Summer Bridge to Engineering[1]

M. Catharine Hudspeth, J. Winthrop Aldrich
California State Polytechnic University, Pomona

Introduction For the past six years Cal Poly Pomona's colleges of Engineering and Science have collaborated to conduct a four-week residential transition program, Quest I, for incoming minority students and selected community college students. This program, funded jointly by the campus, the National Science Foundation Alliance for Minority Participation (AMP) grant, and California MESA, has served three hundred students. Three threads will be discussed: program overview and philosophy, the curriculum and impact upon faculty, and, finally, the perspectives of facilitators and participants with some statistical analysis of program impact on student retention and academic performance.

Program Overview and Philosophy To set the program in context, Cal Poly Pomona is a large, urban campus drawing mostly students from middle- and working-class homes in the greater Los Angeles area. The "typical" student expects to commute to campus and to work while attending college. The challenges to faculty are several:

-The variability of the high school and community college preparation of incoming students does not equip many of them for the much higher level of competition and intellectual sophistication required by science, engineering, and mathematics (SEM) majors.

-The compartmentalization of their previous education is not conducive to the synthesis of material across disciplines that is necessary for sophisticated problem solving.

-The bulk of the students do not submerge themselves in the intellectual life of the campus because of commuting, family, and work commitments.

-Most Latino and African American students perceive academic success in terms of isolated, individual effort in a competitive environment.

The campus has two well-developed academic support programs for historically under-represented students in SEM majors: Maximizing Engineering Potential (MEP) in the College of Engineering and Science Educational Enhancement Services (SEES) in the College of Science. These two programs offer extensive services to new and continuing students once they have matriculated. The Quest I program offers the opportunity for MEP and SEES to provide an intensive intellectual and cultural experience to a subset of the incoming Latino and African American freshmen and transfer students in SEM majors. This group of participants forms a core that leads all incoming students to more sophisticated participation and performance. The goals of the program are several:

- To provide a challenging curriculum in mathematics, chemistry, and engineering.
- To show the interdependence of these three disciplines.
- To strengthen problem-solving skills with the aid of graphing calculators.
- To reinforce the value of collaborative work in all classes and activities.

- To expect college-level work and conduct.
- To reinforce pride in learning.
- To develop oral and written communication skills.
- To provide upper-division SEM facilitators and resident advisors who serve as mentors.
- To familiarize the students with the campus, faculty, and staff.
- To provide faculty an opportunity to work collaboratively across disciplines.

The composition of the target group of approximately 50 students each year generally reflects the enrollments of the campus: 70% engineering/computer science and 9% science/mathematics, with the remaining 21% comprised of community college students with an expressed interest in a technical field. Thus, the program is seen as a way to inculcate the cultures of collaboration and of technical excellence to increase the overall retention, academic performance, and graduation of historically under-represented students in SEM majors. Because the overwhelming majority of students attending Cal Poly Pomona commute, the campus has chosen to invest in an active and directed residential program for Quest in order to submerge the students in a collaborative, academic community.

The Curriculum and Program Impact Upon Faculty The primary goal of the program is to strengthen the mathematical skills of incoming students and increase their facility with a graphing calculator. Cal Poly Pomona faculty and administrators elected to be more ambitious by also involving faculty from Chemistry and from Materials Engineering so that students would see the interdependence of mathematics, chemistry, and engineering. Because too many students never have the experience of sophisticated collaborative study, they do not make the investment to engage in group work. Therefore, the program is designed to have the morning classes and the afternoon labs led by a faculty and an under-graduate facilitator team who require collaborative work in groups. Based upon their mathematics background, the attendees are placed into one of three groups which then determines their schedule for the program.

In an effort to prepare the students for the rigor of a university program and to instill the importance of successful time management, the schedule is intensive. In the mornings, all students attend three 75-minute classes, while the afternoons consist of a 2 ½ hour activity five days a week for the four weeks. The morning classes combine the more traditional lectures on new topics with collaborative problem solving and discussions. The afternoons, on the other hand, consist of laboratory hands-on activities in support of the topics discussed as well as a weekly orientation to college and discussions of what it takes to excel as a technical student.

