's and B's) are clearly stated. Thus participation of those who would ordinarily shun support is gained. The workshops are all but billed as "honors."

There are several critical elements necessary for a workshop to produce the desired results:

> The students must be challenged with novel, inventive problems that require a synthesis of concepts taught.
>
> The structure must reinforce all students' active participation; specifically it should preclude one or two doing the work for the rest.
>
> The evaluation of student work must focus on the positive results and provide guidance on how to eliminate the unproductive strategies so that all aspects of the students' efforts lead to a more full understanding of how to approach and solve problems.

The Workshops *continue* to affect the students' academic performance in subsequent courses. They have learned to value the peer network so that they schedule their future coursework with peers in order to form their own independent study sessions. In these groups they continue to employ the strategies that they learned in the workshop: to question results, to clarify concepts, to encourage each other to a higher level of mastery of the material. They have also discovered that most faculty welcome questions and student involvement so they are more assertive in their classes. More importantly, however, they have experienced the excitement of quality academic performance and know how to work with others to create that same level of intellectual involvement in their other courses. The Workshop, as Dr. Clarence Stephens states, "teaches the students HOW to learn" making them more independent of us.

As an aside, a secondary benefit of the Workshops is the faculty mentoring of the Facilitators: some are now planning graduate study and some are considering a teaching career. With the growing need for American-educated students to enter graduate school in technical fields we need to be alert to means by which we can encourage more of our students to consider graduate study. Further, by guiding the Facilitators through their work, we are giving them the opportunity to see the personal rewards to teaching.

While Cal Poly's program is for a targeted group in the calculus and is structured to be independent of the course, there are other ways to encourage this type of group activity for all students. Some campuses build the study group into the course structure as a lab. Others, where there is strong faculty commitment, model the class itself after workshops as was done at SUNY Potsdam. With some reflection we can find ways to build in a structure through which we can guide students to develop their own problem-solving strategies and become independent learners. If we can create this atmosphere, I believe we will increase the possibility that our students will more nearly approximate our "ideal" mathematics student.