

# Opening the Gateway

## Increasing Minority Student Retention in Introductory Science Courses

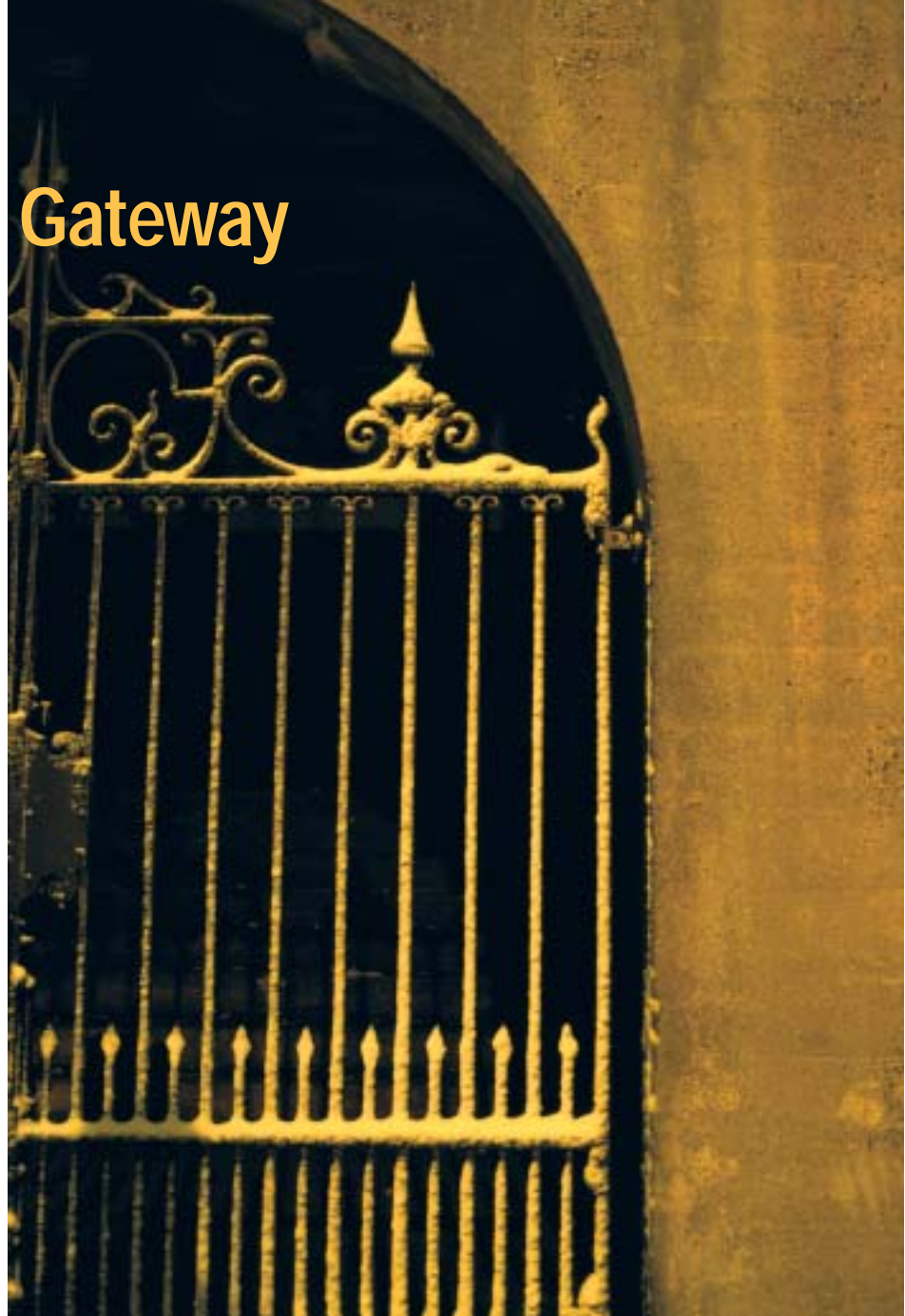
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*The Gateway Science Workshop is a peer-facilitated, problem-focused program designed to improve student retention in the sciences. This article discusses its development, implementation, and efficacy, which is demonstrated by higher retention of workshop students in the course sequences. Evidence suggests that the program has particular benefits for minority students.*

Many colleges and universities across the United States are facing an extremely important educational challenge—a low number of high-achieving minority undergraduates (African American, Hispanic American, and Native American) who successfully persist in premedical and science-based courses of study. This situation poses particular challenges at major research institutions, such as Northwestern University, where students come with strong academic credentials and high expectations.