Senior faculty from the three disciplines teach in the program to encourage interdisciplinary discussions and to foster subsequent curricular and pedagogic innovation. Each facilitator-faculty team is responsible for generating activities and assignments which require collaboration and individual accountability. The students are regularly given demanding homework. There are weekly, graded quizzes and assignments in each class, although no grades or credits are given for participation in the program. To further challenge and motivate the students and improve their oral and written communications skills, they are assigned to teams, each of which makes a formal presentation to their classmates and their families on the last day of the program. These presentations require intensive preparation, library research, and written interim reports.

The interaction among faculty has been a pleasant outcome of this program as it has grown and matured. To be successful, the program necessitates that the faculty collaborate and plan integrated topics from their disciplines. This requires not only group meetings prior to the program, but also weekly progress and planning meetings during the course of the four weeks. There were many lively discussions about how best to accomplish program goals, to assess success and problems, and to coordinate program activities. These meetings, which also include the student facilitators and the residence coordinator, give us all a much better perspective of the learning process and a better appreciation of the student point of view — and the value of collaboration!

An engineering lab is one example of an activity that integrates and reinforces concepts across the disciplines. In this lab the students cold-work a brass sample through a rolling mill. Data are collected to produce a table of the resultant hardness versus the cross-sectional area of the specimen at sequential steps through this process. These data are then plotted as hardness versus percent cold work. The data are then used subsequently in a mathematics session to explore curve fitting to an exponential equation of the form:

$$H = k(CW)^n$$

where the power of the TI-85 graphing calculator is used to reenforce the real-life application of mathematics.

A second engineering exercise involves the three-point bend testing of glass rods where one group of specimens serves as a control and a second group of specimens has been etched in HF acid to reduce the severity of strength-reducing surface flaws. These data are then analyzed in a mathematics session to determine averages, standard deviations, and calculations using the Griffith theory of flaws to reinforce the inter-relationship of structure, mechanics, and properties:

$$\sigma = (2 * \frac{E}{\pi} \frac{\gamma}{c})^{1/2}$$

These data are then used again in a subsequent session involving the use of computer spreadsheet analysis and graphing to produce linear plots of these data. Other examples of cross-discipline reinforcement are the use of the Arrhenius rate equations developed in chemistry as applied to practical diffusion phenomena in metals and electronic processing. The bond types discussed in chemistry are reinforced through examples and discussions of the structure, properties, and performance of engineering and everyday materials. The intention of these cross-discipline exercises is to reinforce the interrelatedness of the tools, techniques, and theories we all use in mathematics, engineering, and science.

Because the resident advisors and the residence coordinators are all engineering and science students, the reinforcement of time management and good study habits continues in the dorm.

The residence staff plans numerous team-building activities for the participants and also provides valuable feedback to the faculty in the weekly staff meetings.

Participants: Over the six years, we have attracted a diverse population to the program.

Table 1: Quest I Participants

		1994	1995	1996	1997	1998	1999
Number of Participants		56	50	50	45	55	47
Native American	M	0	1	0	0	1	0
Native American	F	0	0	0	0	0	1
African American	M	2	6	5	8	4	4
African American	F	4	5	5	8	1	2
Latino	M	39	34	32	17	34	33
Latina	F	11	4	8	12	15	7
TOTAL	M	41	41	37	25	39	37
TOTAL	F	15	9	13	20	16	10
Community College		3	16	6	12	14	12
CPP Freshmen		36	21	35	25	38	34
CPP Transfer		17	13	9	8	3	1
CPP Computer Science		7	0	3	7	5	10
CPP Engineering		40	30	34	22	34	22
CPP Mathematics		0	0	5	1	0	2
CPP Science		6	4	2	3	2	1

The students must be historically under-represented, have an interest in a technical major (for community college participants) or be accepted into the colleges of engineering or science at Cal Poly Pomona, and place at college algebra or higher. All are required to stay in the dormitory during the program. In return, the students each receive a TI-86 graphing calculator for $25 and those successfully completing the program earn a $600 stipend.

