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Post Covid-19: Assessing Secondary School Students' and Teachers' Perception of Virtual Labs Versus Traditional Labs in Biology Education

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Abstract: In 2020, the COVID-19 pandemic has resulted in the closure of schools across the world. As a result, education has undergone a significant transformation whereby the lessons were delivered through online platforms. The new norms were challenging especially in Malaysia to meet the needs of students in conducting practical works as the students have no access to traditional labs. With recent trends of using Information and Communication Technologies (ICT) in education, virtual labs have become more prevalent in classrooms. However, do we still need virtual labs during post COVID-19? So, this study was aimed to (i) to assess students' perceptions of virtual labs compared to traditional labs in terms of conceptual understanding, laboratory activities and motivation and (ii) to assess teachers' perspectives on the potential of virtual labs as compared to traditional labs in teaching Biology. This research employed both quantitative and qualitative methods. A total of 30 secondary school Form Four students and two biology teachers were selected in the study. The survey amongst the students and teachers revealed virtual labs were more preferred in teaching and learning process compared to traditional labs especially during post COVID-19. Hence, the findings of this study are expected to contribute information towards Sustainable Development Goals 4 in providing equitable quality of Biology education.

Keywords: Virtual labs, secondary schools, Biology education

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INTRODUCTION

Education is one area that was severely impacted by the COVID-19 epidemic that surfaced in late 2019 and continued to upset communities around the world until at least in September 2021 (Reginald, 2023). The rapid transition from face-to-face classroom instruction to online learning presented a major issue for educational institutions at the time (Pokhrel & Chhetri, 2021; Sriwiyanti et al., 2021; Vasiliadou, 2020). As with many other disciplines, biology education evolved as teachers and students adopted new approaches to instruction. Traditional laboratory experiments have long been an integral part of biology education, offering students hands-on experience, fostering critical thinking, and enhancing their understanding of complex biological concepts (Harman et al., 2016; Hofstein, 2017). The traditional laboratory, also known as a traditional labs or physical labs, plays a significant role in science education since it enables students to gain theoretical knowledge and practical skills (Gericke et al., 2023). Within this academic setting, enable the students acquiring and developing conceptual and theoretical knowledge (Hodson, 2014). Herranen and Aksela

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(2019) assert that investigations serve as a valuable tool for students in the process of formulating hypotheses, manipulating variables, interpreting data, and drawing conclusions. Moreover, the students are able to enhance their critical thinking, reasoning, and decision-making skills through engaging in hands-on activities (Isozaki, 2017; Peechapol 2021). The main goal of laboratory experiments is to facilitate the acquisition of scientific inquiry skills among students, which can subsequently be employed in problem-solving contexts across various disciplines. Additionally, laboratory activities are designed to cultivate students' ability to provide analytical and critical explanations for scientific phenomena (Byukusenge et al., 2023).

However, with the closure of schools, colleges, and universities due to the pandemic, the laboratory activities became infeasible or posed significant health risks (Gamage et al., 2020). In response to this challenge, virtual laboratory served as a viable alternative to maintain the continuity of biology education. Virtual laboratories, or virtual labs, tend to be defined as software that allows students to perform scientific experiments in a simulated setting (Bogusevschi et al., 2020; Özdemir, 2019). By leveraging technology through virtual labs, students can engage in simulated experiments and observe outcomes that closely resemble those of real experiments (Bogusevschi et al., 2020; Ratamun & Osman, 2018; Saidatul Ainoor Shaharim et al., 2022).

Numerous advantages come with the integration of virtual labs within the classroom. The learning approach through virtual labs emphasize the use of contextual, simulation and animation with concepts that are expected to develop students' creativity and critical thinking (Singhai, 2019). Teachers may empower the quality of teaching as virtual labs provide a visual and immersive experience that helps students learn the difficult concepts much better (Yunzal & Casinillo, 2020; Smetana & Bell, 2012). Therefore, it improves the quality of class teaching and make learning interactive, enjoyable and effective (Abdullah et al., 2023; Akpinar, 2014). Virtual experiments require less time to set up the apparatus, may offer immediate results from extended study and can be performed repeatedly (Byukusenge et al., 2022). In addition, with virtual labs, students can determine their own pace of learning at anytime and anywhere (Hamed & Aljanazrah, 2020; Potkonjak et al., 2016).