### Understanding the Problem

Contrary to widespread belief, this pattern of underachievement does



not usually stem from lack of adequate preparation or intellectual ability (Treisman 1985). Minority students, as a group, enter Northwestern with the same academic potential to achieve their career goals as majority students. In addition, they generally do not experience the same level of difficulty in humani-

ties and social sciences as they do in the natural sciences.

Several strategies have been used to address the issue of underperformance and retention of minority students at the university level. One of the traditional approaches has been to offer remedial programs for minority students. However, there is little evidence for their efficacy. In fact, an evaluation of a remedial program for minority students at the University of Michigan suggested that remedial programs may actually hurt the performance of minority students (Steele 1997). Further, there is little empiri-

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cal evidence that remedial programs have been successful in encouraging minority students to pursue advanced coursework in the sciences, to say nothing of majors or careers in these fields (Born, Revelle, and Pinto 2002). In addition, such programs are often challenged by a national agenda increasingly hostile to what might be regarded as affirmative action programs.

Total undergraduate enrollment at Northwestern University is approximately 7800, with 6% African Americans, 4% Hispanic Americans, and less than 1% Native Americans. These minority students have every reason to succeed, according to their academic records. However, the problem of minority student underachievement in introductory science courses persists. Northwestern approached the problem by offering extra tutoring, remedial instruction, and special introductory programs designed for students deemed at risk. As was the case at many other major research universities, these approaches were not successful. Minority students still performed at a lower level than their majority counterparts with equivalent credentials (Born, Revelle, and Pinto 2002).

Failure of the remedial program approach and the persistent pattern of minority-student underachievement in the sciences compelled the university to explore a range of pedagogical models for understanding and addressing this phenomenon. This work eventually led to the development and implementation of Northwestern's Gateway Science Workshop (GSW) program.

### Treisman's Retention Model

After noticing poor retention and performance of underrepresented groups in mathematics, mathematics professor Uri Treisman developed a successful retention model in calculus at the University of California, Berkeley (Conciatore 1990; Treisman 1985, 1992). Treisman observed the study habits of Chinese American students, who generally obtained high grades

in calculus, and those of African American students, who generally obtained low grades.

Treisman found that, while spending a comparable amount of time studying as their African American colleagues, Chinese American students routinely studied in groups to share knowledge about calculus and other common interests, but African American students rarely did so. In response to these findings, Treisman developed the Professional Development Program—Mathematics Workshop. This program sought to reduce academic isolation and provide a supportive community for participants, who met for several hours per week in small, ethnically diverse groups to work on more challenging problems than those presented in homework assignments. Groups were led by facilitators with graduate training, who asked questions and guided students through the problems without actually doing them for the students.

This program enhanced performance and reduced attrition of participating minority students. Only 3% of African American workshop students received grades of D or F, as compared to 40% of nonparticipants and 33% of a historical control group. Even more importantly, African American students who participated in the workshop as freshmen went on to earn degrees at Berkeley at rates comparable to those of European American and Asian American students (Treisman 1992).

Because it incorporates a number of pedagogical approaches that have been successful in practice, Treisman's model has been adopted in some form by a number of other university programs. Among these is Northwestern's GSW program, which incorporates several elements of Treisman's original model.

*Cooperative small-group learning.* Working in cooperative small groups improves student academic achievement, critical-thinking and reasoning abilities, interpersonal and social skills, and self-esteem

(Johnson and Johnson 1994; Johnson, Johnson, and Smith 1991; Johnson, Johnson, and Stanne 2000). Such an environment allows students to exchange ideas, give or receive assistance, and challenge their own knowledge (Jaques 2000; Johnson, Johnson, and Smith 1991).

