Success in mathematics by underrepresented and nontraditional college students is measured not only by academic performance (grades), but also by the continued participation and persistence of these students in mathematics coursework. The Math Excel program at Oregon State University attempts to build "learning communities" with a sharp academic focus in support of students concurrently taking introductory level mathematics courses. The Math Excel program is based heavily on Uri Treisman's Emerging Scholars Workshop model of collaborative problem solving. In this article, we examine the experience of minority students in the Educational Opportunities Program participating in the Math Excel program. While the program had appeared successful in terms of improving academic performance in the concurrent mathematics course, the continued participation and persistence of these students in mathematics was disappointing. On a trial basis, structural changes were made to build a much stronger identification of the Math Excel learning community with a section of College Algebra. In the next term, there was a much higher incidence of participation in the subsequent Precalculus using the same Math Excel structure. While the collaborative problem solving activity provided in Math Excel was crucial to students' successful academic performance, these results suggest that subtle issues related to students' recognition of and identification with a learning community may be critically important to underrepresented and nontraditional students' continued persistence in mathematics.

Introduction

Success in mathematics by underrepresented and nontraditional college students is measured not only by academic performance (grades) but also by the continued participation and persistence of these students in mathematics coursework.
The Educational Opportunities Program (EOP) at Oregon State University provides academic and special admission support for nontraditional students, including students of color and students with disabilities, to assist them in successfully entering and navigating the educational system. The EOP unit functions as a smaller community within the larger university community, whose student body is predominately European American in ethnic background and middle class in socioeconomic status. Academic and personal advising is provided by counselors who come from diverse backgrounds themselves.

The primary entry-level mathematics course for students at Oregon State University is *College Algebra*. For many students, this course is the first and last college mathematics course they will ever take. For some students, *College Algebra* provides a foundation for additional courses such as business mathematics. For other students, it is the first step toward a technical major in engineering or science, requiring significant additional mathematics coursework, including *Precalculus*, *Differential* and *Integral Calculus*, and several more advanced mathematics courses.

For EOP students entering college with an inadequate mathematics background to enroll in *College Algebra*, the program provides a range of developmental courses and tutoring sessions to provide the necessary mathematical prerequisites. Historically, *College Algebra* has been a terminal mathematics course for many underrepresented minority EOP students at Oregon State University.

Starting in the year 2000, the Math Excel program became an integral part of EOP's mathematics instructional support strategy. The Math Excel program is based on Uri Treisman's Emerging Scholars Workshop model and employs collaborative learning groups engaged in problem solving in support of concurrent mathematics course enrollment. While Math Excel is open to all students, a target audience for recruitment is that of underrepresented students; EOP's involvement accounts for almost all of the minority student enrollment in Math Excel.

In this article, we will consider the experiences of Oregon State University's EOP minority students in Math Excel in terms of academic performance, participation, and persistence in mathematics. In particular, we will discuss how some structural changes made in the Math Excel program for *College Algebra* may have significant implications for the continued persistence of underrepresented students in mathematics. Institutions considering starting similar
programs may find these results useful in making implementation decisions. To provide some background to that discussion, we will review some of the factors related to persistence in mathematics, how collaborative learning models address these factors, and describe the key characteristics of Treisman's Emerging Scholars Workshop model on which the Math Excel program is based.

Factors Related to Persistence in Mathematics

The issue of choosing and persisting in a mathematics-based major, especially when this decision concerns underrepresented students, is one that has received much attention in recent years. Some of the factors thought to be related to students' choices of major are their view of the usefulness of mathematics, their perception of the difficulty of mathematics, their view that mathematics is an asocial discipline, and their enjoyment (or lack thereof) of studying mathematics courses [1]. In Leitze's study, the most prominent reason found for choosing a major was the enjoyment of the field of study, including likes and dislikes regarding experiences with specific courses and professors. While a quality like "enjoyment" is difficult to examine, the asocial aspect of traditional mathematics pedagogy is thought to contribute to a lack of enjoyment of mathematics studies. As a result, "introductory level courses [i.e., lower-division courses] are vitally influential in determining undergraduates' choice of major." [1]