Retention and Academic Performance of Participants One way to assess the performance of the participants who entered Cal Poly Pomona is to examine enrollment and grade point average at the end of fall quarter one year after completing the program. These data can be compared with the performance at the end of Fall quarter 1994 of a similar cohort entering Cal Poly Pomona

Fall 1993 without benefit of Quest. This comparison cohort consists of all students who were admitted to MEP fall 1993. Therefore, they had to be regularly matriculated students who elected to participate in the program. Some were more accelerated than the usual Quest participant; others had a somewhat weaker mathematics background. For each year of Quest, there were one or two students who stated their intention to enroll at Cal Poly Pomona in the fall (or return to their community college), yet whose plans changed. The following table gives retention and grade-point average for cohorts initially enrolling from 1993 through 1996.

Table 2: Academic Performance and Retention

Yr. Entered Cal Poly P.	**'93 Baseline**		**'94 Quest**		**'95 Quest**		**'96 Quest**	
GPA Fall, following year	#	%	#	%	#	%	#	%
3.5 ≤ GPA	2	1.6	6	11.3	0	0.0	5	11.4
3.0 ≤ GPA < 3.5	12	9.8	9	17.0	8	23.5	8	18.2
2.5 ≤ GPA < 3.0	24	19.7	10	18.9	6	17.6	11	25.0
2.0 ≤ GPA < 2.5	42	34.4	8	15.1	5	14.7	5	11.4
GPA <2.0	13	10.7	8	15.1	6	17.6	8	18.2
Changed Major (nonSEM)	1	0.8	1	1.9	3	8.8	1	2.3
No Longer Enrolled GPA ≥ 2.0	5	4.1	5	9.4	1	2.9	3	6.8
No Longer Enrolled 2.0 > GPA	23	18.9	5	9.4	3	8.8	2	4.5
Did not enroll CPP in Fall	0	0.0	1	1.9	2	5.9	1	2.3
TOTAL	122		53		34		44	

In examining the data, there are several sharp distinctions between the students' records who entered in 1993 and those for Quest participants. The percentage of students earning a 3.0 GPA or higher is only 11.4% for the baseline group as compared with 28.3%, 23.5%, and 29.6% for the Quest participants. There are slightly fewer Quest students earning below a 2.0 GPA (both enrolled and no longer enrolled), but more are being retained. For the baseline group, 18.9% of the students were no longer enrolled and had a below-average GPA; for the Quest participants, this group ranged from a low of 4.5% to a high of 9.4%. Thus, while not all students have performed at a satisfactory level, the Quest students remained enrolled, with the possibility of improving their standing.

While the later years of Quest participants have not been enrolled long enough for a longitudinal study, we can examine the subsequent record of those '94 and '95 Quest participants to see their performance at the end of fall quarter 1999. At that point for the '94 cohort, 15 have graduated

and 15 were still enrolled in SEM majors at Cal Poly Pomona. Of the 21 to leave SEM majors, thirteen had GPAs above 2.0 and eight below. Two did not enroll the fall following the summer program. The average GPA for graduates in the College of Engineering at Cal Poly Pomona is about 2.8, so the average of 3.13 for those who have graduated to date indicate a much stronger than average performance by these Quest participants. The six-year time to degree completion is the norm for the majority of students at Cal Poly Pomona.

Table 3: Status of 1994 & 1995 Quest Participants Graduated or Still Enrolled Fall 1999

Academic Status	**Number**	
	1994	**1995**
Graduated	15, ave. GPA = 3.13	1, ave. GPA = 2.33
3.5 ≤ GPA	0	2
3.0 ≤ GPA < 3.5	1	2
2.5 ≤ GPA < 3.0	5	10
2.0 ≤ GPA < 2.5	8	9
GPA <2.0	1	0
TOTAL	30 (56.6%)	24 (71.0%)

For the 1995 cohort of 34, only one has graduated, but 71.0% have been retained (or graduated), again reaffirming the norm of the six-year time-to-graduation at Cal Poly Pomona.

Roles of Facilitators the importance of student facilitators to the program cannot be overestimate. They not only provide assistance to the faculty in managing team activities. They provide concrete suggestions to improve the learning process and teaching effectiveness. They also serve as mentors to the students in how to make a successful transition to the campus and to technical studies. Where possible, facilitators are chosen from previous Quest participants. The following introduction for incoming Quest I students was written by a student facilitator in mathematics who became the president of the campus chapter of the Society of Hispanic Professional Engineers and an experienced Academic Excellence Workshop facilitator.