Introductory science courses at the university level often take the format of large lectures, in which students can feel isolated and unsupported. So, cooperative small-group learning environments may complement large lectures. In addition, it is common in scientific practice that "empirical results are interpreted and conclusions reached through the process of conflict, discussion, and argument as ideas and models are refined and revised" (Tien, Roth, and Kampmeier 2002, p. 608). This opportunity to work in small groups prepares students for future scientific practice.

*Peer-led learning.* A recent review of the use of undergraduates in a peer-assistance role on college campuses concluded that 76 to 83% of all higher education institutions make some use of peer educators (Ender and Newton 2000). A meta-analysis (Springer, Stanne, and Donovan 1999) has suggested that peer-led small-group learning enhances student academic achievement and promotes favorable attitudes toward learning. Additionally, the most effective learning frequently takes place when assistance is offered by someone above, but near, the learners' own educational level or zone of proximal development (Vygotsky 1978). In this respect, as compared with faculty or graduate students, peer leaders are often the perfect choice to offer such learning assistance. Peer leaders also possess similar experience and beliefs as the students, which facilitates a trustful and supportive learning environment.

*Problem-based learning.* Unlike traditional models of learning, problem-based learning begins with a problem that ideally is engaging,

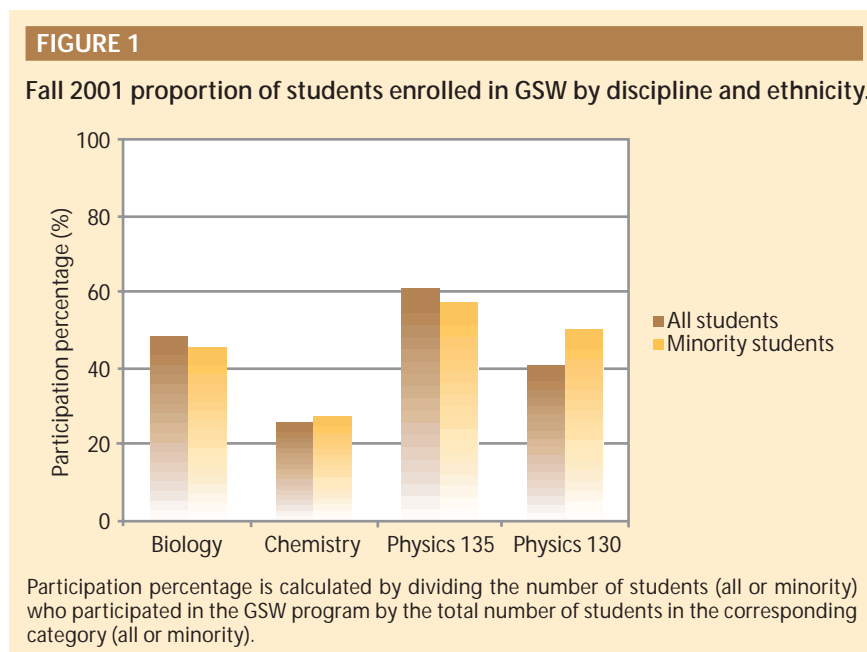
conceptually rich, and relevant to students' experience. The encounter with the problem requires students to identify their learning needs and to take the initiative to acquire new knowledge and skills before answering it (Schwartz, Mennin, and Webb 2001). This model transforms students from passive to active learners; they become motivated to seek new knowledge to solve problems.

Initially introduced in medical education, problem-based learning has been implemented in a wide range of disciplines and professions. Research on problem-based learning suggests that this learning model has a positive effect on student academic performance, knowledge retention, approach to study, and attitude and motivation for learning (Light and Cox 2001; Schwartz, Mennin, and Webb 2001).

Taken together, these findings suggest that the combination of cooperative small-group work, peer facilitation, and problem-based learning enhances all students' educational experience and increases overall retention in the sciences. Although these learning approaches are crucial to GSW, the program is also designed to address the problem of minority student success and retention in the sciences. The approach GSW takes to this challenge is based primarily on Stanford University psychologist Claude Steele's stereotype-threat theory (1997).

