The Impact Of Cooperative Learning In Engineering At California State Polytechnic University, Pomona

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The Cal Poly Pomona Academic Excellence Workshop Program was initiated Fall 1986 by the Minority Engineering Program to increase the academic performance of under-represented minority students in Engineering and Computer Science. Now sponsored jointly by the Colleges of Engineering and Science, the program targets foundation courses in Mathematics, Chemistry, and Physics, as well as Engineering Mechanics, for special supplementary sessions where ten (10) to twenty-five (25) students regularly meet to work challenging problems in addition to class assignments. These supplemental workshops are structured opportunities for students to develop academically through cooperative learning and are modeled after the Professional Development Program (PDP) developed by Dana-Award winner Prof. Uri Treisman, Cal Berkeley. Our companion paper in these Proceedings, "Cooperative Learning in Engineering Through Academic Excellence Workshops at California State Polytechnic University, Pomona," details the structure of the program, its implementation in Engineering Mechanics, and the characteristics of a successful workshop. This paper focuses on the educational impact on the students, the facilitators, and the faculty involved in the workshops.

Non-Quantifiable Impact on Students

General

When students are isolated from each other, they have no opportunity to modify their strategies or to correct misconceptions. On an urban, commuter campus such as Cal Poly Pomona, this isolation is the norm and is particularly destructive for Black, Hispanic, and American Indian students. Since only a small percentage of children from these groups graduate from high school, let alone attend college, those who do enter technical fields are under considerable pressure from their families and communities to continue to excel. When they enter the more highly competitive environment of our engineering colleges, they are frequently shocked by the initial lower evaluation of their performance. They are generally unwilling to admit to any difficulties, lest that be interpreted to mean that they do not belong in the major (or in the college). The hurried exchanges between students and faculty (or among students) that are the norm on a commuter campus do not permit the development of the necessary level of trust for the students to discuss openly the genuine concerns they have about their progress. Thus, the minority students most needing the campus support are least able to avail themselves of the counsel of faculty and fellow students. To further compound their isolation, they seldom have anyone off campus with whom they can consult about academic matters.

The Academic Excellence Workshops, supplemental to the lectures, are built upon the premise that a lively academic community among students supports more than sophisticated learning. Specifically, these student-centered, structured workshop sessions challenge the brightest students while helping the passive learner develop a strong foundation for future academic work. The patterns of cooperative learning that are established in the workshop have a continued application in the participants' subsequent work. This cooperative learning structure strengthens their mastery of the course content, improves their ability to communicate, and teaches them the value of a team.

Content Mastery

The students' increased command of course material is a primary concern. Through workshop participation, they spend more productive time on the subject, thus increasing their mastery of the content. They also learn how others approach the material and expand their repertoire of strategies, including how to know when their work is correct! Through teaching others, they refine their own understanding of the subject. By confronting and solving more difficult problems, they gain self-confidence and increase their efficiency.

In general, faculty expect students to develop on two levels: in the content itself and in their sophistication in analyzing the content. However, most faculty only elaborate on the content and do not model the necessary problem-solving skills. The workshop sessions focus on developing the participants in the second area: "learning how to learn."

The students become active learners who focus on long-term rather than short-term goals. By establishing a pattern of successful performance and a solid understanding of fundamental concepts and techniques, these students continue their strong academic performance as they advance through the curriculum. Thus workshops are an investment in future academic and professional success.

Communications Skills

The workshop's cooperative learning environment requires that all students engage in detailed
discussions of the content. They understand more clearly the importance of a well-organized, neatly-written solution when they must explain it to others. The workshop provides the setting in which they must use technical vocabulary, formulate technical questions, and make presentations—all essential to the successful engineer. They learn to communicate concepts, not just solutions; they learn to question (and accept questioning) rather than agree to the quick, glib answer. For minority students who tend not to network, learning these skills is especially critical if they are to be retained and are to excel in engineering. Campuses, such as Cal Poly Pomona, with a large commuter population have a special responsibility to provide a structure to foster this interaction if they wish to increase retention and academic performance.

Academic Community

The development of an academic community among students is essential to develop their ability to communicate effectively and to increase their mastery of the course content. Many high school students, particularly minorities, achieve their success by isolating themselves from their peers and by working independently. The greater rigor and increased competition in engineering demand more sophisticated strategies. Structured cooperative learning provides the means by which the students may make this transition. By respecting each individual and by requiring a commitment to the group, the workshop facilitators lay the foundation upon which this community is developed.

