

Reflections on Technology-enhanced Learning in Laboratories: Barriers and Opportunities

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Abstract

This preface discusses the potential of virtual labs (VLs) as a flexible and immersive alternative to traditional physical labs on the light of Technology-Enhanced Learning in Laboratories workshop (TELL 2023), which features seven papers showing various methodologies and perspectives on using VLs. The papers cover topics such as VLs in biomedicine, students' perception of VLs, and collaborative learning in VLs, and examine challenges and barriers to VL accessibility. We discuss some of the main findings of the papers, such as the potential of digital applications and online materials to enhance digital teaching and the importance of developing strategies to enhance team-based learning through encouraging students to reflect on their own work. Overall, the preface demonstrates the potential of VLs to enhance students' practical skills, and learning outcomes, with insights into the challenges and barriers to VLs accessibility.

Keywords:

Virtual Labs, digital labs, learning analytics, online learning, collaborative learning,

1. Introduction

Virtual labs (VLs) are simulation environments that give students the opportunity to safely conduct practical experiments at their own pace transcending the barriers of physical and material spaces. When in-person labs are not available, or access to them is limited, VLs can be an attractive alternative due to their flexibility and ability to enhance students' practical skills, knowledge, and learning outcomes, especially after the COVID-19 [1]. Additionally, VLs offer the advantage of engaging content with the ability to perform experiments in an immersive simulation with virtual materials and access to a variety of laboratory tools [2]. Nevertheless, a main disadvantage of VLs is the limited experimentation compared to traditional labs, which may not provide students with the same level of hands-on experience [3].

The Technology-Enhanced Learning in Laboratories workshop (TELL 2023) was held at within what

The workshop proceedings feature seven papers that show various perspectives and methodologies for using VLs, in different countries and education levels. The included topics range from using learning analytics to examine students' interactions and students' perceptions to examining areas for improvement with insights into the challenges and barriers to VL accessibility. The next section of the paper summarizes the main contributions of the TELL workshop.

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2. VLS in Biomedicine

Digital applications and online materials have revolutionized the way students learn in the field of Biomedicine. Kainulainen et al. focused on digital pathology, which has become a standard method for both diagnostics and education, and addressed the limitations of the available digital applications, especially those related to collaboration among peers and teachers [4]. The authors proposed a project aimed at developing an integrated online learning system that would enhance digital pathology through the utilization of an open-source web microscope. The system would enable whole-slide image annotation and integration with assessment and feedback software. A dashboard for synthesizing and visualizing students' responses was also developed, providing a joint platform for communication in both on-site and remote settings. The authors used two teaching pilots to demonstrate the effectiveness of the system for teaching with guided activity, collaboration, feedback, reflection, and the modeling of diagnostic reasoning. Similarly, Pylvänäine et al. addressed the challenges of using online materials for operating microscope by developing Ocul-AR, a mobile application for microscopy teaching and support. It guides students on microscopy, optimizing light paths, and operating light microscopes independently. The Ocul-AR application was assessed in separate sessions during and after the guided practical training of the course. Students who used Ocul-AR reported increased confidence in operating the microscope and using it independently. These two studies highlight the potential of digital applications and online materials to offer a useful solution to the challenges of biomedicine teaching and providing a potential interactive experience for learners.

3. Students' Perception of VLS

Cheung et al. explored the use of digital laboratories in Biomedicine/Life Science courses across two universities: University of Turku and Karolinska Institute. Their findings showed that students responded positively to the use of digital laboratories to complement their theoretical and practical laboratory training. In their study, the digital laboratories helped to increase motivation and interest in the course content and aided in the integration of theory and practice. However, the digital laboratories did not support teamwork between students, which is essential in real-life laboratory sessions. The findings provided valuable insights for university teachers on the use of digital laboratories in course design. Additionally, the study highlighted the importance of learning analytics for identifying difficult concepts and conducting cost-benefit analyses to inform future decision-making regarding education tools. On the other hand, a paper by Ndnagu et al. focused on the technology-enhanced virtual labs in the STEM program in higher education in Nigeria. The study showed that the majority of students preferred conventional labs and highlighted on the benefits of integrating VLS into learning management systems. This integration may reduce attrition among STEM students and facilitate collaboration between Nigerian educational institutions.

