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Martin Vern Bonsangue  
*California State University, Fullerton*

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# Calculus Workshop Groups as a Humanistic Experience

Martin Vern Bonsangue  
Department of Mathematics  
California State University  
Fullerton, CA 92634

The latest mathematics report card from the California State University is not encouraging. In 1989-90, 534 bachelors degrees in mathematics were awarded, about 1.1 % of all bachelors degrees at all 20 CSU campuses. Of these, 36 were earned by Latino students, 7 by African-Americans, and 4 by Native Americans. That same year, 98 masters degrees in mathematics were awarded in the CSU system. Exactly one of the 98 degrees went to an underrepresented minority student, in this case, a Latino male.

These statistics have probably caused some eyes to glaze over by now, perhaps causing an important readership group to stop reading. For the unglazed reader, though, these data are alarming, especially in light of the continued existence of so many programs that target minority achievement in mathematics and related fields. One of the critical elements in many programs is having role models in academia for students of color. I do not know if the lone 1990 MA graduate entered teaching, say, at the community college, but if he did, there are about half a million Latino students in the California Community College system's 107 campuses looking for a role model in their required algebra classes. He will be busy.

In *The Challenge of Diversity*, Daryl Smith discusses what she calls the perceived conflict between access and quality. "The continuing message that a fundamental conflict exists between issues of access to the institution and quality is perhaps the most disturbing indication that present institutional approaches to diversity are inadequate.

1. The concern about preparation of students, while affecting many minority students, is not a minority problem. Indeed, most poorly prepared students are white.

2. Much of the evidence concerning the tension between quality and diversity rests on lower standardized scores. Serious questions exist about the predictive validity and the power of these instruments for women, for many minorities, and for those with learning disabilities.

3. Early evidence focused attention on academic preparation as the most significant factor in achievement, leading many researchers to conclude that academic success is a function of preparation, not race. However, to the degree that issues of racism, sexism, homophobia, and the general presence of an alienating environment also affect performance, then lack of performance cannot be focused entirely on the student. All too often we have assumed the institution's perfection and students' incompetence." The mathematics degree completion data reported above seem to reflect the reality of this dilemma in the mathematics community.

## The Workshop Experience

Consider the experience of the Academic Excellence Workshop Program in Calculus at California Polytechnic State University, Pomona. From 1986 to 1991, 130 African-American and Latino students have taken the traditional one-year

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calculus sequence while participating in twice-a-week workshop sessions outside of class. The AEW program, based on the Berkeley workshop program founded by Dr. Uri Treisman, targeted first-year freshmen students accepted in the College of science or the College of Engineering. Every African-American, Latino, or Native-American incoming student received a personal phone call from a faculty member or student leader in the program inviting the student to attend an introductory meeting about the program. Students paid no additional fees to be in the program, but received no additional credits either. Participation, though encouraged, remained the student's choice.

Based on a 4-point scale, the average grade in first-quarter calculus was 2.67, compared to the department average of 1.91. More than one-fourth (26/130) of the workshop students earned grades of B+ or higher, while fewer than five percent (6/130) failed with a grade of D or lower. Second-quarter and third-quarter averages were likewise one-half to three-quarter grade points above the department mean.

This trend of success continued past the first-year courses, even though workshops were not offered with courses beyond first-year calculus. Between 1986 and 1989, seventy-eight students participated as freshmen in the workshop

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program. About four-fifths of these students (61/78) completed their second-year calculus sequence, this time with 40 % (31/78) earning grades of B+ or higher. Moreover, 75 of the 78 students were still enrolled in some major at Cal Poly after three years, with 85 % (66/78) still in mathematics, science, or engineering. The latest records show that as of Spring 1992, 60 of the 66 students had either graduated or were fifth-year seniors having completed all mathematics prerequisites for their degree.