In the workshops, students learn they can risk making errors and trust that they can receive constructive evaluation. Through open discussions with others, they gain a better perspective on both their frustrations and their abilities. They understand more clearly the expectations of engineering and how they may meet them. Through the mentoring of the facilitators, the students establish a network to exchange information outside the workshop structure. The students learn the value of being in a course with others with whom they can study intensively, so in subsequent quarters they build their schedules to have common classes and study times. Thus, they develop a professional attitude for working as a member of a team; they assume responsibility for their own and others’ learning rather than being passive. This is a dramatic change from the usual pattern of commuter students—whose schedules all too frequently are dictated by traffic patterns and whose classes are chosen to minimize time on campus.

This greater academic commitment is mirrored in increased involvement in professional organizations. A large percentage of the student leaders in the Society of Hispanic Scientists and Engineers and the National Society of Black Engineers have participated in one or more workshops.

Statistical Summary of Workshop Impact

The Engineering Mechanics workshops have demonstrated that structured cooperative learning can dramatically improve the academic performance and retention of under-represented engineering students. The first Vector Statics workshop (conducted in Fall 1987) contained eighteen students. Of these eighteen (18), thirteen (13) participated fully (attended more than 80% of the sessions; mean attendance of 89%), while 5 attended on a partial basis (attended less than 54% of the sessions; mean attendance of 36%). The full participants earned an average grade of 2.88 in the course, a full letter grade above other students in the lecture sections, while the partial participants earned an average of 2.00. There were eight additional under-represented students taking Vector Statics in separate lecture classes not associated with the workshop, and this group earned an average of 1.33.2 The mean grade for all others enrolled (all other ethnicities) over all sections was 1.89, showing the effect of this intensive, structured work. In the three class sections into which the workshop students were clustered, seven (7) of the ten (10) grades of "A" went to workshop students (see Figure 1). Sixty-nine percent of the workshop students who attended on a regular basis earned either an "A" or a "B" grade.

![Figure 1: Vector Statics Course Grades in Targeted Lecture Sections Fall 1987](image)

One might assume from the statistics just cited that the workshop participants were initially superior students who would have excelled without such support. The average Math SAT score, however, shows that the full workshop participants had scores 100 points lower than the non-participants.

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Most of the students are the first in their families to attend college. Figure 2 displays the level of parental education for the workshop participants. Thirty-five percent of their fathers and forty-five percent of their mothers never made it past the eighth grade in school. Thus, the workshop students are not the ones who, by traditional measures, would be predicted to excel.

As important as the class performance is, however, the real measure of the program is the retention of the students and their subsequent academic performance. After six quarters, all full and partial participants are continuing in engineering with a mean grade point average of 2.83 for full participants and 2.69 for partial; the range is from 3.23 to 2.15. The average for the eight (8) under-represented students not affiliated with the Workshop Program is 1.98; two (2) have been disqualified, two (2) are on academic probation, and one (1) has changed his major out of engineering, leaving only three (3), or 37.5%, in good standing.

Impact on Facilitators

The workshop's focus is, of course, on developing the academic skills of the participants; however, the impact on the facilitators is significant. The Cal Poly Pomona program recruits highly-qualified upper-division undergraduates as facilitators, using Black, Hispanic, and American Indian students where possible. These facilitators, through their desire to help others learn what they have already mastered, are changed in the process. As is the case for the participants, three major areas of impact are: the command of the material, communications skills, and ability to work with others. In addition, as they work with faculty they gain a new perspective about themselves.

To run a continuingly successful workshop, facilitators must bring about some changes in their methods of working with others. The workshop structure increases a facilitator's responsibility to be well organized and prepared. The workshops require group interaction in problem solving with questions concerning the worksheet problems constituting a major portion of the workshop. Facilitators carry the pressure of needing to respond to any question that may arise out of the worksheet. The facilitator, therefore, must know the material well so that the students will not lose their confidence in the facilitator's knowledge of the subject.