Brief Overview of Quest I Experience

Welcome to Cal Poly Pomona & Quest! Congratulations on graduating! I'm here to remind all of you that we are no longer in high school. The following script describes a little of what you should expect over the next few weeks.

Two years ago, I was in the exact position each and every one of you are in at this very moment. Coming out of high school with prestigious honors and awards, I thought Quest would be a

program where I would attract everyone's attention with the knowledge I had at that time. Little did I know how wrong I was.

As soon as I arrived on campus, having had my parents drop me off in the dorms we stayed in that summer, I instantly felt totally different about the program. All of us were told about the expectations Quest would require in order to receive the stipend. I looked around me, knowing absolutely no one except myself, telling myself, "What have I gotten myself into?" I was overwhelmed by the size of the campus, the academic transition coming out of high school, and the number of people I did not know. I thought I would surely struggle. High school calculus, physics, chemistry and all the technical classes in high school were so simple. I continuously asked myself, "What have I gotten myself into?"

As it turned out, I had an awful first day. People, for some reason, kept to themselves and I really didn't feel comfortable all Monday. I thought the end of the program was so far away. But I tried changing my attitude, hoping others would see eye to eye with me. Tuesday arrived, and it started out well, as I had breakfast with a group of guys cracking jokes. I was doing a lot of the laughing and none of them seemed to mind my presence. Later that day, we had a materials and science lab where groups of three were requested by the instructor. I thought I would have a hard time finding a suitable group. On the contrary, I had a couple of guys call me over to see if I wanted to be in their group. I then thought to myself, "This may not be all that bad after all." I began talking with more and more people, and by the time I became fairly acquainted with a nice number of the participants, I noticed the week came to an end. I was already looking forward to the following week.

Don't get me wrong; the program wasn't completely wonderful. The mornings, in particular, are what killed me, since I would have to wake up every day an hour and a half before my first class began. A pain in the rear were those mornings, but otherwise, I really had a great time in Quest.

I met so many people, which was great since fall quarter was only two months after the program's conclusion. I also had a feel for the level of expectations Cal Poly Pomona places upon its students. The campus as well became familiar and I was soon able to go to class without looking at a map or asking for directions. The dorm life was also pleasant since we threw a few social gatherings before and after studying. I really was a memorable event for myself, and I know many of the participants that year would testify in the very manner that I have about Quest.

To conclude with my experience in Quest, I would like to see a lot of you take advantage of those around you who are familiar with Cal Poly Pomona. It can be a very depressing and stressful transition from high school if you aren't careful. As long as you are organized, you should manage to do well. But, mark my words, "network and collaborate with those around you. These people are, of course, your classmates, your professors, and potential companies you may someday work for." I wish the best for each and every one of you, and I look forward to working with all of you for the next four weeks.

Sincerely,
Alvin Cruz
Math Facilitator

*By the way, I strongly suggest you get a head start on your presentation. Presenting is never easy, and the longer you wait, the more difficult it is.

*Also, if any of you ever want to talk or need some advice, feel free to call me at (phone number).

To hear more directly about the facilitating experience and its responsibilities and rewards, here is one perspective: "This past summer I was a facilitator in Quest. As a facilitator I helped the Professor Aldrich with his class and was another resource for the participants. For example, if participants had a question they could ask the professor or myself. The advantage of having a facilitator in the class is that sometimes participants might be intimidated by the professor and so not ask questions about something they don't understand. They are much more likely to ask the facilitator. It is also good to have a different perspective when learning a new subject. As a facilitator I encouraged group interaction and I found myself not only a facilitator, but a mentor and a friend. Now when I see Quest participants and they have a problem with school or home, they know that they can come and talk to me and I will try to help them. Not only have I helped my Quest participants learn but they have also taught me. They have taught me to explain problems to them and I have taught them to answer their own questions by asking them a question. A participant may solve a problem different from me, but by learning their method I am able to show another students more then one way of solving a problem. As I look back I see that I have learned many key roles which I use in my personal and student life and will use in my professional career."

