

## **Are virtual Physiology laboratories effective for student learning compared with traditional in-person laboratories?**

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Laboratories are core for physiology education, enabling students to reinforce physiology knowledge and to develop research, technical and employability skills. In 2020, the COVID-19 pandemic forced a rapid transition from interactive, in-person laboratories to virtual laboratories. Given the critical role of laboratories, this transition was expected to induce educational impacts on students, especially for the development of research and laboratory specific technical skills. The aims of this study were to evaluate if virtual laboratories are effective in achieving similar student learning outcomes as in-person laboratories, namely in students' conceptual understanding, research and technical skills development. In 2021, Biomedical science students (n=571) enrolled in a core physiology subject were randomly assigned to either an in-person or virtual laboratory that investigated the contraction of isolated toad ventricular muscle. The in-person laboratory provided students with hands-on experience in data collection and analysis, while the virtual laboratory format included a synchronous 'Zoom' module, guiding students through the same series of experiments using pre-recorded videos and data. Pre- and post-laboratory surveys were used to assess students' conceptual understanding, and self-reported ratings of confidence in research and technical skills. Students' conceptual knowledge was reinforced through both virtual and in-person laboratories, with both groups demonstrating significantly improved performance on conceptual-based multiple-choice questions, pre- vs post- laboratory. Students who attended the laboratory in-person performed significantly better on application-based short-answer research questions, and had greater confidence in their technical skills, compared to their peers in the virtual laboratory. Interestingly, no differences were observed between either group on self-reported ratings of confidence in their research skills of graphing and writing figure legends. These findings highlight the importance in identifying pedagogical approaches that focus on developing students' ability and confidence in technical and research skills within virtual settings.