This trend of continued success past the first year was especially evident for minority women in the workshop program. Twenty-two of the 78 calculus workshop students from 1986-89 were Latinas. After three years, all 22 women were still enrolled at Cal Poly, with 19 remaining in their mathematics-based major (mostly engineering). By 1992, all 19 had either graduated in a math-based field or were within two quarters of graduation. By comparison, 23 Latina women were enrolled in the same Calculus I course as freshmen, but did not participate in the workshop sections. Within three years, only 12 were still enrolled at the university, with seven of these in mathematics, science, or engineering. By Spring, 1992, exactly four of the original 23 students had graduated or were within two quarters of graduation.

### Self-Selection or Program Effects?

The data reported above raises many suspicions about the effects of the program versus those of self-selection. Plainly put, wouldn't these successful students have been successful anyway? The literature on this type of research identifies a host of variables that affect academic performance, including past achievement, motivation, socioeconomic status, and parental factors (for a more exhaustive list, see Sandy Astin's work with the Higher Education Research Institute data). Of course, the data reported above is historical, so that perfect controls, such as a behavioral psychologist might use, are not possible. Did the workshop students have an edge to start with, and, if so, how much?

David Drew, my colleague in this inquiry, and I tried to triangulate the study, that is, look at the above results from three different ways and see if these all seem to say the same thing. First, we gathered all the past achievement data that was available: SATs, high school grades, qualify exam scores (given by the Cal Poly Department of Mathematics). Second, we surveyed the 1990-1991 cohort of calculus students about their study habits and involvement both inside and outside of school. And third, we interviewed juniors and seniors who had participated in the calculus workshops as freshmen (though some had dropped out of the workshop program), to listen to the effects of being in the program as the students had experienced them.

### Academic Achievement

Past academic achievement showed workshop students to be at the same or slightly below the levels of their non-workshop minority and non-minority peers. SAT-math scores averaged around 540 for African-American and Latino students, and around 580 for white and Asian students. Likewise, SAT-verbal scores were lowest for Asians (around 370), medium for blacks and Latinos (430), and highest among whites (480). High school grade point average ranged between 3.3 and 3.4 for all groups except blacks, who were at 3.2. Finally, diagnostic test scores were about 29 (out of 40) for blacks and Latinos, and slightly higher (30-33) for Asians and whites. Moreover, none of the measures described here were different for workshop minority students and their ethnic peers not in the workshop. In

summary, workshop students were indistinguishable on paper from students not in the workshop.

### Study Patterns

The survey did reveal differences among students' study patterns. Thirty-six workshop students and 150 non-workshop students enrolled in the same lecture sections of first-year calculus were asked about their time spent studying individually, in groups, on-school activities, and off-campus commitments. Workshop students reported spending 8.25 total hours per week studying calculus (alone and in groups), while non-workshop students reported 6.25 hours. For workshop students, four of the 8.25 hours were spent studying in groups, while reports for non-workshop students varied: about 1.25 for Asian students and about 0.6 for white students. Interestingly, Latino and black students not in the workshop reported spending nearly 2 hours per week (out of 7 total) studying in groups, probably because most of these students study in the Minority Engineering Program tutorial center. There were no differences between workshop and non-workshop students' involvement off-campus, although workshop students reported spending more time involved in on-campus activities than did non-workshop students.

Although the data are based on self-report, if we assume that students uniformly exaggerate their study time, three patterns seem to emerge. First, students in the workshop spent 25 % more time studying for their calculus course than did non-workshop students. However, this difference was in time spent studying in highly structured groups, not in studying alone. Thus, while there is some evidence that the main difference in calculus performance may be explained by "time-on-task," there is little evidence to suggest that the workshop students were more highly motivated to work on their own than were their non-workshop peers. Second, minority students not in the workshop spent almost as much time per week as did workshop students, even though the average calculus workshop grade was a full grade point higher. This suggests that time-on-task may not be the key factor so much as time on the *right* task. Third, workshop students did not seem to have more "free" time than did other students.

### Student Interviews

Twenty-three former workshop students were asked to describe how they felt their experience in the workshop contributed or did not contribute to their subsequent academic performance in their mathematics-based courses. The interviews ranged from twenty to sixty minutes in length, and were recorded and then transcribed with the student's written permission. Twenty-two of the interviewees were Latino students, including seven women, with one interviewee an African-American male. Rather than merely summarizing the interviews, students'

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comments are reported here in the context in which they were spoken. I think it is important here to let the students speak in their voices.

