Preliminary Analysis of Problem Solving in Introductory Environmental Engineering

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Strong computational and algebraic skills are commonly understood to be a prerequisite for success in engineering. In a 2021 review of the literature on mathematics in engineering education, Pepin, Biehler, and Gueudet discussed a need for "bridging" between school mathematics and the mathematics needed in university engineering courses. This study homes in on aspects of problem solving in engineering that may be challenging for students.

Written data were collected, including homework assignments, midterm exams, and final exams, from consenting students in an introductory environmental engineering course on designing small water systems at a mid-sized university in the Midwestern USA. This poster will focus on a preliminary analysis of the midterm exams of 17 students from this course.

A modified version of Carlson and Bloom's (2005) Multidimensional Problem-Solving Framework was used to code the data. This framework consists of four main phases: orienting, planning, executing, and checking. However, the nature of our data prevented us from being able to identify instances of students' planning and checking in their problem solving. We therefore modified this framework and used an open coding process (Strauss, 1987) to identify instances of students *orienting*, *setting up a problem*, and *executing a solution strategy*. Codes were applied at the level of a question-part. This was then used to determine in which phase of the problem-solving framework students most frequently committed their first error in multi-part problems.

Data analysis is ongoing; in this proposal we present preliminary findings from the midterm exams of five students. Among these five students, no student successfully identified all system boundaries when given a flow diagram for a small water system (Question 2). This task requires only engineering knowledge to complete. However, the subsequent three questions required students to use their knowledge of these reaction boundaries to write symbolic mass-balance equations, and three of the five students were able to write correct equations for all three of these questions. This suggests that these three students did not recognize the significance of the reaction boundaries and their relationship to these equations. On Question 1, students were given information and asked to draw and label a flow diagram for a small water system. All five students drew the correct structure, but two mis-identified masses as volumes and a third produced an incorrect number for a variable that was not given. Both students who incorrectly labeled masses missed follow-up calculation questions because of this mislabeling, suggesting an understanding of mathematics that was undercut by a misunderstanding of engineering content.

Though preliminary, these findings suggest that the engineering students in our sample had the mathematical skills necessary to solve problems related to the design of water systems, but their ability to solve these problems successfully was inhibited by gaps in their understanding of engineering content. In the completed poster, we will present results from the midterm exams of all 17 students in our data corpus, and future research will analyze the final exams and homework assignments of all students in this sample. We will identify the problem-solving phase in which students encounter the most difficulty and examine students' trajectory throughout the course to identify transient and persistent obstacles to their successful solving of engineering problems.

References

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