### Stereotype Threat

Steele found that the underperformance of many minority students is not due to lack of preparation, ability, or motivation, but rather to the threat prompted by social stereotypes about members of minority groups—the "stereotype threat" (Steele and Aronson 1995; Steele 1997). In general, stereotype threat refers to the phenomenon that, when a person enters a situation in which a stereotype of a group to which the person belongs becomes salient, concerns about being judged according to that stereotype arise and inhibit perfor-



mance. For minority students, the perceived stereotype of poor intellectual ability among minority groups may create the pressure for academically ambitious and talented minority students to prove the negative stereotype wrong by achieving excellent performance. However, this strong desire to do well in the academic domain may carry with it a subconscious anxiety, which is detrimental to performance.

This anxiety prompted by the perception of negative stereotypes may bring about a vicious circle of concern and failure—the more the student cares about doing well and disproving the negative stereotype, the more his or her academic performance is negatively affected. Disturbingly, the effect of stereotype threat is most pronounced in the case of high-achieving students, who identify strongly with the academic domain and have every reason to succeed.

### Program Characteristics

The structure of the GSW program follows Treisman's retention model, with a few changes based on the theoretical work discussed above and the unique situation at Northwestern. Students enrolled in gateway science courses (biology, chemistry, calculus-based physics, and noncalculus-based physics) are in-

cluded to participate in the GSW program. Special efforts are made to recruit minority students, such as additional invitations that emphasize confidence in their intellectual and academic ability, and intimate program information sessions with various minority student groups. These special recruitment efforts do not convey the message that minority students need extra help. Rather, they are invited to participate in a program that benefits every student who wants to be challenged and has the potential for a successful academic career.

Interested applicants are selected on the basis of group size limit (five to seven) and class schedule. They are then divided into small, ethnically diverse workshop groups. These groups meet for 2 hours weekly to tackle conceptually based, challenging problems developed by the course instructors. An undergraduate peer facilitator who has successfully completed the course in a previous year leads each workshop group. Figure 1 shows the proportion of students enrolled in the GSW program by discipline and ethnicity during the fall of 2001.

Since 1997, we have continuously sought to refine the GSW program and identify factors vital to its

success. Through our experience with the program over the past four years, as well as our quarterly program evaluation results, we have identified several factors important to the program's success. (A table of these factors is available as Web Figure 1; see Editor's Note at the end of this article.)

**Student recruitment.** As noted, the GSW program is open to all students regardless of gender or ethnicity, and this is consistent with similar programs at other universities. The evidence, moreover, suggests that the program is beneficial to all students (Born, Revelle, and Pinto 2002). Inclusion of only minority students could create the impression that the program is remedial in nature and might trigger the very stereotype threat that Steele's work has shown to be detrimental to minority achievement. To further dispel the idea that the GSW program might be remedial, the workshops are identified as advanced conceptual workshops in the specific disciplines, and all students who fully participate receive notations on their transcripts.

**Facilitator selection and training.** Peer facilitators play vital roles in the GSW program. They contrib-

ute to the intellectual and personal development of workshop participants by moderating group problem-solving processes and assisting students with issues related to college life. Because facilitators are crucial to the program's success, we developed careful facilitator-selection procedures and a comprehensive training program to ensure the quality of our facilitator team.

Facilitator recruitment includes an initial application screening and a personal interview with GSW staff and faculty. Candidates are selected based on a combination of factors, including academic performance, interpersonal skills, motivation to help others, faculty recommendation, and a genuine interest in teaching and learning issues in higher education. For the 2001–2002 academic year, we accepted approximately 25% of the applicants.

Facilitators receive training both in content knowledge and facilitation skills. Content knowledge training is provided through weekly preparation meetings led by faculty. These meetings are organized as workshops, which facilitators can follow as models for their own facilitation practice; they are interactive and facilitator-

oriented. Facilitators gain skills in leading workshop groups through a year-long training series with educational experts. This series provides them with pedagogical knowledge and practical guidelines in relation to learning, teaching, and group management within the structure of GSW. It incorporates various learning approaches, including small-group discussion, group literature review, interactive workshops, talks by guest speakers, peer workshop observation, and group projects.

