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Teaching for Diversity and Inclusiveness in Science, Technology, Engineering and Math (STEM)

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Faculty and TAs in STEM disciplines have long recognized that the students in their classrooms generally do not reflect the diversity of the broader general and student populations. A central question is "What can any one individual instructor do?". In this essay, we propose that STEM instructors use a model adapted from research on problem solving (Bransford et al., 1999; Physics Education Research & Development, online) to explore the lack of diversity in the STEM student population. As expert problem solvers, STEM instructors are well-prepared to begin addressing this issue in their own courses and programs.

Comprehend the problem
Getting started is often the most difficult step. Expert problem solvers begin by assessing the situation, then identifying and comprehending the problem. This step makes it possible to decide what data are important, what can be ignored, and what additional information is needed.

Many STEM faculty see their fields of study as broadly relevant to a wide range of people, independent of their social and ethnic identity. Yet participation and retention patterns show that non-majority students are much more likely to conclude that they do not belong in these disciplines. For example, participation rates for women and students of color in STEM disciplines are far from parity with their proportions in the student and "college age" populations. In 2000, the proportion of underrepresented minorities in the college age population was 34% (National Science Board, 2002a; U.S. Department of Education, 2003). Yet STEM bachelor's degrees earned by students of color ranged from a low of 12% in engineering and the natural sciences, to 15% in math and computer science, and a high of only 17% in the social and behavioral sciences (National Science Board, 2002b).

Represent the problem in formal terms

Instructors who apply the expert problem-solving model to their own teaching may find themselves identifying and challenging assumptions deeply embedded in disciplinary culture. For example, some STEM faculty have suggested that low participation rates for women and minorities result from lack of interest or an inability to do the work required in STEM courses. However, minority and white 12th grade students express similar levels of interest in science and engineering (National Science Foundation, 2003), and a variety of studies have documented that "switchers" or those who leave these fields have academic abilities equal to or more advanced than those who stay (Seymour & Hewitt, 1997; Tobias, 1990; Widnall, 1988).

Could other factors be affecting why interested and capable students choose to graduate with other majors, and how can faculty influence their choices? Research shows that faculty play significant roles in the two most important factors affecting student learning in college, student interactions with faculty and interactions with other students (Astin, 1993). Research examining student attrition in STEM (Seymour & Hewitt, 1997) indicates that faculty actions impact student decisions in a variety of ways, including practices that encourage competition over collaboration, courses that seem uninteresting or irrelevant, negative perceptions of STEM careers, and poor teaching quality. This research also indicates that other students are a source of discrimination but that faculty may not recognize inappropriate behavior or do nothing to prevent it (Seymour, 1995).

Plan a solution

Expert problem solvers outline a solution to the problem to see if it will yield a reasonable result before going through the effort of implementing specific changes. Given new knowledge of the reasons that students opt out of STEM fields, instructors might plan to examine the classroom climate in their own courses. Instructors can observe or gather data on classroom interactions to address questions such as the following, adapted from Lattuca & Strauss (2003): What are my patterns of interaction with male and female students? What are my patterns of interaction with minority and majority students? What characterizes the interactions between male students, between female students, or between male and female students? What characterizes the interactions between students from majority and minority groups? What are the characteristics of students' interactions when they work in teams?

A plan for gathering data might include a faculty self-assessment and/or observations by an independent observer (e.g. a colleague, instructional consultant, educational researcher). The latter permit systematic data collection without requiring an instructor to simultaneously act as the observer and the subject of observation. Additional data about student perceptions of the classroom or program climate can be gathered from anonymous surveys or interviews conducted by an independent researcher, which can increase the rigor of the study and the likelihood that students will provide candid responses. Former students might also be willing to participate in surveys and interviews about their past experiences in a course or program.

Another solution plan might involve implementing strategies previously identified as successful for creating learning environments that make all students feel welcomed to the discipline (Chu Clewell & Campbell, 2002; Johnson et al., 1991; Schibeci & Riley, 1986). For example, do you ask students to make connections between course content and their own lives? Do you create opportunities for group or team learning, as well as independent or competitive learning? Instructors can design assignments and courses to evaluate the effectiveness of different strategies.

Execute the plan
At this stage in the problem-solving sequence, experts implement their plans methodically, in a way that makes it possible to isolate the effects of particular variables. The same methodological rigor STEM faculty bring to their research and design protocols can also serve them as they examine the impacts of different teaching methods and classroom environments on diverse students.

If one's plan is to help all students see the relevance of course content, particularly to students' socio-political and cultural lives, begin by gathering observations about whether students find the examples helpful. Ask students to gather "real world" examples of concepts from reading assignments, class material, or other sources. Ask students to explain how the examples contributed to development of thinking skills or helped connect class content with their lives. These kinds of activities can provide documentation of students' learning of course content through the examples and also help instructors see how effectively they are reaching all students.

Evaluate and interpret the solution.
This final step is one of the most critical and helps differentiate novice from expert problem solvers. Experts check to see that the question is properly stated, data are valid, and solutions are reasonable. Guiding questions for this critical step might include the following: What were the intended results, and what were the unintended consequences of the experimental strategy? Were there any interaction effects or other variables that might have affected the outcome? What are the limitations and what can be generalized to other settings? How do these findings compare to the findings of others who have examined similar questions ?

While these questions do not necessarily yield conclusive answers, they do prepare problem-solvers to better address subsequent questions in the next iteration. As with most complex problems that engage STEM faculty, the challenge of increasing student diversity will not have a single, simple solution. Thus, as they do with other problem solutions, we suggest that STEM faculty consider this problem-solving approach to be only part of their investigatory process.

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