During the pandemic, virtual labs experienced increased popularity as they offered students the chance to engage in practical learning while maintaining compliance with social distance and safety protocols (Ayu et al., 2021; Jain & Kaur, 2022). Moreover, students have the ability to engage in experimental activities, analyze gathered data, and formulate conclusions while working within the limitations of their living surroundings. The school granted students the opportunity to pursue their scientific education through remote methods, while also equipping teachers with a mechanism to evaluate student advancement and comprehension through a virtual environment.

Nevertheless, with the slow decline of the epidemic and the subsequent return of schools to their normal state, inquiries emerge concerning the enduring consequences of this transition on students as well as teachers. In the context of the post-pandemic era, it is crucial to determine the students' perception of virtual labs and traditional labs in three domains: (1) conceptual understanding, (2) laboratory activities and (3) motivation. Conceptual understanding refers to a deep and comprehensive comprehension of a concept or topic which involved the ability to grasp the fundamental principles, connections, and underlying logic of a subject matter (Bajpai, 2013; Hermansyah et al., 2019). Laboratory activities can be described as students performing a procedure of experiment either individual or in small groups (Leite & Dourado, 2013) while motivation plays a crucial role in determining a students' behaviour, choices, and level of commitment to learning tasks or activities (Kaiser

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et al., 2020). This awareness is essential to guarantee that students are provided with exceptional, flexible, and inventive learning opportunities that equip the students with the necessary skills for confronting modern issues.

BACKGROUND TO THE STUDY

Integration of Virtual Labs in Teaching and Learning (T&L) Biology Form Four

In Malaysia context, the Secondary School Standard Curriculum (KSSM) Biology Form Four, comprised of two main themes: Biology Fundamentals and Human and Animal Physiology (Curriculum Development Division [CDD], 2018). This study focuses on Nutrition and Human Digestive System as the learning area has been subject to a substantial number of experiments in the curriculum. For this study, the experiments were initially conducted by the students in traditional labs, followed by subsequent experimentation in virtual labs. For both type of labs, the students performed six experiments using virtual 3D apparatus and substances such as (1) determine digestion of carbohydrates in food sample, (2) determine digestion of proteins in food sample, (3) determine digestion of lipids in food sample, (4) determine the energy value in nuts, (5) determine the concentration of vitamin C in fruit and vegetables juices and (6) determine the effect of temperature towards the concentration of vitamin C in fruit juices. The classroom setting during teaching and learning (T&L) using virtual labs can be seen in Figure 1.

Figure 1. The Classroom Setting in T&L Biology Through Virtual Lab

Statement of the Problem

As school begin to navigate the post COVID-19 era, there is a critical need to assess the effectiveness and acceptability of virtual labs compared to traditional labs in the context of T&L in Biology. However, do we still need virtual labs during post COVID-19? What are the perceptions of students and teachers regarding the overall experience of virtual labs as compared to traditional labs in biology education? How do these perceptions influence the adoption and acceptance of virtual labs in teaching and learning Biology?

Objective Of Research

The primary objectives of this study are as follows: (1) to assess students' perceptions of virtual labs compared to traditional labs in terms of conceptual understanding, laboratory

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activities and motivation and (2) to assess teachers' perceptions on the potential of virtual labs as compared to traditional labs in teaching Biology.

METHODOLOGY OF RESEARCH

This study employed a combination of quantitative and qualitative approaches which the aim of gaining a more thorough insight into the research problem, harnessing the advantages of both approaches (Creswell & Plano Clark, 2018). The findings from the quantitative and qualitative were integrated to offer a comprehensive understanding of how students and teachers perceive virtual labs in the context of teaching and learning biology.

The samples in this study were 30 Form Four Biology students from a secondary school located in Kota Bharu, Kelantan and two biology teachers. For the first objective, the research instrument used was a questionnaire adapted by Schnieder et al. (2022) and Saputri and Saifuddin (2022). The questionnaire was validated by two experts. The questionnaire comprised of two parts: (1) Background of the students and (2) The students' perceptions of virtual labs compared to traditional labs in terms of conceptual understanding (4 items), laboratory activities (6 items) and motivation (4 items). The items utilised a Likert scale consisting of five points, ranging from 1 (strongly disagree) to 5 (strongly agree). The administration of the questionnaire occurred subsequent to the students' completion of experiments pertaining to the learning area of Nutrition and the Human Digestive System, which was conducted via virtual labs. In order to achieve the second objective, the researchers conducted a semi-structured interviews with two biology teachers. Throughout the interview, the researchers took on the role of a facilitator. With the guideline of the interview protocol, the researchers posing questions and adding prompting follow-up questions, encouraging the teachers to elaborate on certain points and offer additional comments.

