University of Louisville
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Literature Seminar

When: April 18, 2024
Time: 12:00 p.m.
Location: CBLL-16

Promoting Conceptual Chemistry Understanding through Engaging and Relevant Laboratory Experiences

Abstract:

The Framework for K-12 Science Education and the Next Generation of Science Standards (NGSS) in the United States emphasizes that students should participate in science and engineering practices throughout their educational journey. These practices set performance expectations for students' abilities upon completion of their studies [1], however, existing studies have shown that traditional chemistry laboratory courses rarely engage in these practices. Recently, 10 guiding principles for enhancing university laboratory education have been outlined and discuss the importance of constructive alignment, the integration of technological advances, diverse assessment types, and sustainable laboratory practices [2]. The aim is to provide research-based practical guidance for educators to improve the effectiveness of laboratory teaching. In addition, researchers develop assessment instruments to investigate students' understanding of various lab-related competencies. In one study, a mix-methods sequential design was used to develop an assessment targeting the flame test and atomic emission. Interviews with chemistry students revealed alternative conceptions which inform assessment design. Administered to 559 university students, the assessment produced valid and reliable data about common alternative conceptions [3]. While investigating conceptual understanding is a critical component to laboratory experiences, many other factors influence student learning. Incorporating real-world authentic research experiences into laboratory courses improve students' perceptions and learning gains, ultimately supporting students understanding of abstract principles. In one study, STEM majors enrolled in a Quantitative Analysis Chemistry course participated in research-based lab modules contextualized with real-world applications where students reported their preference for the research-based modules over traditional experiments. Emphasis on real-world applications and more specifically, personal relevance in chemistry labs is crucial for student engagement and learning [4]. In addition to incorporating real-world contexts in laboratories, universities are organizing curricula to support scientific practices as recommended by the NGSS. These practices include skills such as conducting investigations, interpreting data, and constructing arguments based on evidence. Inquiry-based labs are designed to engage students in a range of science practices, but it is often challenging to accurately assess student achievement. To address those challenges, the IDEAA-GC1 assessment was designed to measure students' ability to design investigations and construct arguments. This study found varying proficiency levels across scientific practices and highlighted the relation of science practices and content knowledge [5]. Developing assessments to measure learning gains and science practice proficiencies inform real-time curricular feedback as well as provide instructors targeted information about their students' understanding. Designing real-world and relevant lab experiments allows educators and researchers to further advance the understanding of student proficiency in scientific practices which informs laboratory education.

References:

1. The National Research Council. A Framework for K−12 Science Education: Practices, Crosscutting Concepts, and Core Ideas; *National Academies Press: Washington, DC,* 2012.
2. Seery, M. K., Agustian, H. Y., Christiansen, F. V., Gammelgaard, B., & Malm, R. H. (2024). 10 Guiding principles for learning in the laboratory. *Chemistry Education. Research and Practice*.
3. Bretz, S. L., & Mayo, A. V. M. (2017). Development of the Flame Test Concept Inventory: Measuring Student Thinking about Atomic Emission. Journal of Chemical Education, 95(1), 17-27.
4. Mutambuki, J. M., et al. (2019). Integrating Authentic Research Experiences into the Quantitative Analysis Chemistry Laboratory Course: STEM Majors' Self-Reported Perceptions and Experiences. *Journal of Chemical Education*, *96*(8), 1591–1599.
5. Hosbein, K. N., & Walker, J. P. (2022). Assessment of scientific practice proficiency and content understanding following an Inquiry-Based laboratory course. *Journal of Chemical Education*, *99*(12), 3833–3841.