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Moving practical learning online

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Abstract
As the pandemic affected many institutions where practical learning occurred in physical laboratory spaces, investigations into online labs surged. Zacharias et al.'s (Educational Technology Research and Development 63(2):257–302, 2015, https://doi.org/10.1007/s11423-015-9370-0) literature review became a guiding point to those choosing to invest deeper into practical online learning experiences. Whilst some practical learning that occurs in laboratories can mimic the required epistemology of discovery learning some require a more guided yet in-depth approach (Bao et al. in Science 323(5914):586–587, 2009; Giere in Argumentation 15(1):21–33, 2001; Zimmerman in Dev Rev 20(1):99–149, 2000). The following summarizes six essays from scholars, researchers and game-based learning designers with suggestions on how to action practical learning in online space

Keywords Computer-supported inquiry learning · Machine learning · Blended learning

As the pandemic affected many institutions where practical learning occurred in physical laboratory spaces, investigations into online labs surged. Zacharias et al.'s (2015) literature review became a guiding point to those choosing to invest deeper into practical online learning experiences. Whilst some practical learning that occurs in laboratories can mimic the required epistemology of discovery learning (i.e., mailed lab-kits from companies such as eScience Labs, Holscience and homesciencetools.com, etc.), some require a more guided and in-depth approach (Bao et al. 2009; Giere 2001; Zimmerman 2000). In the general model of scientific reasoning, investigations use an observed occurrence and triangulate data between the real-world, predictions and explanations. In laboratories this can occur in a constructivist environment where students do, reflect and link observations to pre-formed ideas (Millar 2004). Learning in this way needs a level of guidance which can be supported through the use of Computer Supported Inquiry Learning (CoSIL) environments and Zacharias et al.'s (2015) paper provided a literature review on the types of guidance to support student learning in computer-based environments. This paper allowed respondents to describe, reflect and/or relate knowledge and experiences, thus providing some additional thoughts to those in the STEM-related fields.

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- Chatterjee (2020) discusses the need for more investigations on how the design of CoSIL environments can support student learning. Part of this includes a more in-depth review of tools that are currently known and used with suggestions on how they can be improved to the benefit of the learning outcomes.
- Hoffman (2020) approaches his discussion using student experiences in different contexts as a foundation. Exploring how students in varying contexts use such tools in today's environment where there is a rapid evolution of technology tools that can be key for this field.
- West et al. (2020) elaborates on the article where three of the phases in CoSIL lacked sufficient guidance examples. This team of researchers provided value-added examples for each of the different CoSIL phases (i.e., orientation, conceptualization, investigation, conclusion and discussion), thus building on Zacharias et al.'s work.
- Zhai (2021) hones in on the personalization afforded by CoSIL to propose the use of machine learning methods to increase these efforts without creating additional burdens to teachers.
- Stegman (2021) introduces the concept of using blends of designs which allows for iterative learning experiences. The experiences can include the use of simulations/games with strategically placed authentic home-based experiences thus creating elements of unknowns into the learning space.
- Gamor (2021) draws relevance to other research studies in the field and provides additional insights. These insights include the overall effectiveness of the types of guidance, suggestions on using guidance through automation as a way to improve student access and a discussion on comparing teacher-generated guidance methods. These suggestions explicitly state how research can inform and thus, transform practice.

These responses create fodder for further research and practice opportunities. To add to these responses, some additional thoughts on expanding the literature to address the potential benefits of practical learning in online spaces are presented below for consideration.

- How can we review the affordability and accessibility of CoSIL designs to significantly enhance the reach of the learning opportunity?
- How can we design for persistence as this is key when experimenting towards a prediction (Gamor 2012)?
- Can we consider multi-user online laboratory solutions (i.e., practical learning labs)—two or more students utilizing group learning through co-operation cycles (Dede et al. 2004; Duncan et al. 2012)?

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