Chapter 33

The Multicultural Lab: Diversity Issues in STEM* Classes

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The traditional view that the STEM disciplines are empirically based, and thus culturally neutral, has meant that many instructors in these fields often do not see, or cannot imagine, a connection between their classrooms and laboratories and multicultural initiatives. At the same time, most instructors see that there continues to be a gender imbalance in these areas and a notable under-representation of color and other identities that face social discrimination. Unfortunately, patterns of retention in these disciplines show that the imbalances grow wider as coursework proceeds. This chapter outlines some of the ways instructors can approach these issues in their practices in and outside of the classroom, to enhance the retention and achievement of under-represented students (and future professionals) in the STEM disciplines.

The Dynamics of Group Work

Problem sets, labs, projects, and sequential courses that produce "cohorts" all lend themselves to situations involving working in groups or teams, large and small. How an instructor sets up and manages such groups can play a major role in encouraging the success of all students. Several basic principles for success are that groups should be assigned or chosen by the instructor, they should change (including lab partners) at least once during a semester, there should be procedures to encourage balanced and respectful participation by all group members, and each group should be heterogeneous in perceived ability or performance.

Allowing students to choose their own groups immediately places pressure on the social dynamics of difference in the classroom and foregrounds students' own attitudes and preferences. It creates unnecessary anxiety in

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those students who are unfamiliar to the majority, or who are on the margins, and raises that marginality even higher. Furthermore, instructors all know the irritations of having some students in the lab operating inappropriately, mainly as sets of friends or buddies, rather than as scientists or technicians. Rather than have the instructor try any form of "social engineering," before one knows much about the students and their academic performance, a clearly fair and random assignment will probably produce the best results. Mixed-achievement grouping, discussed further below, can also be achieved by consulting student records, though some may not wish to perpetuate impressions of students that may have come from prior instructors.

These kinds of random assignments, of course, may not always work well for some individual students, and that is why it is important for the groups to change at least once during the semester. Change also allows for any distracting social dynamics within groups, whether positive or negative, to be dispelled in order to keep the focus of the course on the subject matter. Later in the term, when the instructor has some direct knowledge of student performance, making some assignments that pair those doing well with those who are struggling will make the entire class perform better and allow the course to proceed at the quickest pace that remains inclusive.

Instructors might hesitate to make these mixed-achievement pairings, and some students might balk. However, most instructors have also had the experience of feeling a real mastery of their fields and particular topics at the point of having to teach them. Furthermore, cognitive research shows that the ability to explain and the practice of actually explaining a concept, lead to greater comprehension and clarity of thinking. It is for this reason that heterogeneous groupings are of special benefit to the strongest students, who when paired with each other can become bored or disengaged in the lab or classroom because they have no opportunity to teach their peers. For the other students, having strong partners stimulates sharing, opens up ways for them to get many questions answered without monopolizing the instructor's time, and avoids dividing classrooms into obvious groups of those expected to succeed and go on, and those who are just trying to survive the course. It also helps to make students responsible to each other, a kind of behavior that will prove invaluable in future professional group work.

Another way of grouping students is by learning style, a method that quickly proves its value to the students involved, often to their own amazement. This practice is also a valuable classroom technique because it clearly reinforces the benefits of having a diverse team in any scientific or problem solving situation. Mixed learning-style groupings can come from having students take quick diagnostic tests, some easily available on the internet, and then assigning students accordingly. The notes they share and different observations and insights they bring to their teams will be enlightening both for them and for the instructor (see Finelli, et al., 2001).

In courses where students are assigned to groups or labs where they have partners, it is important that for at least some, if not all, of the collaborative assignments a single grade be assigned to the group or partnership. Some instructors ask for student input regarding weighting their own and their partners' contributions to group products. Incorporating some strategies for group-based assessment can be especially helpful to build positive interdependence as an important motivator for high-achieving students who otherwise may resist collaborative learning. Just as scientific research or technological products are given a single evaluation for group efforts, it is important for students to learn early that science is collaborative in nature and cumulative in comprehension (see Ohland, et al., 2001).

Gatekeeping

In many STEM disciplines, there are particular courses or stages within courses that instructors see and sometimes intentionally design as key benchmarks where students prove their ability to continue in the field. While such essential building blocks of skills and abilities do exist in these areas, and while not all students who desire to achieve a degree in a particular area will be capable of doing so, the approach of the instructor to these key concepts or procedures can play a major role for all students.

Instructors who take a "Darwinian" approach of leading students to the hurdle, and then stepping back to see who makes it, often fail to understand the role of social expectation in determining outcomes. Some instructors with deep concerns for diversity issues express their repeated disappointment that "the women" or "the minority students" just "can't make it" even with their genuine good will. Other instructors take a more active role in seeing it as their duty to weed out the students that they feel will not do well at higher levels, and the instructors often see themselves as doing such students a favor. The anxiety and stress created by both of these approaches that assume that "not all of you are going to make it" are particularly acute for those [students?] who already know that demographically they are unlikely to emerge in the lead on the other side of the hurdle. The sense of competition also reinforces a dynamic of "winners and losers" that plays into feelings of demoralizing fatalism, ideas of luck or chance, and a focus on meeting the instructor's expectations rather than mastering the material.