### Study Issues

Students were asked if they felt they would have done as well in the calculus course if they had not taken the workshop. Five of the sixteen men indicated that they would have done just as well, with one male student not sure, whereas only one of the seven women so indicated. There seemed to be two common factors in those who felt they would have done as well: first, that they studied hard, and would have learned the material anyway, and second, that the group was sometimes a "distraction" to learning. However, two of the five men felt that, in retrospect, they should have taken the workshop more seriously. One student felt he was "cocky" coming to college after a successful high school career, and failed his calculus course. R. R., an Electrical and Computer Engineering major, indicated that the workshop was a "disappointment," but that he still should have been more committed:

I underestimated the level of work, particularly in math or science. Calculus is still a block to my other science courses.

The students indicating that they would not have done as well without the workshop echoed the common theme that the workshop sessions were a time of intensive study. More than half of the students mentioned the facilitator's importance in structuring the study time. One student said that the facilitators "pushed you" into being prepared for the exams. Several students indicated that those four hours per week were reserved for calculus, so that there was consistency in their own preparation for the course. Although not asked directly, five students discussed their amazement at being academically challenged by the other workshop students. M. J., a junior in Industrial Engineering, said that he was a

... good student in high school, in the top 5 % of my class. But the workshop people were smarter than me or more disciplined. I saw that people were better than me. They challenged me to get to their level.

However, not all workshop participants desired this level of academic involvement. One interviewee who had dropped out of the workshop indicated that the program was good for "serious" students, but did not provide the social experience he needed.

Twelve of the 23 of the students indicated that their individual study time was affected by their workshop involvement, although the nature of

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that effect varied considerably. Most of these students indicated that the course material that they learned during the workshop sessions decreased the amount of time it took for them to learn the material on their own. Several students, however, felt that the workshop "cut into" their homework time. One of these students felt that the purpose of the workshop session was "like tutoring," and was frustrated that he could not work on the homework during the workshop time. Conversely, two students indicated that the level of difficulty of the worksheets in the workshop sessions made them

realize that they needed to increase their individual work time in order to "get up to level that [other students] were at." One student felt being in the workshop "guaranteed" him four hours per week, especially when he was inclined to procrastinate his studying. R. D., a transfer student in Mechanical Engineering, articulated her realization of the amount of study time necessary to succeed in technical courses:

You realize how much time you put into that one class, and that was, you know, a freshman-sophomore level calculus, so you get higher, you think 'Gosh, it took me that much time, plus the workshop, plus the tutoring,' it makes you really realize that you do need to put in time, it takes time to do your classes.

Hence, although workshop effects on individual study time were mixed, students indicating a change felt that their study time had changed both in terms of quality and quantity.

All of the interviewees indicated that studying in groups was helpful in learning the material, although for the majority of students working collaboratively was a new experience. G. R., a senior majoring in Mechanical Engineering, summed up:

When you teach other people how to do it, you also get a better grasp of it. Sometimes you think you know how to do the problem, but when someone asks you how to do it, you kind of get stuck, and it shows you that you don't really know it as well as you thought you did.

Several other students felt that the workshops "made me explain myself" in working with peers on calculus problems, particularly in solving applied problems. One student who now enjoys working in groups described himself in high school as a "loner," and that working with other students was "distracting." Further, he felt that in high school he could not depend on others for help: "I trusted myself and no one else." He felt that the combination of the social and academic aspects of the workshop were for him important in learning to adapt to group learning. Moreover, one student indicated that although he agreed in theory that group learning was helpful, he didn't perceive the need for personal involvement:

I can do it on my own. I work 35 hours per week. But sometimes I didn't work; I would use that as an excuse. If I did have time, I would waste it, not work on school.

Thus, although his work schedule made workshop participation difficult, he admitted that even without work he probably would not have felt much differently.