A study by Linn and Kessel concerning which students will switch out of mathematics-based majors and the reasons for their switching found that over half of students who plan to study mathematics in college eventually switch to other fields [2]. They found that the GPA difference between those students who switch and those who persist was not statistically significant, but that the switchers, who are often among the most talented males and females, most often complained that the learning environment was what had driven them away from taking further mathematics courses. Students were found to feel frustrated that the courses were designed to filter students out of the program rather than to encourage talented students to persist. The authors raise the issue that "quality of instruction more than success in mathematics motivates students to switch out of mathematics." [2]

Research supports the hypothesis that improved methods of teaching mathematics at the college and university level can have a positive effect on both the success and the persistence of students in mathematics. This may be especially true for minority students, as Bonsangue cites
Collaborative Learning as a Means to Encouraging Persistence

The use of collaborative learning situations is one of the most popular suggestions for improving the rates of participation and retention of students in mathematics classes. The intent of collaborative learning, involving group discussions, is to make the classroom a student-centered learning environment. Hoyles found that group discussions and problem solving possessed three main characteristics that help in the development of mathematical understanding [4]. First, talking and listening involve both the cognitive articulation of thoughts and the communicative sharing of ideas. Second, because the situation demands verbalization, students often think more deeply about the concepts. Third, listening and reflecting allow the students time to think over new ideas and develop reasoning. Hoyles believed this type of classwork could help end the days of students feeling alienated and bored with mathematics.

Linn and Kessel suggest that “all learning takes place in a social context, so the goal [in collaborative learning] is to structure social interactions to support all learners.” [2] Leitze contends, “By incorporating collaborative learning into the classroom, diverse learning styles are accommodated and more positive attitudes about mathematics are promoted.” [1] According to Astin, “students learn by becoming involved,” which refers to, among other things, a continuous “investment of physical and psychological energy.” [5] Tinto adds that group involvement is necessary, but for it to be sufficient the group must be perceived as a central part of the institutional structure [3,6]. Pascarella also found that social integration was a particularly important factor in black students' persistence and degree completion [7]. Thus, integrating collaborative learning into the mathematics classroom would seem to address the issues thought most likely to influence persistence in mathematics, particularly for minority students.

Treisman's Emerging Scholars Model

In 1975, Uri Treisman conducted an informal study of undergraduate students at the University of California, Berkeley (UCB) to attempt to determine “what distinguishes strong mathematics students from weak students.” [8] He noticed that the African-American students were disproportionately listed among the weaker students and the Chinese American students were more often listed among the stronger students. This observation led Treisman to change the
focus of his study to determining “what factors explain the differences in the performance of African-American and Chinese American students in first-year calculus.” [8]

Treisman found that, while African-American students usually studied alone and kept their social life separate from the academic, Chinese American students usually studied in groups which also served as social groups [8]. Treisman found a connection between the two groups’ study habits and their academic success. Based upon these findings, he developed the Mathematics Workshop Program (MWP) at UCB. The MWP was primarily designed as an honors program for African-American and Hispanic freshmen. The program was thought to be successful because the workshops provided students with “academically oriented peer groups” where success was prized, more study time was spent on “learning tasks,” and students acquired both study and social skills they could use throughout college [8].