The renowned high school calculus instructor in urban Los Angeles, Jaime Escalante, has made no secret of his method for success in getting African American and Latino youth from impoverished communities to pass the Advanced Placement Calculus examinations in large numbers and with high marks. He makes it clear in his classroom and in his own expectations that everyone is expected to make it through the exam. He is not the judge of the students, but the coach who makes sure they all get over the hurdle.

Part of this type of coaching is recognizing that academic achievement is based on teamwork and a group approach. If all of the students in a class see themselves as united in an effort to master the material, the class will be lively, and the instructor will feel the rewards of focusing on accomplishment. Lab partners who see themselves truly as partners who need to assist each other to get through the material with confidence and understanding will be well-suited to higher level work in these fields. Success in STEM research and professions depends on groups, intellectual communities, replicable findings, and shared knowledge. This team approach is true from the very beginning stages in introductory courses, and instructors can play an important role in socializing students early to the collaborative nature of intellectual inquiry and achievement. Grading that is based on clear standards and expectations, and not based on relative competitive performance, (for example, grading on a curve) is an important factor in building this shared sense.

Problem-Based vs. Concept-Based Instruction

Many STEM disciplines are dominated by textbooks and teaching traditions that place great emphasis on working problem sets, making calculations, and memorizing long lists of formulae or specific terms, structures, or data. It is a rather specific personality disposition that will easily take on this kind of fact-based skill-building without a clear understanding of why such efforts are being made. Conceptual approaches to knowledge in the STEM fields provide solid undergirding to a much broader range of students, who will then be able to undertake the cultivation of the necessary skills to move to higher levels in these disciplines. When one does not understand why a given experiment or project is relevant, it is difficult to apply the knowledge and connect it to the course, syllabus, readings, and calculations. Instructors need to insure that there is a balance between inductive and deductive reasoning, both in the student assignments and activities, as well as in the class lectures and demonstrations (Tobias, 1990).

Because any real world scientist, engineer, technician, or mathematician would have ready access to charts and tables, it is important to avoid pointless memorization and instead to favor higher-level cognitive skills. The old “plug-and-chug” classroom of solving problem after problem without a larger context, varied approaches, and clear opportunity for application and comprehension is quite alienating for many students, in addition to being dull for instructors. Further, the pitfalls of missed steps or miscalculations common when an instructor is repeatedly working examples on a board or overhead are particularly dangerous. The all-too-frequent similar errors in textbooks of this sort and their "typos" can lead to even greater student confusion and be significantly counterproductive. Overall, the constant repetition of "how" without a clear concept of "why" also discourages the creativity necessary for succeeding in scientific and technical fields.

It is very typical of under-represented students, both women and students of varied backgrounds, to work out their own ways of doing problems that also arrive at the correct answers. Instructors who insist on only one order to the steps that reach an answer, or only one method of problem solving, may close themselves off from important creativity and insight, as well as discourage the promising young scholars for whom their fields purport to be searching. Such rigid behavior on the part of instructors will also blind other students to the possibilities for creativity and intellectual engagement with examples that, when taught with an insistence on uniform procedure, will look to many students like only rote learning. The number of times one encounters under-represented students in STEM disciplines who work out their own methods and shortcuts only to hide these skills because they are embarrassed or ashamed of doing their work differently from the way prescribed by instructors is surprising and discouraging.

Conceptual knowledge is also not individuated into discrete problems and answers, but can be elaborated, explained, and applied, which then presents the instructor with much greater opportunity to employ cooperative, collaborative, and other forms of participatory and peer instruction. An experiential and interactive classroom provides much better retention and comprehension for students and allows an instructor to devote attention to those most in need of it, thereby keeping the entire classroom operating at a closer-to-common pace. Placing the problems and demonstrations out in the classroom and dependent upon students' collective observations, interpretations, examples, and suggestions rather than keeping them on the board from a single hand, makes them real, dynamic, and creative. Passive learning becomes active, and the monotony of teaching or lecturing on "the basics" becomes more rewarding for the instructor.

Study Groups

One of the main factors in student success in STEM disciplines is the participation in out-of-class study groups (Fullilove, et al. 1990). Instructors should not only encourage students to form such groups, but give such groups tasks, provide study aids for group work, and check up on when and if they are functioning well and actually meeting together. As noted earlier, groups assigned by the instructor in a random manner are most effective, but they can also be assigned according to the convenience of campus residential geography or other considerations. It is helpful if such groups have within them students with differing academic or departmental majors or goals and that they not be based on preexisting social cliques or past study groups from previous courses. Again, having the study groups change once in a semester is a healthy practice that promotes broader learning and mediates any tension or distracting dynamic that might develop within one particular study group. To the degree that it is possible, it is also a healthy practice not to isolate under-represented students as single members of different study groups.