Conclusion: A program such as Quest can have lofty goals and assess its success through statistical analysis of the subsequent performance of its participants; however, the students themselves must endorse the program if it is truly to have worth. To assess this aspect, a former facilitator interviewed numerous former participants for their perspectives of the Quest program. They feel that Quest shows them how to study, how to manage time, and how to make a professional presentation. They also learned how to communicate, to work in groups, and to be a leader. To quote one student, "As a freshman entering college I didn't know anyone and was a very quiet and shy person. Quest introduced me to many people in my major. By working in groups I learned that I had to speak up if I wanted to be heard. After completing Quest I could see a tremendous change in myself; no longer was I the quiet and shy person, now I was doing the talking."

Another student appreciated the classes — "they were a quick preview of what we were going to learn when we took the class. Now that I have completed all the classes that they taught in Quest, I feel that I had an advantage over the rest of my classmates because I could understand the material because I had already been introduced to it." Quest participants liked the classes offered in Quest because they are taught like real college courses and they get a feel of what college was going to be like that fall. They learned that a lot of studying was needed to

understand the materials covered. They also learned not to wait until the day before the homework was due to work on it because if they did, they would be up all night studying.

Yet another student focused on the leadership skills. "I believe that Quest has made me an effective leader. Most of the Quest participants are the ones that have become facilitators for Academic Excellence Workshops and are on the executive boards of clubs like the Society of Hispanics in Science and Engineering or the National Society of Black Engineers."

A Quest I and II participant and Quest II facilitator for two years had this to say: "Quest was an inspiration in my life. Quest has helped me adjust my personal and academic life. Without it I think I would have dropped out." He is now enrolled in a Ph.D. program.

The data show the increased retention and academic performance of Quest participants. Their comments attest to the value the participants see in the program. Those results are the primary motives to offer such a program, but there is more. The collaboration among faculty working across disciplines and colleges breaks down barriers. The exchange of information among departments and colleges is increased, and faculty are more aware of the common problems departments face. Further, faculty have a better understanding of course content in the various disciplines.

The facilitators and resident advisors serve as mediators -- to coach students about how to approach faculty and to straight-forwardly discuss what it takes to be a successful technical student. Because the facilitators and resident advisors come from the same communities as the participants, they can discuss candidly how to balance school work with the many personal demands of commuting, family expectations, and personal finance. The collaboration between faculty and facilitator allows the faculty the benefit of student feedback given by the facilitator. For instance, the facilitator can suggest concrete changes to classroom conduct like: "Ask more questions." "Wait longer for responses to questions." "Draw information out of the students rather than tell them." The faculty — facilitator relationship also is a collaboration where the facilitator now has an entree into the world of faculty. Frequently these relationships are maintained for years and the faculty member becomes a mentor to the facilitator.

The faculty are able to establish a less formal relationship with a significant group of incoming students. These students will often drop by to greet and chat with the faculty member even though they are not in the major of the faculty -- another chance for informal mentoring. In addition, faculty get a better understanding of the assumptions and backgrounds of incoming students. Too frequently, faculty also learn how little has been expected of students in their previous schools and the passive learners such systems create.

Here, however, the link with the facilitators becomes crucial. Frequently the facilitator will discuss with the class their own personal experience so that participants realize that one can rise above hardship, that perseverance, self-discipline, and clarity of goals are the real measures of success. Thus, faculty, facilitators, resident advisors, and participants all are enriched by their joint collaborative experience.

1. An earlier version of this paper was published in the American Society for Engineering Education, Pacific Southwest Section, 1998 Conference Proceedings: "Educating Engineers for 2000 Plus," pp. 33-143.

WINTHROP ALDRICH
J. Winthrop Aldrich is a Professor in the Chemical and Materials Engineering Dept. at California State Polytechnic University, Pomona, and has been involved in the Quest program since its inception in 1994. He received his BSME from Rensselaer Polytechnic Institute and his M.SC and Ph.D. in Materials Science and Engineering from Brown University. He worked at American Optical Corp. and Polaroid Corp. for many years before returning to academia.

M. CATHARINE HUDSPETH
M. Catharine (Kay) Hudspeth is the Director of Maximizing Engineering Potential (MEP) at California State Polytechnic University, Pomona, and also serves as the NSF AMP campus coordinator and co-directs the Academic Excellence Workshops. She received her B.A. from the University of Texas and her M.S. in mathematics from Syracuse University. She has extensive experience in teaching mathematics.