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Evaluating and Enhancing Problem-Solving Skills in a Physiology Course for Biomedical Engineering Students (Work in Progress)

Reva E Johnson MS, Northwestern University

Reva Johnson is a PhD candidate in Biomedical Engineering, and is completing her doctoral research in the Center for Bionic Medicine at the Rehabilitation Institute of Chicago. Her research interests include learning and adaptation during prosthesis control, human-machine interfaces, and STEM education.

Dr. Robert A Linsenmeier, Northwestern University

Robert Linsenmeier is a Professor of Biomedical Engineering, Neurobiology, and Ophthalmology. His interests are in the microenvironment of the mammalian retina and engineering education. His teaching is primarily in physiology for both biology and BME majors He is a fellow if the Biomedical Engineering Society, American Institute of Medical and Biological Engineering, and Association for Research in Vision and Ophthalmology.

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Abstract

Biomedical engineers need to solve problems systematically, but the necessary skills are not often explicitly taught or evaluated. Instead, problem-solving strategies are assessed simultaneously with content knowledge. Students often feel uncomfortable solving problems that require appropriate simplifications, assumptions, and estimations. In this work we combined problem-solving activities, assessments, and evaluations to improve complex problem-solving skills in a junior-level physiology course for biomedical engineering students. Our goal was to encourage students to develop both metacognitive awareness and confidence in solving complex problems. Preliminary results are encouraging, and the implemented teaching methods will be adjusted and further evaluated during the course in 2015.

Introduction

Solving complex problems is a highly valued skill for biomedical engineers in both industry and academia. However, the process of solving complex problems is often not explicitly taught or evaluated in undergraduate courses (Huntzinger et al. 2007). The typical engineering homework assignment includes several well-structured, predictable word problems completed outside of class. These well-structured problems help students practice course concepts, but do not develop the skills needed to solve ill-structured real-world problems (Jonassen, Strobel, and Lee 2006). Without these skills, students feel uncomfortable when faced with problems that give too little or too much information, and have trouble approaching the problem systematically.

In this preliminary work, we combined activities, assessments, and evaluations to encourage students to develop both metacognitive awareness and confidence in solving complex problems. The course was a junior-level physiology course for biomedical engineering students. Each week included three 50-minute lectures and one 75-minute discussion section.

Approach

Problem-Solving Activities

During the first discussion section of the course, we focused on a multi-step word problem unrelated to course content (Figure 1). The unfamiliar problem separated problem-solving skills from content material and allowed students to focus on the problem-solving process. As in real engineering problems, there was both too much and too little information. The successful student would 1) decide how to approach the problem, 2) draw a diagram in order to reduce the cognitive load, 3) label the diagram, 4) decide what information is relevant, 5) determine how to deal with missing information (approximation? find resources?), and finally, 6) generate a numerical solution. After allowing students to work on the problem, and then allowing time for them to abstract the steps they had taken, we discussed successful and unsuccessful strategies.

Next, we devoted several follow-up discussion sections to guided multi-step problems that incorporated course content material—a departure from previous years in which homework was discussed by teaching assistants, but students received insufficient practice in working with the material. The strategy was based loosely on Process-Oriented Guided Inquiry Learning (POGIL)

(Douglas and Chiu 2013). These sessions gave students problem-solving practice in small groups with immediate feedback available from teaching assistants.

A centrifugation step removes H_2O at a rate of 100 lb/hr from a stream of wet sewage sludge (400 lb/hr) that contains 50% H_2O by weight. Sludge is further dried by air to 10% water by weight. Moist air used to dry the sludge enters a heater at 70° F, 50% relative humidity, and with P = 760 mmHg. Moist air that exits the heater is fed to the drier, from which it later exits at 100° F with a dewpoint of 94° F and P=750 mmHg. How much moist air in ft^3/hr is required for the process?

