Transitioning Lab Courses to Online Platforms by Higher Education Institutions during COVID-19: Strategies, Learning Outcomes, Perceptions, and Challenges

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INTRODUCTION

The COVID-19 pandemic has caused significant disruptions in institutions of higher education (IHE). Not all IHEs had strategies to ensure academic continuity. This was especially true for the science, technology, engineering, mathematics, and medicine (STEMM) lab courses, as they require extensive hands-on participation, which took a lot of work to achieve on an online platform. Since classes and labs could no longer meet in person, educators had to develop or adopt new innovative tools, approaches, and teaching methodologies as they moved to remote platforms. This systematic review focuses on the challenges experienced while shifting from in-person to remote teaching, the strategies adopted by the IHEs, the assessment of online lab courses, and the perceptions of students and instructors.

METHOD

The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses framework (Moher et al., 2011) and examined articles from ERIC and ProQuest databases. To be included in this review, each article needed to be a study conducted in the STEMM field, written in English, include adaptations and strategies made by the institutions in transitioning from in-person to online instruction and provide evidence for teaching methods employed and student learning outcomes. Various search terms were considered and refined to be appropriate for the research questions. The keywords listed below were combined using Boolean operators (and/or): COVID-19, Digital learning tools, Distance/Remote/Online/Virtual learning, Higher education, Labs, Teaching methods. A total of 33 articles met the inclusion criteria and were analyzed.

RESULTS

The review findings indicated that IHEs used various strategies and technologies to transition to online labs. The most used strategies included pre-recorded videos (46%), simulations (27.6%), home labs (6.3%), and live-streamed videos (6.3%). Other strategies included online panel formats, analysis of previous data, remote machine learning modules, remote programming labs, remote titration units, remote partner models, online learning platforms with data acquisition equipment, and visual tutors. The effectiveness of the transition to online labs was evaluated in terms of student learning outcomes and satisfaction. Overall, learning outcomes remained similar compared to in-person instruction. The utilization of simulations, which permitted students to repeat experiments until achieving the desired results, resulted in enhanced performance and improved learning outcomes in online labs (Gao et al., 2020). However, online labs relying solely on video recordings resulted in passive observation and limited hands-on engagement (Anstey et al., 2020). According to the results of a student survey, it was found that video recordings were effective in teaching scientific concepts where students viewed them multiple times (Hamed & Aljanazrah, 2020). On the other hand, the feedback from instructors on home labs indicated their benefit in offering students a practical, hands-on experience. These labs enabled students to physically interact and engage with readily available home equipment such as electric stove, smartphones etc., and lab kits (Gao et al., 2020). Similarly, instructors' feedback on simulations revealed that students were satisfied with the virtual experiments and found them useful for repetitive practice (Gao et al., 2020). Challenges during the transition included technology issues, workload and expertise limitations, academic integrity concerns, and the need for a complete lab experience fostering technical and non-technical skills and retaining student engagement.

DISCUSSION

IHEs have primarily focused on online lab experiences through videos and simulations. There was limited usage of home lab kits, and none of the reviewed studies included the integration of videos, simulations, and home lab kits. It is necessary to increase the accessibility of home lab kits for students to facilitate hands-on learning experiences. Nevertheless, safety concerns can arise as these kits involve handling hazardous substances. This can be addressed by incorporating immersive virtual reality simulations alongside desktop simulations or as an alternative when home labs are not feasible. IHEs can carefully consider the lab requirements, learning outcomes, feasibility, and cost-effectiveness when deciding on the most suitable combination of strategies. Offering software and technology training to instructors could help them create engaging simulations and effectively use web conferencing platforms such as Zoom and Blackboard. To ensure technology accessibility, institutions can provide students with free laptops and Wi-Fi connections. Academic integrity concerns can be addressed using methods such Multiple Attempts Format (MAF) (Estidola et al., 2021) and fostering self-regulated learning skills (McAllister & Watkins, 2012). To improve student engagement in online learning, institutions can provide online team collaboration spaces, collaborative activities, group discussions, and other forms of student interaction (Dixson, 2010). These strategies can encourage active participation and interaction among students in the online learning environment.

CONCLUSION

The systematic review concludes that using a combination of home labs, simulations, and video recordings could be a potential way to support academic continuity than using each strategy individually. To ensure that remote labs continue to be used and enhance the learning experience of students, it is critical to conduct more research and create evidence-based guidelines. This will help educators make informed choices and improve the effectiveness of remote lab practices.

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