Treisman's model has been adapted and implemented at more than 100 colleges and universities since his initial program was developed at UCB. Treisman himself later implemented the program at the University of Texas at Austin under the name of the Emerging Scholars Program (ESP). According to Bonsangue, some of these Emerging Scholars Programs have “dramatically lowered drop rates and increased the number of minority students majoring in MSE [Mathematics, Science, and Engineering] fields.” [3]

Bonsangue also conducted a study at California Polytechnic State University, Pomona, that included a group of African-American and Hispanic ESP students, a group of African-American and Hispanic non-ESP students, a group of Caucasian non-ESP students, and a group of Asian and Pacific Island non-ESP students, all of whom were enrolled in the same lecture sections of first-quarter calculus [3]. He analyzed the students' academic performance over three to five years, had the students complete a Student Involvement Questionnaire, and interviewed upperclassmen who had participated in ESP as freshmen. When he compared results concerning achievement and persistence between the corresponding minority groups, he found that ESP minority students earned higher mean grades in first- and second-year calculus than their non-ESP peers. He also found that, due to course failure, it took the non-ESP minority students an average of one quarter more than the ESP students to complete their first-year calculus sequence. Additionally, the study showed that “within three years after entering the institution, more than half (52%) of the minority non-workshop students had either withdrawn from the institution or changed to a non mathematics-based major, compared to fifteen percent of the workshop [ESP]
students.” [3] When comparing the ESP minority students with the non-ESP white and Asian students, Bonsangue found that the ESP students' achievements and course-repeating patterns were not significantly different from the others. The Caucasian and Asian students had a higher withdrawal or switching rate at 50% and 41%, respectively. While stating that all of the factors that contribute to this outcome cannot be determined, the author concludes that “achievement among underrepresented minority students in mathematics, science, and engineering disciplines may be less associated with precollege ability than with in-college academic experiences and expectations.” [3]

Treisman's ESP model of collaborative learning workshops appears to be a particularly promising means of positively influencing both performance and persistence of underrepresented students in mathematics. On one hand, the opportunity to engage in discourse with other students on problems directly related to the academic coursework has direct cognitive benefits. On the other hand, the affective benefits to be gained from belonging to a social learning community that is considered an integrated part of students' academic lives appear to have a real impact on persistence in mathematics coursework.

The Math Excel Program

In 1990, Professor Michael Freeman of the University of Kentucky founded the Math Excel Program as an adaptation of Treisman's Emerging Scholars Program workshop model. It is this adaptation on which Oregon State University’s Math Excel Program is largely based [9]. Math Excel was first implemented at Oregon State University in Fall 1998, with workshops for College Algebra, Precalculus, and Differential Calculus. Workshops for Integral Calculus were added in Winter 1999. The regular introductory mathematics courses involve three lectures (80–200 students) and one recitation (30–40 students) per week. In general, there are limited opportunities for discourse between students and instructor during the lecture sessions. Activities during the recitation session include discussion of homework problems and some structured problem solving “labs” where students may work either individually or in small groups.

A student may enroll in Math Excel for one or two additional credits as a separate course and participate in two workshop sessions each week (eighty minutes each for College Algebra and Precalculus; 110 minutes each for Differential and Integral Calculus). Any student taking the corresponding course is also eligible to enroll in the Math Excel section supporting that course, though enrollment is strictly limited to 25–30 students per workshop. Thus, the students
in a single Math Excel workshop may come from several lecture sections with different instructors. Grading for the Excel workshops is Pass/No Pass, and based on a minimum of 90% attendance. The Math Excel program is not considered to be either an honors program or a remedial program, but to provide an opportunity for any student willing to make the commitment to participate faithfully in the workshop sessions.

During the workshop sessions, students are arranged and rearranged into groups of three to five students that work together on a set of problems designed to reinforce and extend their understanding of that week's course work. The workshop is led by a graduate teaching assistant along with additional TA’s and student helpers (a ratio of one assistant to eight students is considered optimal). The goal of the leaders is not to tutor nor to provide direct instruction, but rather to facilitate group discussion of the problems and thereby assist the students to develop and carry out solution strategies on their own. Creating and maintaining expectations for effective group dynamics are major responsibilities of the leaders and assistants.

The workshop leader communicates with the lecture instructors throughout the term and creates worksheets that are tied to the course content being covered in the lecture section each week. Before midterm exams, Excel workshop leaders often create worksheets based on problems obtained from exams of previous terms. This communication between the Excel leader and the instructors in designing the worksheets is important in establishing some level of integration with the concurrent mathematics course.