4. Collaborative Learning in VLS

From the learning analytics perspectives, the paper by Mairinoja et al. explored the implementation of an online team-based learning approach for biomedicine students from four Nordic universities. The study focused on the performance of students during online teamwork, as well as students' feedback at the end of the course. The authors utilized the Community of Inquiry (CoI) framework to explore the interaction between students during the collaborative learning approach. Data was collected from the Discord platform and analyzed using process mining and network analysis to understand the multidimensional property of collaboration. Learning analytics showed that the social dimension of CoI was considerable, but the cognitive dimension could be improved by increasing teaching presence. One of the advantages of VLS is that students can conduct their experiments in groups which enhance teamwork and social engagement [5]. This research could

serve as a crucial stride toward narrowing the knowledge gap in learning analytics of VLS [6]. Additionally, the study highlighted the need for developing strategies to enhance team-based learning through encouraging students to reflect on their own work, contribution, and cognition.

In another paper focused on learning analytics, Misiejuk et al. reported on the challenges of conducting learning analytics research with limited access to relevant data. The authors described a case study examining how students collaborate in a virtual lab. The data provided by the virtual lab vendor was not sufficiently granular to be used for learning analytics. Therefore, the authors had to redesign the study to allow alternative data collection using the Discord platform. Based on the obstacles encountered in this process, the authors outlined several recommendations for future learning analytics studies, including planning alternative data sources when designing a study where there is little information about the types and granularity of data that will be collected, or considering incorporating conventional data sources into the study design, such as surveys. Misiejuk et al.'s paper contributes to the broader discussion about the practical challenges of conducting learning analytics research using data from private vendors.

5. Barriers and Challenges to VLS

Finally, the challenges for learners to virtual learning accessibility were addressed by Deriba et al. The authors investigated the accessibility barriers in VLS and explored the solutions to overcome them through a review of literature. The findings indicated that some barriers in accessing VLS still exist either technological, pedagogical, or cultural barriers. To address these barriers, a range of solutions have been proposed in the literature. This paper provided valuable information that might improve the accessibility of VL to use such innovative educational tool.

6. Conclusions

The papers in TELL workshop collection reported on the current research trends in VL research: development of new tools, student collaboration patterns when using VLS, integrating learning analytics and VLS, and accessibility of VLS. As we move forward, VLS continue to play a significant role in education, particularly with the advancement of technology improving accessibility. While the research shows several positive developments, significant challenges still need to be addressed in future research. We believe that this collection of articles can inspire further innovation and exploration in the use of VLS in education.

7. TELL 2023 Articles

- Digital labs as a complement to practical laboratory training for Bachelor and Master biomedicine students: Louisa Cheung, Leena Strauss, Per Antonson, Sanna Soini, Matthew Kirkham and Rachel M Fisher.
- Towards an integrated online learning system for microscopic pathology: Two teaching examples: Mikko Kainulainen, Laura Helle, Pauliina Kronqvist, Koen L. Vincken, Friedrich Pawelka, Katarina Korpinen and Bas de Leng.
- Supporting microscopy learning with Ocul-AR, a virtual and augmented reality -powered mobile application: Joanna W. Pylvänäinen, Laura Mairinoja, Junel Solis, Diana M. Toivola and Pasi Kankaanpää.
- Virtual Laboratories for STEM in Nigerian Higher Education: The National Open University of Nigeria Learners' Perspective: Juliana Ndunagu, Kingsley Ukhurebor and Adewale Adesina.
- International online team-based learning in higher education of biomedicine: Evaluation by learning analytics: Laura Mairinoja, Sonsoles López-Pernas, Ramy Elmoazen, Einari A Niskanen, Tiina Kuningas, Anni Wärrri, Mohammed Saqr and Leena Strauss.

- Tackling the challenges with data access in learning analytics research: A case study of virtual labs: Kamila Misiejuk, Mohammad Khalil, and Barbara Wasson.
- Exploring Barriers and Challenges to Accessibility in Virtual Laboratories: A Preliminary Review: Fitsum Deriba, Mohammed Saqr and Markku Tukiainen.

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