How Important Is Achieving Equity in Undergraduate STEM Education to You?

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Nationally, 70% of college students are from groups underrepresented in the sciences, but only 45% of those receive STEM (science, technology, engineering, and mathematics) undergraduate degrees (President’s Council of Advisors on Science and Technology [PCAST], 2012). Important enhancements at the academic periphery, such as tutoring, mentoring, bridge programs, and supplemental instruction, have had success (e.g., Maton, Pollard, McDougall Weise, & Hrabowski, 2012; U.S. Department of Education, 2012) but have not achieved the goal of national broader participation in STEM. This is true despite nearly a half-century of national efforts to address these inequities (American Association for the Advancement of Science, 2011; National Academy of Engineering, 2014). So, what will “reverse our deepening divides?” (American Association of Colleges and Universities [AACU], 2015). Our answer: increased pedagogical change in the classroom.

Our own work as faculty professional developers requires that we integrate research across branches of the learning sciences, from discipline-based education research to cognitive neuroscience to social psychology to education. This bird’s-eye view of the teaching and learning enterprise is different from those doing the disciplinary research (Coppola & Krajcik, 2014; Talanquer, 2014) and convinces us that significant progress toward equity and inclusion will only be achieved when evidence-based pedagogies (EBPs) are deeply embedded in all classrooms.

Practices informed by research on how people learn are defined in PCAST (2012) as EBPs and include active learning; increased course structure; case-based curricula; peer instruction; guided inquiry; and community-based, problem-based, and team-based learning (e.g., see National Research Council, 2015). These approaches are all based on empirically supported learning principles (e.g., Ambrose et al., 2010; Brown, Roediger, & McDaniel, 2014). Pedagogical tools might activate prior knowledge, scaffold complex ideas, provide opportunities for retrieval, or tap into intrinsic motivation. These flexible principles allow context-dependent adaptation to individual institutions, faculty members, and classroom environments.

EBPs transform learning by guiding students to process information more deeply, developing habits of mind for living and working in today’s world, and by supporting the ability to transfer knowledge to novel contexts (Pellegrino & Hilton, 2013). The learning principles and associated gains are well-documented in national reports, (e.g., Pellegrino & Hilton, 2013), scholarly books (e.g., Ambrose et al., 2010), and textbooks (e.g., Sousa, 2011). Learning environment features shown to promote transfer include (a) having high expectations, providing students with early support to progress toward those expectations, and growing their independence to accomplish complex learning tasks; (b) explicitly connecting new content to existing knowledge and life experience through use of examples, cases, and laboratory experiences; and (c) creating opportunities for students to regularly elaborate content to themselves and others through writing, drawing, or speaking. Students also need explicit assistance in organizing incoming information according to the underlying structure of the discipline and in developing a rich set of connections among the old and new material (Bransford, Brown, & Cocking, 1999).

It is critical to understand that in general these learning gains are independent of institution and classroom specifics, discipline, and characteristics of the learner (e.g., age, socioeconomic status, race, gender, ethnicity; Bransford et al., 1999; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Freeman et al., 2014; National Research Council, 2015). That is to say, when thoughtfully designed for a given set of conditions, EBPs benefit all learners. They do this at the same time that they help students think deeply and critically (Bolar & Staples, 2008;
Freeman, Haak, & Wenderoth, 2011; Pellegrino & Hilton, 2013).

This is worth saying again: EBPs increase rigor and success for all students. Because EBPs improve performance of low-achieving students, who are disproportionately members of underrepresented groups (AACU, 2015), a greater diversity of students are successful.

But EBPs hold an even greater promise: They can close achievement gaps because they can have a greater positive impact on underperforming students than on those that are already high achievers (Dasgupta, Scircle, & Hunsinger, 2015; Eddy & Hogan, 2014; Haak, HilleRisLambers, Pitre, & Freeman, 2011; Harackiewicz et al., 2014; Hsu, Murphy, & Treisman, 2008; Kogan & Laursen, 2014; Lorenzo, Crouch, & Mazur, 2006; North Central Regional Educational Laboratory, 2004; PCAST, 2012; Stephens, Markus, Fryberg, Johnson, & Covarrubias, 2012; Yeager & Walton, 2011; Yezierski & Birk, 2006). Nelson (1996, p. 172) made this same argument, asking decades ago whether “it has already become immoral to teach without extensive use of the active learning techniques that so enhance performance,” and ethical arguments for EBPs have been repeated recently (Freeman et al., 2014; Waldrop, 2015).

How can EBPs make such gains possible? When viewed through the lens of traditional pedagogies, this seems unlikely; slowing down a lecture, covering less material, or including remedial assistance does not enrich the experience of the best students. But the view through the lens of EBP is dramatically different because an important part of what is being taught is how to learn complex material in a discipline-based context.

Students at the top of a class are often advantaged beyond having a stronger content background; they also have better mastery of the learning process and of the culture of higher education (e.g., Darling-Hammer, 2001; Hackman & Farah, 2009; Hackman, Farah, & Meaney, 2010; Lareau, 2015; Padgett, Johnson, & Pascarella, 2012; Stephens et al., 2012; Stephens, Brannon, Markus, & Nelson, 2015; Wilson & Kittleson, 2013). The top-performing students come to classrooms already having acquired some of this knowledge from schooling, family, or community. Underperforming students lack these advantages. EBPs are effective at closing the achievement gap because they better support growth of cognitive skills (Ambrose et al., 2010; Bransford et al., 1999; Pascarella, Wang, Teneriell, & Blaich, 2013) and make intellectual processes explicit (e.g., Feldon, Timmerman, Stowe, & Showman, 2010). When faculty make their expectations clear—for example, with homework reading guides—underprepared students see what “reading pages 17–32” really means (e.g., Heiner, Banet, & Wieman, 2014). They are able to catch up on learning skills and simultaneously learn content. For example, they can learn that bold headings help organize material and can be turned into questions for self-quizzing or that they ought to interpret a figure before looking at the explanatory text. The best students already use these strategies, but they often do so unconsciously. Thus, even the best students will benefit when the expert makes his or her learning process transparent.

Additionally, EBPs help develop interpersonal (e.g., collaboration, tolerance of difference, social influence) and intrapersonal (e.g., intellectual openness, conscientiousness, self-monitoring) skills also associated with learning (American Psychological Association, 2012; Pellegrino & Hilton, 2013). Skills in these areas—such as adaptability, self-regulation, and complex communication and social skills (Hilton, 2010; Pellegrino & Hilton, 2013; Singer, Nielsen, & Schweingruber, 2012)—have been identified as particularly important for navigating the 21st century. Here again, everyone benefits from attention to these personal characteristics, including the top performing students.

Expert scientist–teachers should continue to urge caution and argue about the strength of evidence for EBPs (e.g., Benassi, Overson, & Hakala, 2014). But even those most skeptical should heed research that converges on how learning can be improved for all students. The time is now for STEM faculty who care deeply about equity and broadening participation to do something different in their classrooms—for all students—everyday.

References
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