It is important to note that other adaptations of the ESP model provide a much higher degree of integration with the mathematics course they support. For example, the Math Excel model at the University of Kentucky establishes a direct linkage between the workshops and a specially designated lecture section of calculus in lieu of recitations. That is, all students enrolling in a particular lecture section attend three Math Excel workshops instead of two recitations. This model has the advantage of tighter integration at the expense of some scheduling flexibility.

Math Excel and Performance Results for EOP Minority Students

Duncan and Dick conducted a study to assess Oregon State University’s Math Excel program's effectiveness in helping students earn higher mathematics grades [9]. For each of five academic quarters (Fall 1998–Winter 2000), they tracked students who were grouped by
enrollment in College Algebra, Precalculus, Differential Calculus, or Integral Calculus and by enrollment or non-enrollment in the Excel workshops. During the last term of the study, minority students made up 34% of the Excel enrollment and 64% of the College Algebra Excel enrollment. The data collected in the study included scores from the mathematics portion of the Scholastic Achievement Test (SAT-M) and the mathematics course grades on a four-point scale.

For each term, a linear regression prediction equation was derived for each course with grades predicted by the SAT-M scores. A predicted mean was computed based on each Excel workshop's mean SAT-M score and compared with the actual workshop grade average. The study found that "the overall mean difference between the actual grade averages and predicted grade averages for the Math Excel sections was 0.615, significant at the .001 level." [9] Also, the Excel students, on average, earned higher grades than the non-Excel students, and overall the difference was more than half of a grade point.

Of special interest here was the Winter 2000 College Algebra Excel workshop, for this marked the first major involvement of EOP students within the Math Excel program. For this group, the actual class grade average in College Algebra was 2.31 as compared to the predicted average of 1.87, a positive difference of 0.44 grade points. Thus, the Math Excel workshops also appeared to be successful in improving the academic performance of the EOP minority students.

Math Excel and the Persistence of Minority Students in Mathematics

Student involvement in programs using collaborative learning groups appears to have a positive and significant effect on academic performance. These types of programs seem to address many of the issues that, especially for minority students, play a large role in choice of major, persistence in that major, and overall self- and group-perception of academic worth and ability. However, the factors related to persistence in mathematics are more difficult to quantify and their influence may be subtle. As mentioned above, this study found encouraging academic performance results for the program in general, and for EOP student involvement with College Algebra in particular [9].

How did involvement in the Math Excel program affect EOP minority student participation and persistence in mathematics beyond College Algebra? For a baseline comparison, course enrollment data was gathered for all EOP minority students enrolled in College Algebra during the six previous academic terms, 1997–99. The numbers of these
students who successfully completed College Algebra with a grade of C- or higher were tracked for subsequent enrollment in additional mathematics courses. Numbers of attempts and successful completions (again, defined as a grade of C- or higher) in subsequent courses in either the business math sequence or the technical precalculus/calculus sequence for science and engineering majors were recorded through Fall 2001. Table 1 summarizes these results.

Table 1
Numbers and Percentages of Underrepresented Minority Students in Oregon State University’s EOP 1997–98 and 1998–99 Mathematics Enrollment History (through Fall 2001)

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<tr>
<td>1997–98; n = 31</td>
<td>20 (64.5%)</td>
<td>26 (83.9%)</td>
<td>14 (45.2%)</td>
<td>10 (32.3%)</td>
<td>10 (32.3%)</td>
<td>7 (22.6%)</td>
<td>5 (16.1%)</td>
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<tr>
<td>1998–99; n = 41</td>
<td>26 (63.4%)</td>
<td>33 (80.5%)</td>
<td>14 (34.1%)</td>
<td>12 (29.3%)</td>
<td>10 (24.4%)</td>
<td>15 (36.6%)</td>
<td>13 (31.7%)</td>
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Starting in Winter 2000, EOP students began participating in Math Excel. Table 2 summarizes similar course enrollment data for EOP minority students who participated in Math Excel in 2000 and 2001. Tables 1 and 2 together provide an opportunity to compare the participation and persistence of EOP minority students before Math Excel with that of EOP minority students involved in Math Excel.