For quantitative data, a descriptive method was used to analyze the data, and the results are shown as a percentage. The qualitative data will undergo thematic analysis, a method that entails systematically examining a dataset to identify recurring patterns and themes that emerge from the data (Braun & Clarke, 2006). Figure 2 summarized the methodology used in this study.

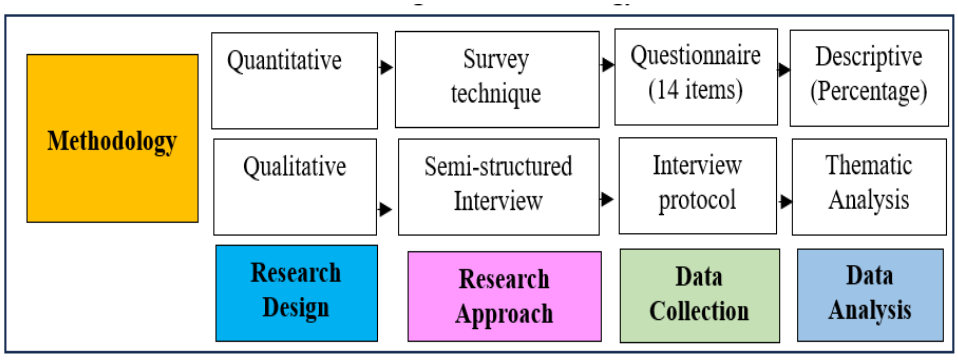

Figure 2. Summary of Methodology

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FINDINGS AND DISCUSSION

The Students' Perceptions of Virtual Labs Compared to Traditional Labs

Figure 3 illustrates the perceptions of students with regards to their conceptual understanding.

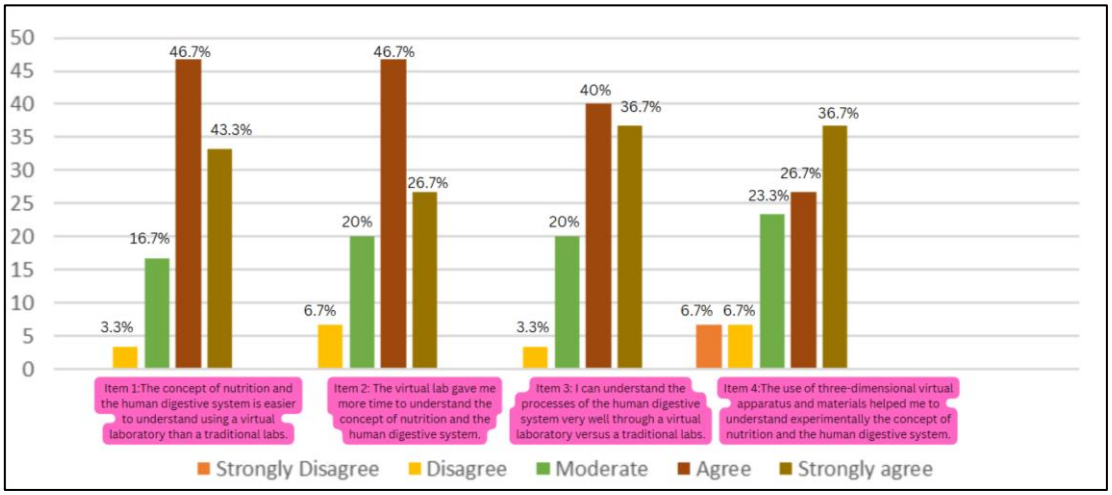

Figure 3. The Perception of Students' Conceptual Understanding

Figure 3 shows that most students (46.7% agree) or (33.3% strongly agree) that virtual labs made it easier to understand the concept of nutrition and the human digestive system than traditional labs. In addition, the vast majority of students (63.3%) either agreed or strongly agreed that the virtual labs helped them better grasp that gave them more time to understand the concept the concepts of nutrition and the human digestive system. Forty percent of students also revealed that they gained a better understanding of the digestive system than they would have in a traditional lab. In addition, 36.7 percent of students strongly agreed that the three-dimensional (3D) apparatus and materials aid in their visualization and understanding of the concept of digestive process in humans.