Through the workshops the facilitators develop listening and communications skills. Prior to being a facilitator, most technically capable students tend to be shy and reserved and not as apt to work with others in pursuing a common interest or goal. They may also lack practice in expressing and reasoning ideas with different types of people. In order to be successful, the facilitators must be able to effectively and efficiently communicate their ideas to the participants.

The ability to motivate people to do things for their own benefit can be used at anytime and under any situation the facilitator might encounter in his own life: in school work, school activities, employment, and in community involvement. The organization, communication, and motivational skills used in the workshop are also used out of the workshop. In effect, the life of a facilitator will tend to revolve around success in and out of the workshop. This life will tend to impart some degree to those who work with the facilitator, for example, students, professors, and co-workers.

Being a workshop facilitator is more than a job, and all new facilitators might not fully realize what they are getting into. Not until they have experienced it themselves do they come to appreciate the rewards that come with the "job".

Satisfaction is felt in helping others and in giving of one's self to benefit others. Increased self-esteem is brought about by being able to impart knowledge to others and by seeing proof of this through the students' work, grade performance, and the acknowledgement by others.

One of the things that most facilitators do not realize is that participants look up to them as role models. They view the facilitator as some one who is doing very well in the system and who has accomplished much. Realization of this role model image may have several effects on the facilitator. One effect may be to raise the facilitator's consciousness about their actions. Another effect is the self-imposed expectation to always do well in their studies. Because facilitators stress academic success, they, too, are expected to succeed academically.

The close relationship developed between the facilitator and the faculty affects the facilitator's image of the faculty. A common weakness in most students is the tendency to be afraid to talk with professors outside of the classroom. This new relationship with the faculty places them on an equal level and makes them members of the same team with equal goals and interests. Most faculty members are seen as being very knowledgeable people with academics at the back of their minds. Having to work with the faculty on a continuing basis gives the facilitator the opportunity to know them from a different perspective. The facilitator soon realizes that professors are "real people" too, and is then able to communicate more easily with them. The facilitator is not
afraid to give his own feedback and outlook. This new and stronger view of professors leads to a better appreciation of the faculty role. Facilitators feel more comfortable in seeking faculty advice which they would not have attempted to seek previously. This advice is especially valuable when it concerns choosing a teaching career, pursuing graduate studies, or other career choices.

Several facilitators are now considering making changes in their career paths because of their experience with workshops. One, an electrical engineering student, will now pursue a minor in physics, the subject for which he facilitated. Instead of graduating with a bachelors degree and immediately joining the work force, some facilitators will pursue a masters program; others are considering a doctorate. The understanding of the faculty role and the rewards of working with students has caused other facilitators to consider teaching at the university and college levels.

Two facilitators, an Hispanic female and a Black male, had never considered college teaching prior to their facilitating and are now considering this as a possibility. Thus the workshop program is indirectly addressing the profession's need for more minority faculty.

Impact on Faculty

Teachers of Engineering Mechanics classes with a companion workshop session are required to put forth some extra effort during the school term. They are asked to prepare a syllabus in conjunction with the other faculty who are teaching the targeted lecture classes. During the school term they are asked to meet with the student workshop facilitators for approximately one half-hour each week. There they recite the material to be emphasized during the workshop sessions and gain feedback from the facilitator about the students' general understanding of the previous week's work.

For a modest amount of time and effort, the instructor receives considerable benefits—a primary one being the increased motivation level of the workshop students. The students come to class, do their homework on time, ask more questions and are not afraid to participate in class. This increased involvement of the workshop students sparks increased involvement of the other class members in class discussions, homework, and test preparation. Thus, the class as a whole is improved because of the increased student interest. Because the students master the fundamentals more quickly, the professor can spend more time on the problem areas and, perhaps, can cover more material. In addition, feedback from the facilitators helps the instructor know in which areas the students are having problems. Because of the added emphasis on the course and the facilitators' feedback, the instructors are often motivated to work more diligently in the course. This leads them to reflect on the goals of the course and this, in turn, stimulates discussions with other faculty relative to these goals and how to best achieve them.

One of the main benefits to the faculty from the workshop is the feeling of accomplishment that is developed when a class or group of students excels academically. In this particular case, the under-represented minority engineering students who have too often performed poorly in the past have excelled. To quote one of our faculty, "I'd like to have more of the workshop students in my classes." There is a genuine desire to work with these bright students because they are perceived as intelligent and motivated. This attitude is conveyed back to these same students which increases their confidence. This in turn strengthens the relationship between student and faculty and allows them to take advantage of the faculty's desire for their success.

