INTEGRATED STEM: IMPACT OF ENGINEERING DESIGN AND COMPUTER SCIENCE IN STEM LABS

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Abstract

By integrating physics laboratories with engineering design and computer science, students apply physics principles to ill-structured and complex problems, engage in knowledge transfer, and gain interest in STEM. The introductory physics labs at Purdue have been updated to include engineering design and computer science principles that ground physics in authentic problems. Integrated labs have been evaluated using student perception post-surveys, student course performance, interviews, and case-study observations. Preliminary results indicate that integrated physics labs promote transfer, enhanced metacognitive skills, student interest, and motivation.

Integration in STEM

Introductory STEM courses traditionally assign students well-structured problems with single-path solutions that do not prepare students with problem-solving skills needed to solve complex problems within authentic engineering contexts. When presented with complex problems in authentic contexts, engineering students find it difficult to transfer the scientific knowledge learned in their STEM courses to solve integrated and ill-structured problems. The incorporation of engineering design in science classrooms enables students to realize the relevance of science to everyday problems (Hmelo et.al., 2000); can lead to improved interest, motivation, and performance (Guzey et.al., 2017); and can facilitate transfer between science, engineering, and computational thinking (Kaufman-Ortiz et.al., 2022).

Integrated STEM lab Design and Results

Over the course of a semester the physics labs integrated two engineering design challenges, each of which spanned five weeks of lab. The first and last lab of each design challenge was focused on developing and refining a solution for the design challenge and asked students to reflect on the physics principles relevant to their design. The second, third, and fourth labs focused on gathering data, scientific inquiry, making connections to physics concepts taught in lecture, and computational modeling. Student surveys indicate increased interest, engagement, and connection to their major and future career in the labs. Through case studies and surveys, there is evidence that students can transfer between domains, develop computational thinking, and perceive that integrated labs improve learning. However, a small number of students hold epistemological positions that STEM content should not be integrated. These students do not demonstrate the above learning outcomes. Future research will investigate methods for helping students address unavailing epistemological beliefs.

References

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