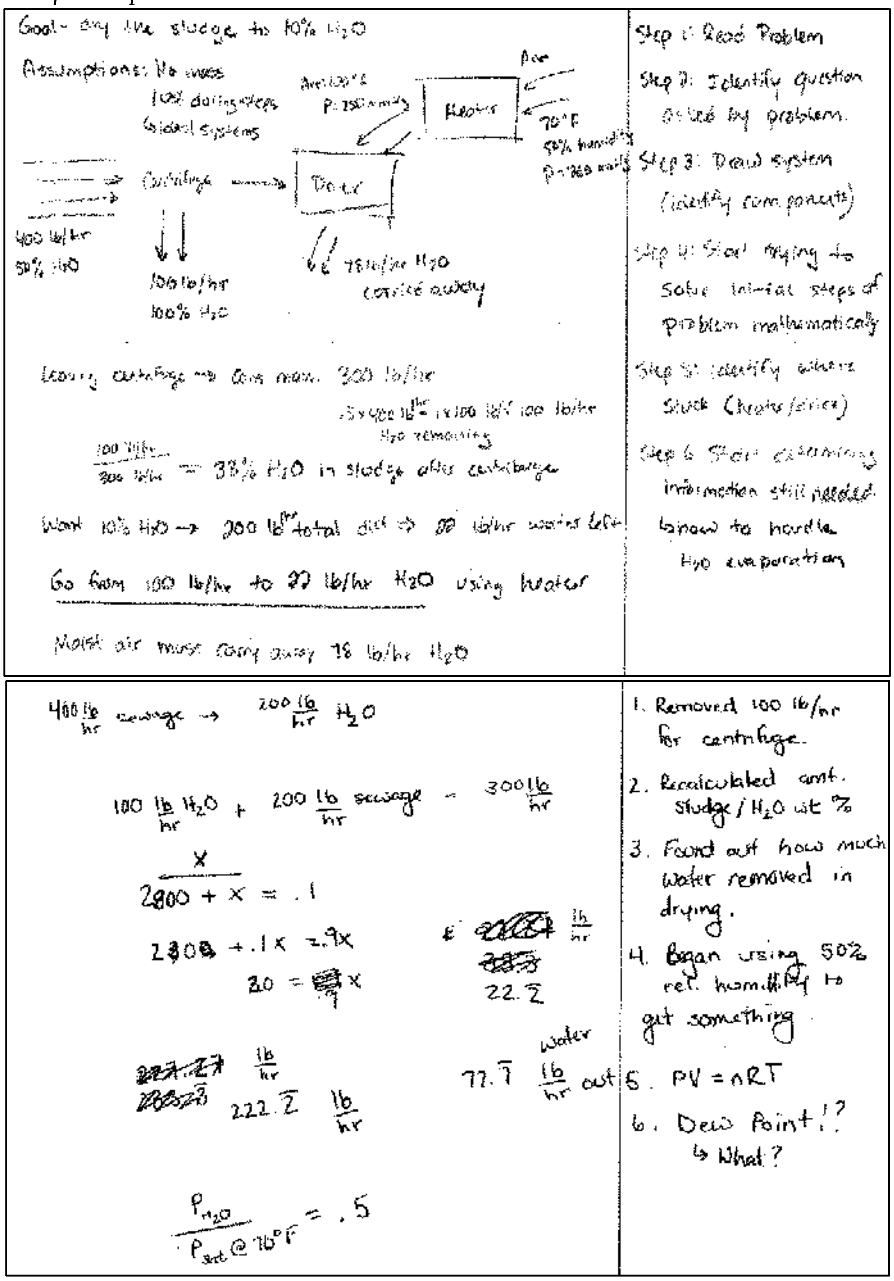

Figure 1. The Sludge Problem, a word problem for discussion. We borrowed this problem from W. Newstetter (Georgia Tech). Two example solution strategies are shown. Successful strategies (top) included drawing diagrams, organizing relevant information, and recognizing appropriate assumptions.

Assessments
For homework assignments, points were awarded separately for appropriate assumptions and estimations. This both enhanced awareness of problem-solving strategies and reinforced knowledge that was needed to make reasonable assumptions.

Evaluations
We surveyed students' attitudes towards problem-solving and their perceived education on problem-solving (Figure 2). We found that over half of students agreed or strongly agreed that the initial discussion of problem-solving was useful, and that they were interested in seeing how other students approached the problem. Almost 30% of students reported that they had never discussed problem-solving strategies in previous courses.

At the end of the course, we evaluated students' perceptions of the problem-solving activities during discussion section (Figure 3). About 67% of the students reported that solving additional problems in discussion section was important or very important to their learning. This approach to problem solving in a physiology lecture course can also improve teaching by the graduate teaching assistants assigned to discussion section by facilitating the organization and planning.