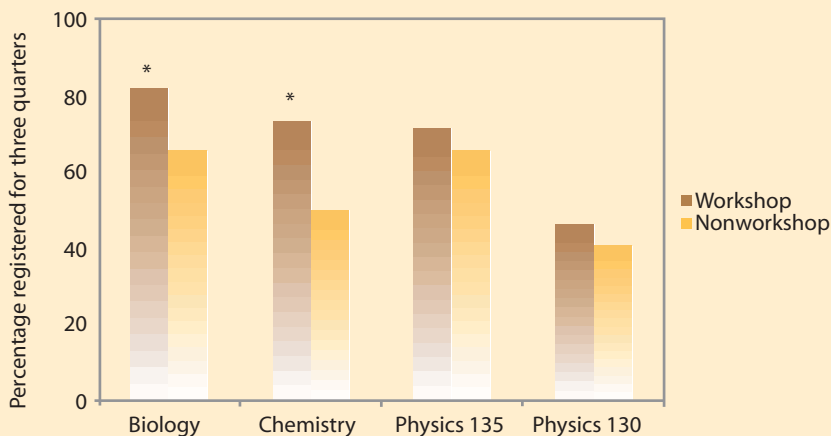
*Inclusion of only minority students would create the impression that the program is remedial and trigger the stereotypical threat.*

**Faculty buy-in.** Faculty involvement and investment are fundamental to success in educational interventions such as GSW (Treisman 1992). However, many science faculty must focus primarily on their research and teaching obligations. For most of them, there is little time available to contribute to educational innovations like GSW. At the same time, most faculty are extremely concerned with minority underachievement and are willing to contribute to the program if they feel it will be effective and that they will receive support.

We use a combination of strategies to encourage faculty buy-in, the most important of which is identifying and supporting advocates among faculty. Hearing about the value of the GSW program from devoted colleagues makes it more likely that a faculty member will consider and eventually adopt the idea. The expansion of our original program from biology to other disciplines was due mainly to the effort of one highly invested faculty member. In addition, we actively arrange regular meetings between the project team and the

FIGURE 2

2001–2002 all student retention over three quarters by workshop participation and discipline.



Retention is defined as the proportion of students who complete all three quarters of the course sequence.

\*Significant chi square,  $P < 0.05$

faculty to familiarize faculty with the program, report program progress, and seek faculty's insights. We have also arranged various social activities, such as quarterly GSW faculty dinners, to create a supportive community.

In our model, faculty who teach GSW-related courses take primary responsibility for developing the conceptual workshop problems and training facilitators on content knowledge in weekly meetings. These tasks can consume a great deal of time, creating resistance among faculty with heavy research and teaching loads. Indeed, as we learned through our interviews with faculty members, the time commitment appears to be the greatest barrier to faculty involvement. We are currently developing ideas to reduce the time commitment for faculty while preserving their investment in the program. One promising solution is the construction of a problem bank that catalogs previously used workshop problems and records student feedback for each problem, which can assist in faculty's future problem development effort.

*Workshop material design.* Workshop problems should be conceptual, challenging, interesting, conducive to discussion, and relevant to course material. The focus should be on teaching the concepts underlying the phenomenon described in the problem as well as the procedures used to find the solution. Problems that incorporate multiple concepts, particularly those learned at different stages of the course, are especially well received by students. These problems require students to integrate their knowledge and find links among different concepts. Students generally consider this type of problem to be "interestingly challenging," as opposed to "tediously difficult." (To illustrate this difference, examples of a well received workshop problem and a poorly received one are presented in Web Figure 2; see Editor's Note at the end of this article.)

Feedback on workshop problems was collected mainly through

facilitators' comments on weekly workshop report forms. Facilitators evaluated every problem based on the criteria listed at the beginning of this section. This feedback system helps us understand what an effective problem looks like and thus prevents less-effective problems from being recycled.