Figure 4 illustrates the perceptions of students with regards to the students' laboratory activities.

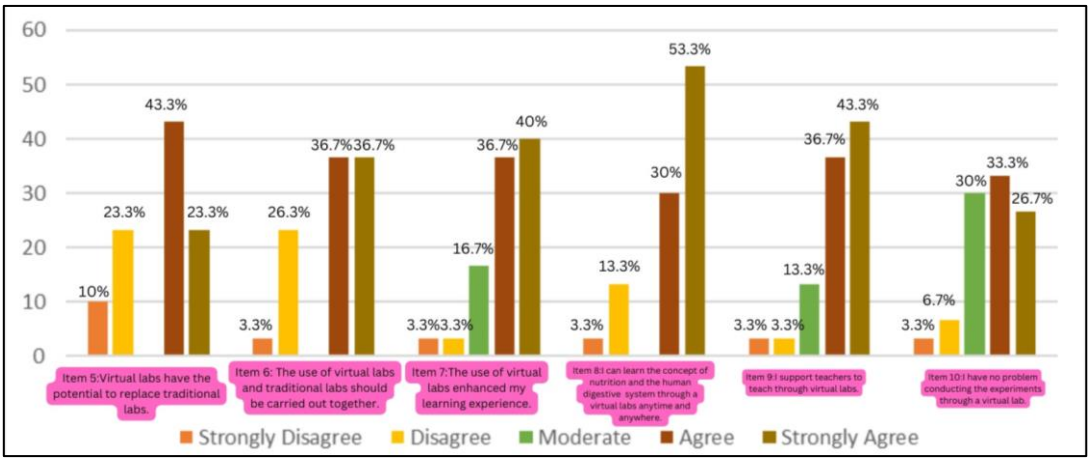

Figure 4. The Perception of Students' Laboratory Activities

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Figure 4 shows that amongst students, a majority of students feel that virtual labs have the potential to replace traditional labs, with 43.3% either agreeing or strongly agreeing with this statement. In addition, nearly as many students (36%) as strongly agreed (36%) that teaching and learning Biology should incorporate both virtual and traditional labs. Additionally, 40 percent of students felt that their learning experience was improved by using virtual labs. Moreover, 53.3 percent of students feel that a virtual lab is an excellent tool for learning at anytime and anywhere. The vast majority (43.30%) agree that teachers should implement virtual labs to introduce students the concepts of nutrition and human digestive system. More than a third of the class (33.3%) expressed agreement that they had no trouble conducting the experiments using the virtual lab.

Figure 5 illustrates the perceptions of students with regards to the students' motivation.