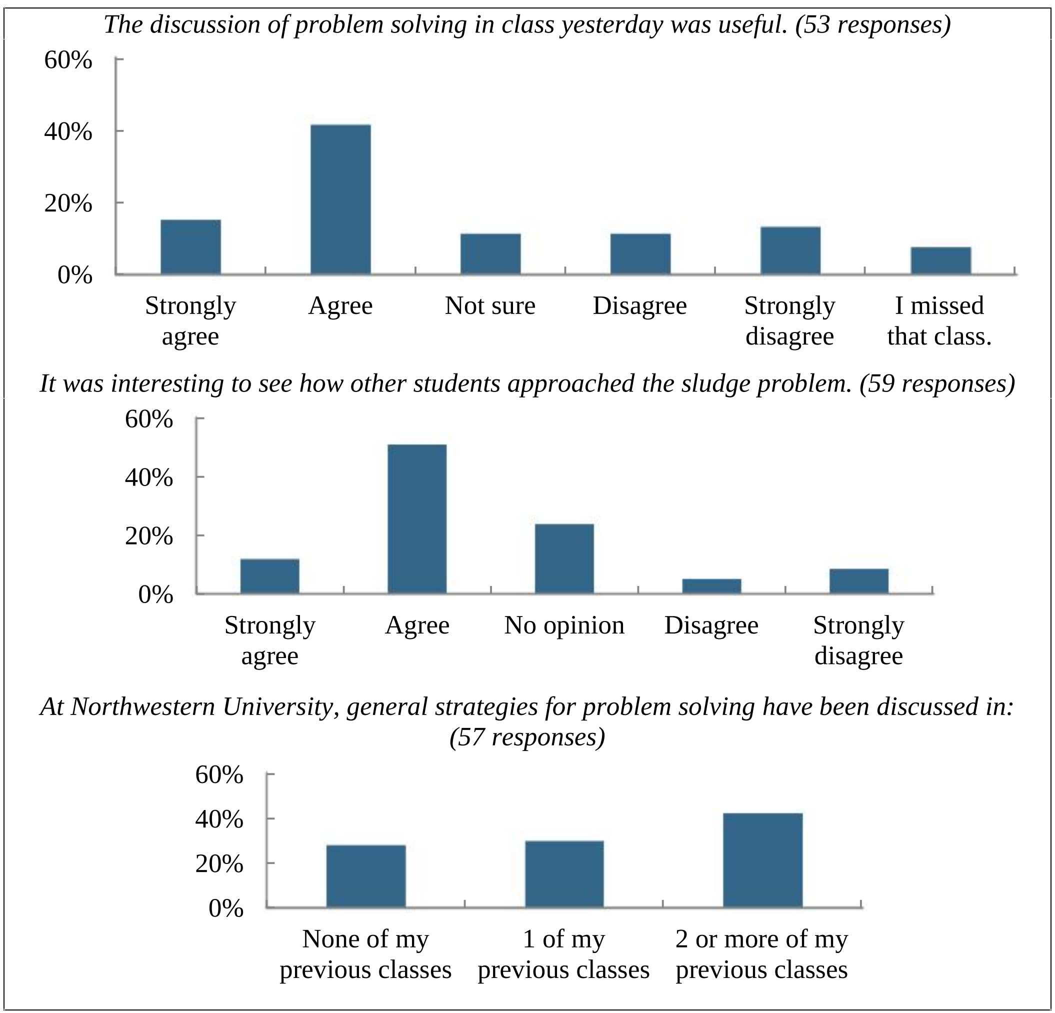

Figure 2. Evaluation after first week of class.

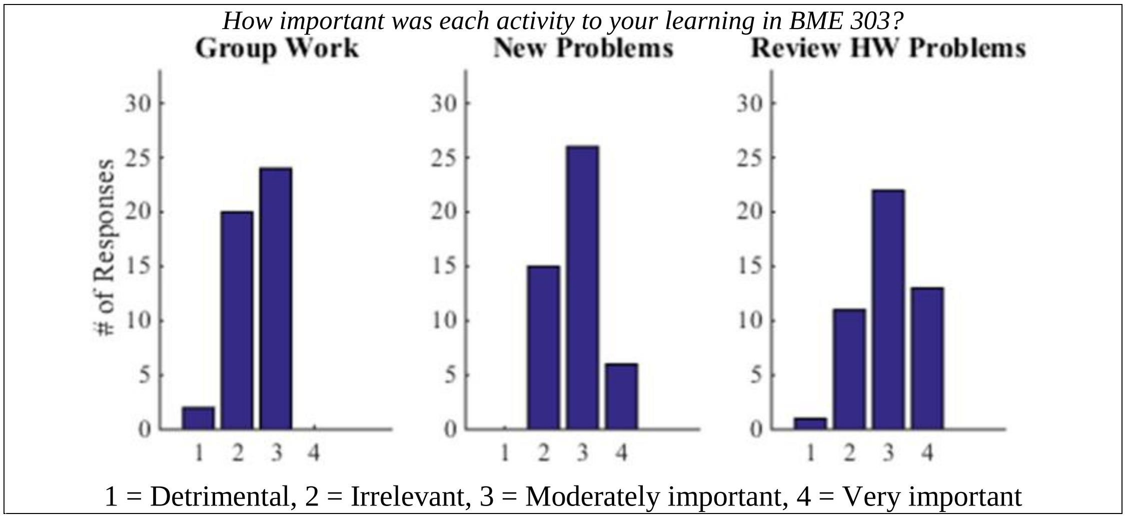

Figure 3. Evaluation of discussion section activities at the end of the course.

Adjustment of Teaching Methods

In next year's course, we will assess students' problem-solving skills before and after the initial discussion section on a problem unrelated to course content. The assessments will include more detailed qualitative analysis of diagrams, estimations, and assumptions, as well as quantitative analysis of answers at each step. We will focus on making group work more useful for students and on using discussion time more effectively. We will also evaluate students' attitudes towards problem-solving and metacognition of problem-solving strategies. These data will be used to guide future initiatives on problem-solving education and strategies.

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