Instructors should also reinforce the message that working together is expected and that excluding anyone, as well as operating as a "loner," is not acceptable. Meeting with every group as a whole at least once in a semester will allow the instructor to monitor the group dynamics and get feedback on the balance of participation and roles within the group. Leaving groups alone to negotiate their own ways of operating is likely only to replicate some of the negative social dynamics found on campus and in society for some groups of students. While it may be appropriate to have certain problems designated to be solved on an individual basis for assessment purposes, instructors should also make sure to provide a good number and range of problems for study group work.

Under-Teaching

Many instructors are quite conscious of those students with identities that are under-represented in their disciplines, and sympathize with both their possible isolation as well as conspicuousness. One well-meaning response is to try not to put such students "on the spot" during class or in front of others. It is important to recognize that this sympathetic action runs the danger of depriving these students of important practice, modeling, and teaching attention and opportunities. National studies have shown, for example, that both male and female instructors typically walk a male student through a problem eliciting next steps and allowing him to figure things out and possibly make mistakes along the way. Female students are more typically told the answer or instructed what to do next, thus depriving them of clear coaching through the learning process. Women are also less often asked to explain answers or their reasoning, thus additionally depriving them of opportunities to demonstrate mastery of the material. It is important that a classroom not only be open to the participation of all students, but that the kind of ways that students participate also be comparable, fair, and balanced, so that the attention and resources of the instructor are evenly distributed among all students and that students of all types and backgrounds can clearly be seen to be valued in the classroom (Musil, 2001).

Modeling, Relevant Problems and Projects, and Examples

While the particular concepts and building blocks of comprehension and skills within more empirical disciplines like the STEM fields are often accepted as standardized and universal, their presentation and teaching always take place in a cultural context. Furthermore, their applications are also always culturally bound when carried into the "real world," whether that world is portrayed in the classroom through hypothetical problems, a research agenda, or a social or institutional context. It is therefore important that instructors pay attention to the variety and types of examples, applications, problems, and research settings included in any given course. This attention is also important when listening to student responses and examples, especially when students draw from experiences or settings that might be unfamiliar to the instructor. This is an area where diverse faculty colleagues in these disciplines can readily share experiences and ideas with each other for more varied approaches, in addition to paying attention to student interests and ideas.

Making room for student-identified examples or even problem definition can assist an instructor to cover more varied, multiple, and diverse considerations and contexts. It also introduces or enhances the team building and cultural exchange skills that are so necessary to successful work in scientific or technical research in academia or industry in an increasingly globalized economy, student body, and workforce. It is also valuable to have technical projects, sponsored research, and scientific problems come into the classroom from community groups and organizations. Many campuses rely on industry sponsorship for such projects, internships, and design experience, but community nonprofits can supply additional ideas and projects, and such partnerships provide productive and different settings for learning. The incorporation of academic service learning into scientific and technical fields has been very successful at Purdue and the University of Michigan, and has produced a very high level of student satisfaction with real-world projects and work with clients on very human terms.

Conclusion

In this short chapter, I have sought to outline a number of areas in which the STEM disciplines can and have achieved real progress and made strong contributions in multicultural teaching and learning. It is also important to notice that all of the suggestions given here are focused on the classroom. While many schools and colleges have very valuable support programs, student organizations, special recruitment activities, scholarships, and summer bridge programs to recruit and retain students from under-represented backgrounds to their degree-earning majors, the more support that can come from within the classroom, the better. Of course, it is also important that all instructors be familiar with these programs and organizations in their departments and fields as a part of being an effective advisor and mentor to all students. These are not remedial programs for the students, but rather programs to solve the institutional deficiencies that lead to the phenomenon of under-representation in the first place. Instructors, as significant members of the institution, have an important role to play in these efforts at institutional change.

Building the multicultural lab is a challenge for all scientists and technicians, but one that meets a strong demand for scientists and technicians able to operate easily in a diverse society and the world. Direct modeling and clear descriptions of these and other practices are essential for faculty, nearly all of whom were not educated in the multicultural lab. My experience teaching physics using many of these methods has convinced me that the demographics of the STEM disciplines can and will change profoundly as the pedagogical concerns in these areas also incorporate the issue of inclusion.

Faculty developers need to invite more of their STEM discipline faculty to replicate these results and to move the multicultural agenda across campus into the lab, senior design project, and introductory calculus. Teaching inclusively is not only a matter of curriculum, distribution requirements, good will, common sense, and pedagogy, though all of these are important. It is also a matter of praxis, where faculty members experience their disciplines as sites of diversity and all students find and notice the experience of inclusion in all settings, including the multicultural lab.

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