Table 2
Numbers and Percentages of Underrepresented Minority Students in Oregon State University’s EOP Math Excel Winter 2000–Winter 2001 Mathematics Enrollment History (through Fall 2001)

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<tr>
<td>n = 31</td>
<td>21 (67.7%)</td>
<td>26 (83.9%)</td>
<td>10 (32.3%)</td>
<td>9 (29.0%)</td>
<td>5 (16.1%)</td>
<td>12 (38.7%)</td>
<td>8 (25.8%)</td>
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It is important to note that the subsequent course enrollment data is only through Fall 2001; hence, the data for the Math Excel EOP students are not “final” (in the sense that many of these students are still currently enrolled as undergraduates and may well attempt additional mathematics courses in the future). Nevertheless, it is not unreasonable to assume that students intending to pursue additional mathematics coursework beyond College Algebra would likely attempt such a course shortly after successfully completing College Algebra. So, while the performance data in College Algebra as reported by this study is promising, the participation and persistence data are less striking [9].

**A Pilot Program—A Change in Structure for Math Excel**

Student evaluation of the Math Excel experience has tended to be overwhelmingly positive (every term since its inception, over 90% of the students involved report on end-of-term evaluations that they perceived Math Excel had a positive impact on their learning and on their course performance). However, if students view the Math Excel experience primarily as a helpful peripheral aid and not as a centrally integrated part of their learning, then its benefits may tend to be more short-term in the sense of performance in the concurrent course and not long-term in the sense of encouraging further participation and persistence [6]. In an effort to build stronger recognition for and identification with the "learning community" that a Math Excel workshop section seeks to establish, Oregon State University’s Department of Mathematics and the Educational Opportunities Program piloted structural changes in the program for College Algebra for Winter 2002 followed by similar changes for Precalculus in Spring 2002. The goal of these changes was to encourage the view of participation in a learning community as an integral part of success in the course in the hopes that more minority students would persist on to the next mathematics course. These changes were:

1) designation of a special section of College Algebra that required concurrent enrollment in Math Excel in lieu of a recitation session; and,

2) direct involvement of the instructor for the lectures for College Algebra with the Math Excel workshop sessions.

Table 3 shows the EOP minority student participation in the special College Algebra and their subsequent course enrollment results for the term immediately following (Spring 2002).
Table 3
Numbers and Percentages of Underrepresented Minority Students in Oregon State University’s EOP Math Excel Winter 2002 and Mathematics Enrollment Spring 2002

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<tbody>
<tr>
<td>n = 38</td>
<td>34 (89.5%)</td>
<td>34 (89.5%)</td>
<td>20 (52.6%)</td>
<td>9 (23.7%)</td>
<td>8 (21.1%)</td>
<td>9 (23.7%)</td>
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Discussion

The recent structural changes to Math Excel at the College Algebra and Precalculus levels do indeed seem to be making a positive difference in participation and persistence. Since the lead instructor for the pilot sections of Math Excel also had experience with the original structure, he was in a position to share observations on how the changes made in the Math Excel program might impact the factors affecting student participation and persistence mentioned earlier in the paper. While his reflections are admittedly anecdotal, the persistence data suggest that the changes made some significant positive differences.