The reflection on the course can frequently benefit the entire department by encouraging new techniques to enhance the students' mastery of the material. As a result of the Engineering Mechanics workshops for the minority students, Prof. Shelton applied for and received a grant to create a video. This video will be available for all students and will illustrate the techniques used to create free-body diagrams, a concept that hinders many students. Overall, the workshop program on the Pomona campus has brought together faculty from engineering and the sciences. Their common interest in academic excellence has drawn them to greater cooperation both as individual faculty and as representatives of the Colleges of Engineering and Science.

Conclusion

A project designed to help under-represented students achieve at a higher level has resulted in stronger performance by the workshop participants in the associated course and in later courses as well. All people associated with the project have benefitted: participants, undergraduate facilitators who are drawn closer in to the academic and professional community, and the faculty who have had the opportunity to work with bright, enthusiastic students. The costs of the Academic Excellence Workshop program are small compared with the tremendous value that is realized.

References

1. Black, Hispanic, and American Indian minority groups are under-represented in Engineering in proportion to their representation in the population; Asians, while a minority, are not under-represented in technical fields.

2. A ninth non-participant was unable to be in the Statics Workshop because he was facilitating a Physics workshop for the program. He earned a C+, the highest grade among the non-participants, and graduated in March in Electrical and Computer Engineering. He is deleted from the non-participants as he was fully connected with the workshop program.
Academic Excellence
Workshops for
Underrepresented Students at
Cal Poly, Pomona
New Directions, New Beginnings for Equity Education
Paul C. Hiemenz and M. Catharine Hudspeth

The Academic Excellence Workshop program at California State Polytechnic University, Pomona, may well serve as a highly useful model for an academic support system specifically designed for underrepresented students in math-based disciplines. The reasons are twofold: California's current demographics would appear to replicate the projected shifting of the national demographic picture at the end of the century, and a shortfall is projected of graduates with degrees in science, mathematics, and engineering.

Cal Poly, Pomona, part of the California State University system with an enrollment of 20,000 students, is located about 30 miles east of downtown Los Angeles. As its name implies, it has a technical tradition that includes strong engineering and science programs. The communities served by the university display considerable ethnic diversity. The overall service area is 30-40 percent Hispanic, the city of Pomona is 14 percent Afro-American, and metropolitan Los Angeles has one of the highest Native American populations in the country.

These ethnic groups, historically underrepresented in technical fields, define the population in the program described here. Since the Asian population tends to pursue math-based majors in large numbers, they are not included as a target group.

Pomona's Minority Engineering Program (MEP) was established on campus in 1983. The program had about 450 members when it inaugurated a pilot-workshop program in 1986. In the fall of 1987, the Science Educational Enhancement Services (SEES) program was started in the College of Science, and it established a close collaboration with MEP.

Both are college-based equity programs designed to increase the retention and graduation of historically underrepresented ethnic groups.

By the fall of 1987, MEP was a flourishing program with an array of matriculation, advisory, and professional services to aid its members. SEES had a study center, committed faculty advisors, and not much more. In both programs, the idea of group-study workshops offered in conjunction with certain foundation courses in math and science appeared to be an area for collaboration that would benefit underrepresented students from both colleges.

The workshop approach was devel-
developed by Dana-Award winner Uri Treisman at UC Berkeley where it has been particularly successful in calculus courses (Treisman, 1985). The workshops themselves are facilitated group study sessions that meet for two hours twice a week in addition to the regular lectures in designated foundation courses. At Cal Poly, the workshops are facilitated (not taught) by undergraduates. Participation is voluntary (students receive no credit for attending). The supplementary problems are intentionally challenging (the emphasis is excellence, not remediation) and the goal is to make the student consciously aware of the learning process.

Academic Excellence Workshops have become the primary academic component of each program. Between the fall of 1987 and the spring of 1990, almost 600 students (80 percent in MEP and 20 percent in SEES) have participated in over 50 different workshops. The parent equity programs have also flourished: SEES presently enrolls about 150 underrepresented science majors and offers a growing list of services to participants. MEP, with over 600 members, has seen the number of its students with GPAs of 3.3 or higher increase by 50 percent since the inception of the workshop program.