The effect of the workshop experience on personal study habits was mixed. About three-fifths (14/23) of the students felt that the workshop

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had a definite impact on their study habits, particularly in working together in groups. Five students mentioned that they now seek out other students in their classes to study with, even though the students were not workshop classmates. Several students remarked that they had learned from their facilitators how to use different study tools, including writing their own worksheets as test reviews. Two of the students that did not indicate any changes in their own study habits still felt that group learning was "fun," and felt that the workshop experience had been beneficial. Two students indicated that they had gained very little benefit in learning how to improve their study effectiveness.

Students were asked if participation in the workshop had affected their decision to continue in their MSE major. More than half (4/7) of the women reported a direct effect, compared to less than a third (5/16) of the men. The common theme among the nine students indicating a positive effect was that of encouragement. Although the interview sample is small for general inference, the importance of encouragement from peers and from the facilitator seemed to be especially important to the women. This encouragement sometimes came in the form of discipline and accountability. O. S., a senior majoring in Computer Science, reflected about her first year:

I never thought I could do it. I had to take remedial courses, couldn't pass the stupid diagnostic test. I got a B+ in physics. Before it was, like, C's. It brought me up one to two levels from F to C, or D to B.

[The facilitators] push you to a limit that you think you're gonna die, that you can't do it any more, and they say, 'It's not that hard.' I had many facilitators stay with me until I got that problem, 'cause they knew I wouldn't do it if I left.

S. B., a senior in Electrical and Computer Engineering, mentioned the importance for her of the facilitator as a role model:

I remember one specific math facilitator. She was Tau Beta Pi, the top 20 % for engineers. You look up to them.

However, several of the men indicated the importance of encouragement of their peers. M. J., a junior in Industrial Engineering, summarized the importance of encouragement after a test:

It's the whole thing about the workshop, you know, to get you up there to another level. It's discouraging sometimes, you do bad on a test, you go to the workshop, it's like, 'Man, how you doing?' 'Not too good.' 'Let's talk about it. What was the problem?' [Your peers] encouraged you a lot.

Conversely, about two-thirds of the students felt that the workshop had not guided their decision to stay within a technical field. However, several students stated that working in an environment where excellence was expected confirmed their sense of being potential engineers or scientists.

### Ethnic Issues

Interviewees were asked if the workshop experience had affected their perceptions of minority students in the mathematical sciences. Exactly half of the 22 Latino students said that it had, while the other half said that it had not. There were strong feelings on the part of some students on both sides. Almost all of the students answering no indicated that their high schools had been ethnically diverse, with minority students enrolled in the top mathematics and science courses. Conversely, most of the students answering yes came from backgrounds where minority participation in academic pursuits was the exception. One student indicated that in high school there were few Hispanics in the advanced mathematics courses; here, he felt like "part of the crowd." C.A., a senior, shared a strong personal experience:

In high school, I never considered myself Hispanic. Sure, my name was Antonio, but everyone called me Tony. I felt white,

I didn't feel Hispanic. I felt myself being prejudice against Hispanics. I denied my heritage. Coming to Cal Poly, I was shocked. I'd never seen so many blacks and Hispanics. But I was signed up for the workshop. Plus I found out that this place was OK. People knew my name now, this is pretty good, y'know? Wow, suddenly these guys are OK, and I started perceiving them differently, like, 'Yeah, I'm Hispanic. What's wrong with saying my name, 'Antonio,' or saying I'm Hispanic?' I started feeling Hispanic, and admitting it, and not feeling ashamed, like, 'Yes, I'm part of this group.' With minorities I used to look down upon, I feel now that I'm one of them. It changed my entire perception of them.

Conversely, A. B., a junior transfer student majoring in Chemistry, felt resentful that the workshop program was aimed only at minority groups:

Why is it just for us? Do we really need that much more help? In [previous institution], the workshop was open to all groups. I was uncomfortable that the workshop was for minorities only. It felt like cultural singling out.

A. B.'s was the only strong negative reaction to the question. However, it does suggest that while many students enjoyed the fellowship of other minority students, there were some who were not comfortable with the ethnic selectivity of the workshop.