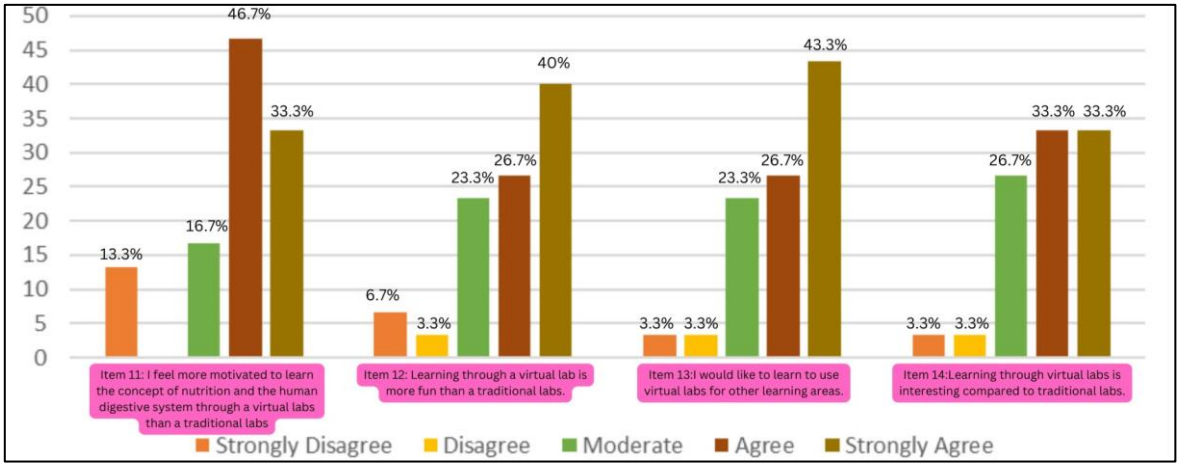

Figure 5. The Perception of Students' Motivation

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Figure 5 shows that over half of students agreed that using a virtual lab is a better way to learn about nutrition and the digestive system than using a traditional lab. In addition, a high percentage of students (40.0%) stated that learning the concept of nutrition and human digestive system through a virtual lab was more enjoyable than using a traditional lab. Additionally, 43.3% of the student strongly agreed that they were interested in learning through virtual labs for other leaning areas. More than a third (33.3%) of the student agreed or strongly agreed that learning using virtual labs was more engaging than using traditional labs.

The Teachers' Perceptions of Virtual Labs in Teaching and Learning Biology

Theme 1: Problems to conduct experiments during and post COVID-19

The researchers initially discussed with the teachers regarding the difficulties encountered when conducting experiments within the COVID-19 pandemic, specifically in relation to health and safety considerations. During the discussion, both teachers addressed inability to provide sufficient time and resources for the conducting of experiments within the context of online instruction. A possible strategy employed to address this issue involved recording video of experiments and afterwards uploading them onto the YouTube platform for students to access and view. Nevertheless, the video proved to be ineffective in facilitating the acquisition of knowledge and scientific abilities among the students.

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The researchers further inquired with the teachers regarding the challenges that have emerged in the post COVID-19 pandemic. Both teachers faced difficulties in effectively conducting experiments physically within the limits of restricted time. During that part of the interview, the researchers asked the teachers what they thought about using virtual labs. Both teachers agreed that the implementation of virtual labs provides an opportunity to overcome these problems. In virtual labs, students can quickly set up and conduct experiments without waiting for equipment or dealing with the limitations of physical resources. This can significantly increase the number of experiments students can perform within a given timeframe.

Theme 2: Effective Teaching Strategies

The next question posed by the researchers pertained to the potential of virtual labs as successful ways for teaching Biology. According to both teachers, virtual labs offer significant potential as a teaching strategy to enhance the development of 21st century skills among students encompass a range of abilities that are essential in today's rapidly evolving world especially during post COVID-19. The soft skills or future-ready skills can be obtained as virtual labs can simulate complex experiments that require students to analyze data, identify patterns, and solve problems. Also, students can formulate hypotheses, design experiments, and test their ideas within a controlled virtual environment. The teachers believed that the virtual labs can replicate real-world scenarios, challenging students to think critically about solutions and allow students to modify parameters to fostering innovative thinking.

Theme 3: Advantages of Virtual Labs

When asked about advantages of virtual labs, both teachers agreed that the main advantages of virtual labs are allow students to conduct experiments in short time. They came into point of view that the traditional labs often require setup and preparation, which can be time-consuming. Virtual labs eliminate this need, allowing students to start experiments immediately. Additionally, virtual labs often offer the ability to simulate experiments, making it possible for students to repeat procedures and make adjustments easily. This enhances the learning experience by allowing students to learn from their mistakes and gain a deeper understanding of scientific concepts.

Theme 4: Training and Professional Development

The last question asked the teachers what kind of training and professional development they needed in teaching Biology using virtual labs. During the discussion, the teachers demonstrate a high level of preparedness, particularly in terms of their mindset, to effectively implement virtual labs in the teaching and learning of Biology. Nevertheless, with regards to knowledge and abilities, it is imperative that teachers have adequate training and opportunity for professional growth in order to attain proficiency in utilizing virtual labs. The teachers suggested they should be familiar with the technology, the specific virtual lab software or platforms, and best practices for integrating them into their teaching Biology.