In subsequent sections we describe the structure, philosophy and results of our experience with workshops during the first three years of this collaboration.

STRUCTURE

The structure of the Academic Excellence Workshop Program parallels the university line organization. The MEP director and the SEES coordinator, reporting to the deans of Engineering and Science respectively, share responsibility for the program. Targeted courses are from four departments: mechanical engineering in engineering, mathematics, chemistry, and physics in science.

This organization of the workshop program is noteworthy inasmuch as it brings together faculty from two colleges and four departments in a commitment to action on behalf of excellence for our underrepresented students. Given the traditional compartmentalization of academic units, this interdisciplinary faculty network to assure the integrity of the program is especially valued. As shown in Figure 1, the workshop program brings together a number of elements to support the workshop student: the facilitator, the developer, the course instructor, and a counselor.

The facilitators are critical because they have primary responsibility for conducting the workshop. They are all undergraduates, mostly from the target ethnic groups themselves and, now that the program has been in place for several years, frequently "workshop alumni." The most successful display considerable ingenuity in keeping the workshop stimulating and lively, varying the workshop format by embedding problems in humorous settings, and by conducting contests, preexam preparation, postexam parties, and so on. Their goal is to establish a welcoming camaraderie among the participants while expecting intellectual rigor and collaborative effort.

In order to be successful as a facilitator, candidates are well grounded in the subject area to be facilitated, usually having completed work at least two quarters beyond the workshop course. They must also be able to communicate effectively and excel in community building. More than once, candidates with better academic records were passed over in favor of others who were more aware of and empathetic with student needs. Clearly the selecting and training of facilitators is an important part of the program.

Because the program strives to reinforce the learning in the specific disciplines, a faculty member is designated in each department to serve as a liaison and as a resource for the facilitators. We call such a faculty member the "developer" for the discipline, a title that reflects the crucial role played by faculty members in initiating and sustaining the workshop. These developers for the discipline work closely with the facilitators and coordinate faculty and department support. To sustain the academic integrity of the program, they always participate in the facilitator interview and frequently recommend candidates. They continue to work with the facilitators as resource persons, providing reference material, suggesting strategies and even occasionally coming to the rescue when facilitators feel overwhelmed. Within their respective departments, the developers explain and promote workshops among faculty.

Cal Poly's structure offers some unique challenges to maintaining focus in the workshop. In a given quarter, it is not unusual to find 6-10 sections offered of a basic course for which the program conducts a workshop. Unsynchronized lecture and test schedules are inevitable with many instructors, so effective group study means block registration of students into one or two of the possible sections. The department chair, the developer, and the designated lecture instructors work cooperatively to achieve
two goals: to register participants properly and to support the facilitators. Throughout the quarter the developer fosters the weekly discussion between the facilitator and the designated lecturers.

The lecture instructor plays a different but equally vital role in the workshop structure sketched in Figure 1 by agreeing to meet weekly with the facilitators. Otherwise, the professor conducts the course as usual. Instructors are enlisted because they have reputations for approachability and thoroughness. For their cooperation, participating faculty receive information from the facilitator about troublesome points and the guarantee of a student core who are keeping up with the material, working problems, and developing the self-confidence to participate actively in the class. Several instructors have commented positively on the intellectual liveliness that the workshop participants create in a class.

The fourth element in the base of Figure 1 is a counselor, a staff member of MEP, whose duties include routine visits to workshop sessions. The facilitators, who rapidly get personally acquainted with participants, are able to alert the counselor if anyone in the group appears to be having difficulties, so that timely intervention is possible.

The fact that the counselor regularly drops in for informal chats allows this intervention to occur inconspicuously. The counselor is also able to keep a watchful eye on the facilitators who, as undergraduates themselves, are subject to the same stresses as the workshop participants.

The counselor thus serves as an additional resource person for the facilitator, covering a different area of need than the developer. Considering the various interactions among the elements represented in Figure 1, it is apparent that the base upon which participants depend is well reinforced indeed.