The interview group included one black student, H. A., a senior majoring in Computer Science. When asked if the workshop experience had affected his perception of Blacks in the MSE fields, he responded candidly:

I always tried not to think about it [being one of the few Black students], 'cause it's what I've grown up with. I try not to put any undo pressure to say, 'You're the only one here, you gotta booster the culture, the society. I just try to say, 'Let's do what we can...and do it as well as we can.' Every now and then I'll look around again and say, 'Yep, [I'm the] only one again.' I think in this quarter I have four classes, two of them are CS, and I have 2 Blacks in those four classes."

Although H. A. was otherwise very enthusiastic about his experience in the workshop, his response

indicated a mix of frustration and determination in representing the very small community of Black students succeeding in the mathematics, science, and engineering majors.

The effect of the workshop upon perception of minority students as a competitive group in technical fields seemed to depend largely on the students' previous experience. Students attending institutions with diverse populations felt far less of a change than did students who attended schools where minority students were not greatly involved

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in advanced mathematics or science courses. Some interview students indicated finding a true sense of community with fellow ethnic students, while others felt resentment or embarrassment at being singled out. The one Black student interviewed articulated his frustration at being one of very few Blacks who have managed to get through the mathematics pipeline into higher level courses.

### Gender Issues

The seven women who were interviewed were asked if their workshop experience had affected their perception of women in technical fields. Each of the students indicated that it had, with several of the students having a strong reaction to the question. The common theme was that of isolation in a male-dominated discipline. C. T., a senior in Electrical and Computer Engineering, summarized the problem:

There are very few women in ECE classes. You look around, see half Asian, half white, and you're the only one. It's kind of lonely.

O.S., a Computer Science major, implied that for her, the issue of gender was far more important than ethnicity or race:

There are very few women in Computer Science and in technical fields. Being a minority, Hispanic, and being female, when you're walking to class, you're the only girl, and it was very awkward. It doesn't matter if you're Hispanic, or orange, or purple, or whatever. It's like the guys are, 'What is she doing here?', that kind of attitude. They get over it, 'cause...you're doing good in the class. When you are doing better [than the men], it's a shocker!

Moreover, C. L., an above-average student majoring in Mechanical Engineering, indicated the importance of having met "a lot" of female engineers. Although she was glad to have had two workshop facilitators that were women, she discussed the barriers to women in engineering:

You hear about how few women actually graduate in engineering, even the ones that start in it, and I seem to think it might be harder for women to actually graduate in it. Whether they mean to or not, you see a lot of, you know, prejudice against the women...within the teachers or fellow students as if they don't seem to think you can actually make it sometimes.

Although not prompted to do so, she went on to discuss more specifically the issue of sexism in her engineering courses.

You also hear about the teachers that are sexist, or the ones maybe you shouldn't take. Of course, there's no way to prove anything about that, but the teachers themselves say that sometimes it causes a difference in their grading, even though they don't mean to.

She concluded with the importance of women role models who have completed the engineering degree:

Just seeing that other women have made it, you feel that maybe you can make it.

Still, success seemed to be something that was not entirely in C. L.'s control, in spite of earning grades that were higher than those of most of her male colleagues.

The concerns that these women raise are reflected in the low proportion of women graduates in engineering discussed at the beginning of this chapter. From 1985 through 1990 at Cal Poly,

12.3 % (382/3112) of the graduates in the College of Engineering were women, with 11.5 % (44/382) of this group Black or Latino. Stated differently, African-American and Latino women accounted for less than 1.5 % of the engineering degrees at Cal Poly over a five-year period. The extent to which academic or social barriers in technical courses affected the women in the sample

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is difficult to determine without other instruments of precise measurement. There is, however, strong evidence that the experience of women in the technological courses is qualitatively different than that of men. The extent to which ethnicity of the student or gender of the instructor play a role was not measured in this analysis. However, the women interviewed here articulated a strong need for women role models in engineering with whom they had direct contact, as well as a peer community of women sharing the same or similar experiences in college. R. D., a transfer student in Mechanical Engineering, succinctly described the importance of the community for women generated during the hours spent together in workshop sessions:

Your minority women, it gets them together, and it's like, 'Let's hang together and get through this.'

