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CHALLENGES AND OPPORTUNITIES IN FACULTY TRAINING ON ACTIVE LEARNING TO DELIVER CRITICAL THINKING FOR UNDERGRADUATE BIOLOGY STUDENTS

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Abstract

Compared to traditional lecturing, active learning (AL) provides a more effective way to achieve higher cognitive levels in all areas of science, technology, engineering, and mathematics (STEM). Paradoxically, in many universities worldwide, training of faculty in STEM fields on AL is very limited or completely absent and lecturing remains as the most commonly used instruction method. We developed an unbiased training program for biology faculty on evidence-based AL tools and supervised the planning and implementation of activities to assess critical thinking in undergraduate biology students. We present preliminary data on faculty perceptions and expectations of this training program. Particularly, we report that 90% of faculty members involved in the training either did not know or did not have the tools to implement AL in their courses. Furthermore, we report on the challenges, obstacles, limitations, and strategies that faculty experience after participating in the program.

Keywords: *Active learning, undergraduate education, STEM, faculty training.*

1. Introduction

In 1956, Bloom and Kratwohl proposed a conceptual framework to design learning objectives for increasing cognitive levels (Bloom and Kratwohl, 1956). Achieving top cognitive levels in this framework is essential for higher education in STEM fields, where students are expected to acquire skills such as scientific reasoning, abstraction, and critical thinking (Bailin, 2002). Scientific evidence has shown that these skills are much more easily achieved through active and student-centered practices rather than traditional lecturing (Handelsman *et al.*, 2007). Active Learning (AL) is a student-centered model of learning that engages students in self-reflection, discussion, writing, and/or problem-solving activities (Prince & Fedler, 2007). In several studies and meta-analyses, AL has been shown to improve student performance (Freeman *et al.*, 2014), reduce the gap for underrepresented students (Theobald *et al.*, 2020), and even improves mental and emotional health among students (Ribero-Silva *et al.*, 2022).

Despite that AL is beneficial for students, teaching innovations towards AL methodologies are still not widely adopted (Miller *et al.*, 2008), particularly in STEM courses with rich conceptual contents such as genetics or anatomy. One of the reasons why AL methodologies are not widespread in undergraduate STEM education is the lack of faculty training (Umbach & Wawrzynski, 2005; Nguyen *et al.*, 2021). A study by Andrews *et al.* (2011) found that faculty participation in professional development increased the use of AL, suggesting that access to resources can improve the likelihood that faculty will implement them in their courses. In Mexico's main university, Universidad Nacional Autónoma de México (UNAM), traditional lecturing remains a common practice in STEM teaching, despite efforts of faculty professionalization programs (Sánchez Mendiola *et al.*, 2019). We implemented an AL training program for biology faculty at UNAM to improve critical thinking skills in an undergraduate genetics course. Here, we report on the perceptions of the faculty participating in this training program.

2. Methods

We invited a group of faculty members teaching a Genetics course for second-year biology students at UNAM to participate in a program that involves: (1) To take an intensive workshop on AL

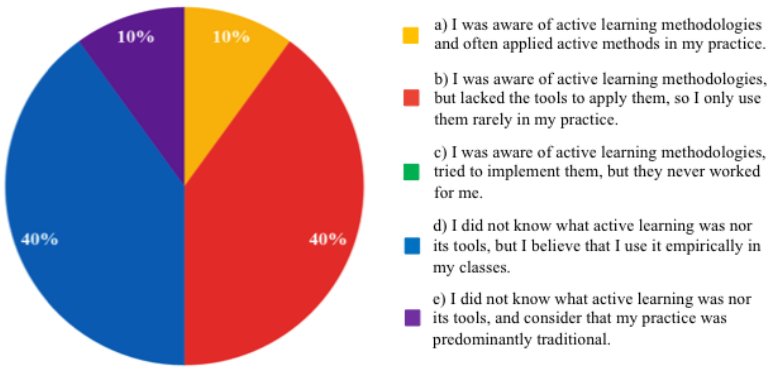
concepts and skills. The workshop provides participants evidence-based tools and confidence to implement AL strategies effectively in their classrooms using hands-on activities and discussions including problem-solving tasks, case studies, peer discussions, and interactive demonstrations; (2) To participate in weekly consultation sessions to design, and effectively deliver at least one highly-structured AL module in their courses; (3) To evaluate students with an instructor-blind critical thinking assessment. The evaluation of students' critical thinking is still in progress and will be reported in a follow-up study.

In order to evaluate the perceptions of faculty participating in this program, we designed a survey to identify prior experiences as well as the challenges, obstacles, limitations, and strategies that participants faced when implementing AL methodologies in their teaching practices. While sample size in this study is relatively small (n=10), it reveals key points for identifying areas for improvement and developing strategies for faculty professionalization in evidence-based teaching.