WORKSHOP PHILOSOPHY

Treisman developed the workshop structure after closely examining the sharp difference in performance between Asian and Afro-American/Hispanic students in calculus. By thoroughly immersing himself in the lives of both groups, Treisman observed that the Asian students had fully integrated the academic and the social. Studying together was an integral component of their day. By contrast, the Afro-American and Hispanic students, however rich their social lives, tended to be academic loners. The difference in behavior can be discussed in two respects: collaboration and connectedness.

Collaboration is the cornerstone of sophisticated intellectual accomplishment. In part, this comes from explaining concepts in detail to others and in part by being challenged by another’s probing questions. Whether we speak in terms of “study buddies” or “cooperative learning,” the essence is the same: collaboration between learners helps keep all more actively involved and decreases passivity and complacency, thereby maximizing understanding.

The premise that the workshop problems are to be solved through group effort requires the use of more challenging problems on the worksheets. Several advantages follow from this dynamic. Demanding problems elicit genuine debate as to the principles and strategies required to solve them. Analytic and synthetic thinking can be consciously modeled through the facilitated group effort applied to difficult problems. Second, the awareness that the group successfully solved some really demanding problems builds self-confidence and removes any hint of remediation which sometimes taints minority programs. Finally, the student is more likely to take a difficult exam in stride if his/her preparation routinely includes difficult problems.

Connectedness arises from the workshop’s place in the larger setting of the equity programs. In the workshop, successful academic strategies are taught through group work in the context of a specific course.

Outside the workshop, the common professional goals and curricula continue to bring these same individuals together.

Table 1a. CHEMISTRY
AVERAGE GRADE EARNED

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<th>COURSE/OTR</th>
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<th>UNDERREPRESENTED MINORITY STUDENTS</th>
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Table 1b. PHYSICS

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Table 1a and 1b: For science workshop courses the columns show the average grade earned by all students, the number and average grade of workshop participants and the number and average grade of underrepresented students who did not participate in workshops. Part (a) for chemistry; part (b) for physics.
Both MEP and SEES have study centers that serve as hubs to support this sense of community. In this way, the workshop strategies can be utilized long after the student has completed the course for which the workshops are offered. A sense of community pervades the broader equity programs and the individual workshops: a sense of belonging, of security, and of trust.

Why is connection to a community so important for underrepresented students, especially in technical majors and on a commuter campus? First of all, it is precisely because they are underrepresented. It is not uncommon for these students to find themselves the only member of their ethnic group in a class; some perceive themselves to be the only person of their ethnicity in a major until they join these programs. In contrast to the situation just described, some of these students have never attended a school that was not composed primarily of students of their own ethnicity. It is generally recognized that all students, regardless of ethnicity, experience a degree of culture shock on transition to the university. How much more intense this is for the underrepresented student!

A second consideration is the intrinsic difficulty of the subject matter required in technical majors. A student may have sailed through high school earning good grades with relatively little effort. Now in a technical major at a university, the students frequently find that the strategies that worked in high school are woefully inadequate for more intense college work. The isolated student may interpret the difficulty encountered as an indication of his/her unsuitability for the chosen major. The well-meaning professor says “ask questions,” but to the unconnected student this is just another burden rather than helpful advice. The paucity of role models at home and in the professions compounds the self-doubt.

By being connected to an ethnic community in the same field, several elements of this scenario are alleviated. Of special value to the tentative student are the undergraduate facilitators, many of whom have confronted these same issues very recently in their own lives. Above all, the student discovers that being questioned and challenged are integral parts of university life and are not personal or ethnic attacks.

RESULTS
As we have noted, workshops are offered in conjunction with courses in four different departments. Results obtained in chemistry and physics workshops are the focus of this paper. The performance of workshop students in engineering mechanics has been reported elsewhere (Hudspeth, M.C., M.T. Shelton, and H. Ruiz 1989; Shelton, M.T. and M.C. Hudspeth 1989).

Tables 1a and 1b list all the workshops offered in chemistry and physics, respectively, between fall 1987 and spring 1990. Also shown are the number of workshop participants for each and the average grade (on a 4.00 scale) earned by the group members. As a kind of control, the number and average grade of underrepresented students who did not participate in workshops are also included.

Nonparticipants include underrepresented students from all sections of the course in a given quarter, not just those sections in which participants were enrolled. The difference in average grade between the participants and the control was checked for statistical significance. In those cases marked by an asterisk in the table, the probability is greater than 10 percent that the observed difference could arise randomly.