### Summary

Interviews with former workshop students who have persisted in their Mathematics, Science, or Engineering majors suggested that the quality of study may be at least as important as the quantity. Active involvement in the two-hour workshop sessions was a key component in the learning process, with students having to explain their own and challenge each other's solutions to mathematics problems, particularly with applications. About one-half of the students thought the workshop



actually decreased or made more effective their individual study time, although several students felt they had to increase their time outside the workshop in order to keep up with their workshop

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peers. All of the students found the collaborative model to be effective to varying degrees, although some did not indicate that the workshop had any lasting effect on their personal study methods. About three-fifths of the former workshop students indicated that they had since studied in groups regularly, often forming their own groups with non-minority students in their major classes.

The most prevalent interview theme centered on academic involvement and awareness. In working difficult mathematics problems designed by the facilitator during workshop sessions, interview students recalled not only developing a deeper understanding of the material, but becoming acutely aware of the level of comprehension that their professors would expect of them. Especially helpful was the interactive nature of the sessions, where students verbalized their ideas to one another. Community-building and developing interpersonal relationships occurred within the context of academic rather than social activities, although a number of students stated that the best workshops were ones in which the facilitator used games and other activities in some sessions.

Working in peer groups seemed to be a new approach for most of the workshop students. About three-fifths of the group indicated that this technique of group learning had carried over beyond the calculus classes into junior and senior-level courses within their major. However, the extent to which this carry-over was directly

associated specifically with the calculus workshop was difficult to determine, since some of the interviewees had taken workshop sections of other courses as well, including Mechanical Engineering, Physics, and Chemistry. Fewer than half of the workshop students indicated that their workshop involvement had affected their decision to stay in a technical major, although the workshop may have had a greater impact on MSE persistence for women. The strongest reaction to interview questions regarding effects of group learning came from the women, with each student reporting that she had experienced some degree of isolation enrolling and competing quarter after quarter in classes dominated by men. The workshop seemed to provide a bi-weekly network for the women that was not possible in a tutorial drop-in setting. Several women described feelings of self-doubt in their ability to succeed in engineering, even though their in-major grade point average was higher than those of most of their male peers. In summary, the experience described by women of successfully getting through a mathematics, science, or engineering major was qualitatively different than that described by men.

### Conclusion

In the interviews students describe a rich tapestry of experiences that were associated with the calculus workshops. Few, if any, of the students interviewed had ever studied in peer groups before their calculus courses. However, most of the students attribute their success in varying degrees to their workshop involvement. Of course, it is still not resolved whether these particular students would have done as well anyway, just as one's headache might have gone away even without the aspirin. However, almost every student reported that the workshop affected their academic lives, many in permanent ways. At any rate, the Cal Poly Workshop experience shows that there exists a nontrivial number of students who will participate, will succeed, and will form the nucleus of a successful group of minority students in mathematics-based disciplines that currently have little minority representation.

Dr. Treisman talks about workshop classes being "inroads to the major," where students spend a lot of time in the department or study room where the sessions are held. In this sense, students feel that they are part of the academic life of the department, and feel a connection to the department

and some faculty. Thus, workshop-type programs may be less about enhancing academic performance

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as about creating structures by which students can become assimilated in a meaningful way into the department. *Science* magazine recently reported that currently at the University of Texas at Austin, 23 % of the approximately 500 undergraduate mathematics majors are minorities, largely due to their participation in the Emerging Scholars Program, a workshop program for entering calculus students.

Julian Weissglass of the Mathematical Sciences Education Board proposes that "changing the system means changing ourselves" as a mathematics community. He poses the following beliefs and values that describe the practices of many mathematics classrooms.

- Competition is necessary to motivate learning.
- Noise is distracting.
- Telling is teaching.
- Paper-and-pencil assessment is adequate.
- It is cheating to get help from another person.
- Feelings are not part of the academic environment.
- The system is O.K. (after all, I succeeded).

At the very least, the Cal Poly Workshop Experience suggests that achievement among underrepresented minority students in mathematics, science, and engineering disciplines is less associated with pre-college ability than with in-college academic experiences and expectations. The rub is that academic departments must see as part of their work the creation of structures and fostering of attitudes that develop academic talent and promote student involvement.

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