*Program management.* Managing the program's day-to-day operation requires continuous and detail-oriented attention. A dedicated full-time program coordinator is crucial to this effort. Our program coordinator oversees the program operation, works with faculty, manages and supports students, supervises and trains facilitators, contributes to program evaluation, and participates in program dissemination activities.

In addition, a separate full-time evaluation coordinator leads a multidisciplinary team to assess the effect of the program and to identify key components of an effective program. Program and evaluation coordinators work in the same location, because communication between them is central to the success of our evaluation efforts and to the implementation of ongoing changes.

### Program Effectiveness

Our evaluation efforts in the 2001–2002 academic year included statistical analyses to compare retention and course grades of participants and nonparticipants; satisfaction surveys and focus groups with GSW students and facilitators; interviews with students, facilitators and faculty who have taken part in the GSW program; and observations of weekly workshop group sessions. For this article, we focus on student retention in the relevant science course sequences as a key measure of the program's effectiveness.

We assessed retention by comparing the proportion of GSW participants and nonparticipants who completed all three quarters of a course sequence during the academic year (Figures 2 and 3). This definition of retention is chosen

because the introductory science courses associated with GSW are coherent course sequences taught over three consecutive quarters (fall, winter, and spring). Students enrolled in these course sequences are typically expected to complete the entire sequence by taking it for all three quarters.

Retention of GSW participants was significantly greater than retention of nonparticipants in biology and chemistry. This pattern was even more evident for minority students, for whom the retention differences were particularly dramatic and, despite low numbers, statistically significant. In biology, minority students who participated in GSW remained in the course sequence at nearly three times the percentage (70 versus 25%) of and approximately twice the number of those who did not participate (7 out of 10 versus 3 out of 12). In chemistry, 69% (15 out of 22) of minority participants continued through the entire course sequence, as compared with 42% (24 out of 58) of minority nonparticipants. In addition, the retention of minority workshop participants surpassed that of majority non-workshop students. In both physics courses, we observed similar trends favoring workshop participants, although the results were not statistically significant.

In examining these findings, it should be noted that students were not randomly assigned to participate in the program, leaving open the possibility of a selection bias. For example, factors related to program participation, such as student ability, motivation, and interest, may account for differences in retention rates. The program was available to all who demonstrated an interest, making it difficult to rule out this explanation for the results. One way of addressing this concern is to determine if participants and nonparticipants differ with regard to pre-existing characteristics such as academic ability. An independent-samples *t* test indicated no differences between groups on measures of grade point average and SAT scores.

An additional method of addressing this concern is to determine if workshop participation is related to retention when possible confounding variables are included in the statistical model. A binary logistic regression procedure was conducted with participation status, grade point average (when available), and SAT math and verbal scores predicting retention status. Results suggested that participation status significantly predicted retention above and beyond ability measures, implying that pre-existing differences in academic ability do not explain retention differences. Unfortunately, additional data on motivation and interest were not available, but are being collected to address this issue in the future.

## Conclusion

With nationwide efforts to recruit more minority students into colleges and universities, we are facing a more and more diverse student population (Lowe Jr. 1999). Whether this increase in the number of minority students in college leads to an increased number of minority scientists and doctors is still an open question. The GSW program offers an effective and practical model to address this issue.

We have presented the factors that are essential to the success of a large-scale workshop program implemented at a private research university. We have identified these factors through our experience, and we continue to evaluate their importance. Although there are still many areas for improvement, we are having a positive effect on students, particularly on minority student retention in science sequences.

Although the program is still a work in progress, positive feedback from students, facilitators, and faculty suggests that it is on the right track and that our efforts hold considerable promise in reducing minority student attrition from the sciences. During a time of renewed national debate about affirmative action in higher education, our program provides an alternative that benefits minority and ma-

jority students alike. Improving minority student achievement in the sciences is a challenging task. Programs such as the GSW offer superb opportunities to open what has often been a closed gate for substantial numbers of excellent students.

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## Editor's Note

NSTA members can access the supplemental Web Figures for this article in the online version. Please go to [www.nsta.org/college#journal](http://www.nsta.org/college#journal) and click on this article, in which you will find live links to the figures.

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