Editorial

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The use of innovative active learning strategies on student learning outcomes

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Editorial

More than half of the remarkable growth in the 20th century and the per capita income in the U.S. was due to advances in science and technology. However, the decline in students majoring in Science, Technology, Engineering, and Mathematics (STEM) fields and subsequent decrease in the number of STEM undergraduates continuing to graduate school, has raised serious concerns about the social and economic impact of these two trends. Attracting students to STEM degrees and retaining them in their majors could be affected by the classroom experience where poor teaching practices appear to be a key cause. Improving teaching and learning in STEM classrooms to attract and retain students in this field is a priority and thus most efforts to reform undergraduate STEM education is focused primarily on in-class innovation. In fact, the National Science Foundation (NSF), the National Academies of Science, and the Accreditation Board for Engineering and Technology have expanded their focus for basic and applied research to improve the quality of undergraduate teaching and student learning in these disciplines. In 2009, the NSF and the American Association for the Advancement of Science published *Vision and Change in Undergraduate Biology Education:* A Call to Action which identified a series of strategies to promote educational gains in undergraduate science instruction. These included active learning methodologies in undergraduate biology training that are evidence-based to illustrate concepts, interdisciplinary applications, and quantitative competency. The combination of high expectations and adequate support has been one of the most impactful strategies for improving academic achievement. One such methodology is student-centered active and collaborative instructional strategy, which is more effective than traditional lecture across most, if not all, dimensions of student learning.

Another key factor in improving STEM undergraduate education lies in encouraging the majority of STEM faculty members, who typically use a lecture-based curriculum, to use more effective pedagogical techniques such as active/collaborative instruction. The success depends on how well faculty members improve their teaching relative to optimal instructional standards and how much student learning improved from the introduction of these innovative approaches. If the goal is to encourage widespread use of effective instructional techniques, then a description of what it takes to implement the innovations is as crucial as the evidence of their effectiveness. Therefore, to encourage STEM faculty members to adopt a particular instructional approach, research should provide sufficient detail about the course setting, and resources required to comprehend the relevance of the approach to their own work. The greatest gain in student learning in STEM areas can be achieved not only through the adoption of innovative teaching practices in the classroom, but also through the elimination of "worst" practices. Though a well crafted and captivating lecture presentation may seem to be a time efficient way for an instructor to cover course content, converging evidence implies that listening to a classroom lecture is not an effective way to promote deep and lasting student learning. The didactic method of teaching has proven to be less engaging than inquiry-based education, especially due to the abundance of easily accessible resources. Studies suggest that student concentration during lecture begins to decline after 10 to15 minutes. The flipped classroom (FC) methodology is a reverse teaching approach, where the lecture content is introduced outside the classroom allowing more time during class to process the information and practice the content in a variety of active learning strategies including teamwork and instant feedback. This approach requires students to assume responsibility for their own learning-mainly the basic knowledge and comprehension of content, which are often considered to be the foundational elements of the learning process. The availability of study material prior to the scheduled class time can help students be self-paced and self -disciplined in a more learner-oriented manner. Assuming students have utilized learning resources prior to class, active learning strategies in the classroom offer opportunities for deeper understanding, and to apply and analyze the content, thus allowing students to achieve more in the overall learning process. In fact, the FC model has shown to improve student preparedness and increase students' level of engagement during class. The success of this emerging teaching methodology, however, depends on the instructional design requiring highly structured activities before, during and after class which demands an enormous amount of faculty member's time and skills. A flipped side of this model is its dependence on student preparation prior to active learning in the classroom where motivation appears to be the key for success. Hands-on experience through active learning, peer teaching, and repeated exposure to the content through FC seems to be a motivation factor which hopefully will excite students to not only remain but also further their education in the STEM curriculum.

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Conflict of interest

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