3. Results and discussion

The survey revealed that most (90%) of the faculty participating in this study did not have the concepts and/or tools to implement AL (Figure 1, blue, red, and purple). While the sample is too small to generalize this result, we found it deeply concerning that most participants reported having no prior training or practice on evidence-based teaching, confirming that the lack of appropriate faculty professionalization on innovative teaching methods is a barrier to effective learning (Sánchez Mendiola *et al.*, 2019; Nguyen *et al.*, 2021). The fact that 40% of participants consider employing AL empirically (Figure 1, blue) suggests that they already find AL engaging, exciting, and/or useful for their students.

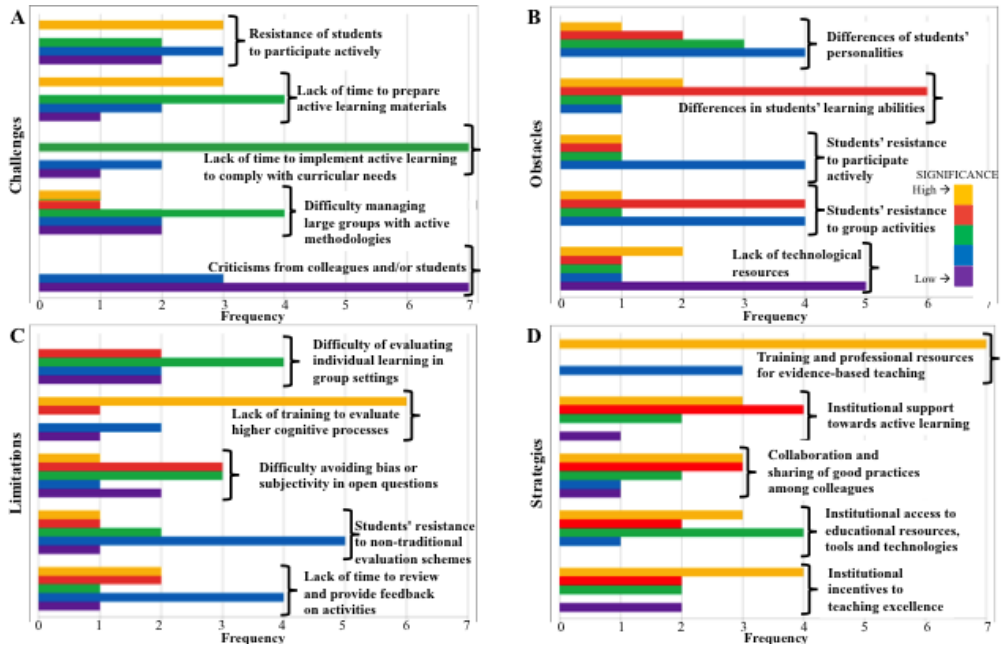
Figure 1. Faculty members' experiences with AL prior to their participation in the program. n=10.



We then asked participants to rate among different *challenges*, *obstacles*, *limitations*, and *strategies* that they have encountered when implementing AL in their teaching practice following the training program. The answers are presented using a rainbow colormap, ranging from yellow, if they consider the statement highly significant, to purple, if they consider the statement poorly significant (Figure 2). Among the *challenges*, survey participants rated student resistance and preparation time as the most significant items (Figure 2A). Overcoming student resistance to active participation may require strategies such as clearly communicating the benefits of AL, fostering a supportive and inclusive classroom environment, and gradually introducing AL techniques to help students become more comfortable with them over time (Fedler, 2007). Addressing the time constraints for preparation could involve providing teachers with additional support for designing and implementing AL in their classrooms; these tools are becoming more readily available as artificial intelligence tools will become more familiar among faculty. In addition, collaboration among faculty members and sharing can also help alleviate the burden of preparing evidence-based resources. Differences in learning abilities were reported as the most significant *obstacle* among survey participants (Figure 2B). This possibly arises from the high diversity of backgrounds, learning styles, and prior knowledge levels of undergraduate students in Mexico City. To address this obstacle, faculty members require training to accommodate various learning preferences and abilities. Additionally, providing support and resources to help students navigate these differences may enrich the effectiveness of AL approaches in diverse classrooms (Theobald *et al.*, 2020). Among the *limitations*, the most significant item was the lack of training to develop evaluation instruments for the evaluation of higher cognitive processes (Figure 2C). Assessing higher-order thinking skills such as critical thinking, problem-solving, and scientific creativity requires skills that are difficult to evaluate even for trained specialists. Without adequate training and supervised practice in assessment design, faculty members will struggle to create assessments that accurately reflect students' mastery of these skills. Finally, survey participants reported the need for more training to implement efficient *strategies* for AL in the classroom (Figure 2D). This response is consistent with the first question of the survey (Figure 1) that prior to this program, AL methodologies were lacking in faculty professionalization

and demands new programs that implement evidence-based practices at the university (Sánchez Mendiola *et al.*, 2019).

Figure 2. Faculty members' perceptions when asked to rate common challenges, obstacles, limitations, and strategies when implementing AL strategies in their classrooms. The color code used in all panels indicates significance and is shown in panel B; when a color bar does not appear, it means that frequency is zero. n=10.



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