DISCUSSION

The use of virtual labs in Biology education has been proposed as a solution in post COVID-19. The present study was conducted to explore the perceptions of secondary school students about the use of virtual labs in learning biology compared to the use of traditional labs. The response provided by the students in the survey indicates their favorable acceptance of virtual labs in comparison to traditional labs. The students acknowledged the positive impact of

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virtual labs on conceptual understanding. They indicated the abilities to grasp complex concepts and develop practical skills effectively through virtual labs when compared to traditional labs. Wang et al. (2015) claimed that the use of virtual labs may enhance students' conceptual knowledge more than real experiments. The students in the virtual lab environment demonstrated superior conceptual understanding and procedural abilities compared to students in the traditional setting (Kollöffe & De Jong, 2013). Therefore, students are allowed to discuss their scientific findings amongst themselves, which can only benefit their learning (Raman et al., 2020; Ratamun & Osman, 2018). When combined with direct practice, students who participate in a science practicum using a virtual lab get a more thorough and sophisticated comprehension of the topic being taught (Toth et al., 2014). Hence, it is more efficient to use virtual labs compare to traditional labs (De Jong et al., 2013).

The results of the present study additionally demonstrated that the utilisation of virtual labs facilitated students' practise of experimental design. The students felt that the virtual lab was easy to operate compared to traditional labs. According to Falode (2018), the students found the virtual lab to be user-friendly. Meanwhile, Abu-Dalbouh (2013) asserts that the adoption of a specific technology should not necessitate any physical or cognitive exertion, thereby reinforcing the user-friendly nature of virtual labs. The findings also indicated that positive intentions to use virtual lab for their learning experience. The virtual lab exercises allowed students to learn at their own pace and repeat experiments without lab access (Lynch & Ghergulescu, 2017). This new method promoted student-centered learning (Tardia, 2023).

Additionally, virtual labs exhibit a notable degree of student motivation in contrast to traditional labs. The utilisation of virtual labs for learning offers the advantage of introducing diverse approaches to the learning process, hence enhancing student engagement and enthusiasm towards active participation (Saputri & Saifuddin, 2022). According to Sriadi et al. (2022) virtual lab satisfies students' need in terms of feasibility, learnability and interactive interfaces which enhanced students' learning motivation in science education. Students' motivation and engagement in the virtual laboratory can be increased by the use of visual aids like animation and video (Alneyadi, 2019; Suyanta et al., 2021; Tardia, 2023).

Based on an interview with the two biology teachers, the challenges they face in transitioning from traditional to virtual lab environments is inadequate knowledge and skills about virtual labs. The teachers suggested training and resources are necessary to support teachers in effectively delivering virtual biology lab experiences. Daineko et al (2017) agreed this has led to a surge in demand for innovative pedagogical approaches that make use of internet and for computer-based training systems that incorporate a range of teaching methods. Virtual labs often involve complex software and equipment simulations (Van Nuland et al., 2020). The teachers need to be well-versed in operating and troubleshooting these tools to ensure a smooth learning experience for students (Jain & Kaur, 2022).

Overall, the perceptions of students and teachers regarding the experience of virtual labs as compared to traditional labs in biology education were positive. This may influence the adoption and acceptance of virtual labs in post-Covid 19. For long-term sustainability, considering potential future disruptions, the schools can develop sustainable strategies for incorporating virtual labs into biology education, either as complements to traditional labs or as stand-alone alternatives.

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CONCLUSION

The COVID-19 pandemic triggered an unprecedented transformation in the field of biology education, compelling institutions to adopt virtual labs as a new suitable approach in teaching and learning Biology. As we have assessed students' and teachers' perceptions of these two approaches in a post COVID-19 era, several key findings have emerged, shedding light on the evolving landscape of biology education. Firstly, it is evident that virtual labs have played a crucial role in bridging the gap left by the closure of traditional labs during the pandemic. Students have generally found virtual labs to be accessible, convenient, and, to some extent, engaging. This adaptability has been particularly beneficial for students facing geographical or resource-related barriers to traditional labs.

Our findings have also highlighted the resilience and adaptability of teachers who swiftly embraced virtual labs to ensure educational continuity. Teachers have demonstrated their commitment to providing quality biology education, even in challenging circumstances. Nevertheless, the transition to virtual labs has presented educators with a unique set of challenges, including the need for additional training, technological infrastructure, and the development of effective pedagogical strategies for implementation of virtual labs. This approach necessitates careful planning and resource allocation to ensure a seamless integration of virtual labs in teaching and learning Biology parallel to the development of technology.

Declaration of Interest

The authors declare that there is no conflict of interest.

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