Student Perceptions of Collaborative Learning as Central to Institutional Structure — Registration for College Algebra was limited to sixty students and also required that each student register for a section of Math Excel in lieu of recitation. The course requirements and grading structure as outlined in the course syllabus addressed the Excel workshops and the lecture as two components of a single course. Based upon a study of assessment practices in a cooperative learning setting, individual incentives for group success were established (if everyone in the course earned a passing grade on a given exam, a 2% bonus was awarded to all students) to emphasize cooperative goals [10]. Since all students in the same lecture section were involved in Math Excel workshops, it was possible for the instructor to make explicit references to worksheet problems in lecture as well as to comment on lecture material during group work in the Excel sessions. Over time, the instructor noticed the culture and mores of collaborative group work in the Excel workshops carrying over to the lecture section and even outside of class. In lecture, when the instructor had difficulty presenting a concept in a way that was understandable to a particular student, other students would offer their own understanding of the concept, which would lead to greater understanding on the part of the other students. The instructor noticed
several of the Excel groups studying together outside of class. A number of students were witnessed checking up on each other whenever one of them missed a day or two of lecture. Because of the Excel workshop, students felt more comfortable asking questions in lecture as evidenced by one student comment:

I liked the way that we were allowed, and even encouraged, to socialize with others in the class, which made the atmosphere comfortable. Because I felt comfortable in class, it was easier for me to ask questions when I didn't understand the material.

Lowering Risk and Building Confidence — Providing an environment in the Math Excel workshops where students felt safe to ask questions of each other carried over to the lecture environment. Seeing the same students in this setting lowered the risk of making comments and engaging in discourse with the instructor. Since the majority of the tougher problems were approached collaboratively within the Excel workshop, the students developed less apprehension toward attempting challenging word problems. Some even came to enjoy the more challenging problems and requested that similar problems be put on the exams. While students were reluctant at first to discuss their understanding of a concept, by the end of the term most of the students surveyed reported that sharing their views helped to refine and improve their understanding of the concept, and it also made learning enjoyable. One student sums this up well with the comment:

One thing that this class taught me was that I could figure many things out on my own without the help of anyone. That was especially due to the fact that the teacher assistants refused to walk me through problems and instead just gave me a few clues to help me, and then trusted my ability to solve the problems. Even though I wasn't very grateful at the time it did help me a great deal.

Students appeared to build their personal math confidence level over time. A number of students commented on a pre-assessment form that one reason they did not enjoy math was because they did not feel confident doing math. Once they made it through a few problems with only minimal help from the assistants, they would comment on how their math confidence was back or how good it felt to feel confident for the first time. They felt that the instructors trusted their ability and so they came to trust themselves. One student summed it up best when she stated,
"As soon as I started Math Excel immediately I started seeing my math confidence increase, and saw drastic improvements in my math skills."

Conclusions and Recommendations

Math Excel was initially implemented at Oregon State University with the goal of enhancing student performance in concurrent introductory mathematics courses and persistence in continued mathematics coursework. While the academic performance results have been encouraging, the goal of increasing the persistence of students, especially underrepresented minority students in the Educational Opportunities Program, has proved more elusive. The initial results of structural changes made to increase the integration of Math Excel with College Algebra appears promising enough to merit consideration of expanding the pilot project to include differential and eventually integral calculus courses and beyond.

The Emerging Scholars Workshop model has shown itself to be flexible to different types of implementation in adapting to the particular needs of institutions. For institutions considering implementing an Emerging Scholars program, the implications of our experience depend on the goals of the program. If the primary goal is strictly improved academic performance in the associated course, then a less integrated, stand-alone implementation affords scheduling flexibility and less complexity in instructional organization. However, if another goal is improved participation and persistence in subsequent mathematics courses, then a strong consideration should be given to tighter integration between the workshop and lecture, especially if the target audience is that of underrepresented students.

Acknowledgments

The National Science Foundation awarded funding from 1997-2002 to the Oregon Collaborative for Excellence in the Preparation of Teachers (OCEPT). An explicit goal of OCEPT from its beginning has been the promotion of programs in mathematics and science based on Treisman's Emerging Scholars model. The Math Excel program at Oregon State University began in 1998 with initial funding from OCEPT. We would like to express special appreciation for the helpful advice and encouragement from Professor Emeritus Michael Freeman, the founder of the originally named Math Excel program at the University of Kentucky. Thanks, too, to the Dana Center of the University of Texas at Austin for providing their Emerging Scholars instructors’ workshop.
Bios

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References