Except for two cases (neither of which is statistically significant), workshop participants outperform the nonparticipating underrepresented students in their workshop courses. The average grade for participants versus non-participants (recalculated via grade points and averaged over all courses) is 2.22 for participants and 1.57 for nonparticipants in chemistry; in physics, these averages are 2.48 and 1.79, respectively.

To put these grades in context, the average grade for students of all ethnicities in all sections of the workshop courses is about 1.92 in chemis-

<table>
<thead>
<tr>
<th>Course</th>
<th>Course description</th>
<th>Calc-based major?</th>
<th>Class Standing</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHM 104, 105</td>
<td>Qtrs 1 &amp; 2 of 3-qtr College Chem sequence</td>
<td>N</td>
<td>1</td>
<td>Importance recognized by pre-professional students</td>
</tr>
<tr>
<td>CHM 111, 112</td>
<td>Qtrs 1 &amp; 2 of 3-qtr Gen Chem sequence</td>
<td>Y</td>
<td>1</td>
<td>Not highest priority for many students</td>
</tr>
<tr>
<td>PHY 121</td>
<td>Qtr 1 of 3-qtr College Phys sequence</td>
<td>N</td>
<td>2</td>
<td>Many students pre-professional</td>
</tr>
<tr>
<td>PHY 131, 2, 3</td>
<td>3 Qtrs Gen Phys</td>
<td>Y</td>
<td>2</td>
<td>Calculus pre-requisite screens out less prepared</td>
</tr>
</tbody>
</table>

Table 2: Course descriptions for the courses listed in Table 1. Also indicated are the preponderance of calculus-based majors in workshops, the typical class standing of participants, and other comments relevant to student performance.
try and 2.29 in physics. Thus the workshop students not only outperform other underrepresented students who do not participate in workshops, but actually do better than the class as a whole.

In chemistry, 40 percent, and in physics, 44 percent of the workshop participants earned either an "A" or a "B" in the workshop course. The higher average grade in physics compared to chemistry arises from the fact that only 7 percent of physics workshop participants receive grades of "D" or "F" in their workshop courses. In chemistry, 21% received grades of "D" or "F." Table 2 describes the courses listed in Table 1 and indicates some relevant factors which partially account for these differences.

Finally, it should be noted that the discipline showing the most successful workshop is mathematics. We have offered 19 mathematics workshops between fall 1987 and spring 1990, including college algebra, trigonometry, pre-calculus, and all three quarters of calculus. Averaging across all workshop courses in math, participants average 2.73 compared with an average of 1.66 for the nonparticipating underrepresented students. The average for students of all ethnicities in all sections of mathematics for which workshops were offered was 2.06.

CONCLUSIONS

When the equity programs in Cal Poly's College of Science and Engineering joined forces to offer the Academic Excellence Workshop Program, the objective was to apply Treisman's workshop strategy to the foundation courses taken by our students. Inculcating good study habits and communication skills as well as enhancing mastery of foundation courses were the goals. Though largely successful in achieving these objectives, refinement of the process continues so that more students will participate with even more striking success.

In addition to the success of workshop participants, the program has produced other benefits that were not fully appreciated at the program's inception.

- The first is the reciprocity of benefit between the workshop program and the parent equity program.
- For an established program like MEP, the workshop provides a strong academic thrust: the "new directions" of the title.
- For a new program, the workshops establish a tone that is strongly academic and leaves no doubt among students, faculty, and administrators of the academic integrity of the venture: the "new beginnings."
- The workshop component itself is sustained by the programs from which participants are recruited and within which workshop-learning strategies can be practiced after a specific workshop course is completed.

Finally, the workshop program has provided a vehicle for cooperation among faculty members from four departments and two colleges. The success of the program has also attracted the attention of faculty from other institutions, thus establishing a network at the faculty/institutional level to allow the interchange of ideas and information. The model also includes the potential for partnerships among faculty and student-support personnel.

Technical faculty have long challenged students with the facts and theories of science and technology. The activities described here are an attempt to respond to a challenge offered to us by our students: to create an environment in which all students are encouraged to participate and to succeed. It is a challenge, but something can be done.

Notes

1 Based on a presentation at the National Meeting, National Science Teachers Association, Atlanta, April 1990.

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References

