Design for Impact: Reimagining Inquiry-Based Activities for Effectiveness and Ease of Faculty Adoption

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Standard lecture-based educational approaches are of limited effectiveness in repair of students' misconceptions as much as it does at improving students' computational abilities. Educational efforts to improve conceptual learning using approaches such as inquiry-based activities have been effective, but have not been widely adopted by engineering educators. The goal of this work is three-fold: First, we will re-create our inquiry-based activities for heat transfer by specifically modifying them in ways that make them easier for faculty to implement in the classroom; Second, we will measure the effectiveness of these modified activities as they are implemented by our partner institutions; Third, we will provide both the full menu of activities and the effectiveness data to faculty broadly and monitor the adoption "in the wild".
We have completed year one of this project, in which we surveyed faculty on the ways in which they found the original activities challenging to implement. The original activities rely largely on student experiment, and faculty comments discussed how money, space, and time all constrained their ability to assign experiments to small groups of students. Based on this feedback, we have produced four new variations on the inquiry-based activities. These involve: a) replacing the students' experiments with simulations; b) replacing the students' experiments with the students observing the experiment as an in-class demonstration; c) the students' watching the simulation as an in-class demonstration and d) replacing both simulation and experiment with an in-class thought experiment. These variations will be tested in different institutions over the course of the coming academic year.

Introduction

In previous work, we developed inquiry-based activities to address students' common misconceptions in heat transfer. While these activities were highly effective as promoting students' conceptual change (Prince, Vigeant, & Nottis, 2012a; Prince & Vigeant, 2007; Prince, Vigeant, & Nottis, 2009a), they found somewhat limited adoption in the broader engineering faculty. Further, when faculty were adopting the activities, they were modifying them to make them better fit their particular situations. For example, some faculty members were using the experimental part of the activity as an in-class demonstration rather than having small groups of students complete the experiment themselves.

This work seeks to address two questions. First, what changes in the inquiry-based activities would best spur widespread adoption by faculty? Second, what effect would these changes have upon the educational effectiveness of the activities themselves? To address these questions, we have gathered a faculty advisory group from diverse institutions who are willing to use modified versions of our existing activities in their courses. They have also assessed our current activities and given us feedback upon which aspects are most challenging to implement. Ultimately,

once we have assessed the effectiveness of the modified activities, they will be published and adoption "in the wild" will be noted.

Progress

We have surveyed our advisory board for their feedback on the ease (or lack thereof) with which they were able to implement existing activities. The previous activities required 5-20 minutes of time for a small experiment that could be performed by a group of 3-5 students. The equipment required for these was generally simple (pipes, heat lamp, thermocouples, stir-plates) and readily available at most engineering schools. The feedback indicated that even though this was the case, the activities were cost-prohibitive for large classes. Further, most classes on heat transfer did not have a laboratory section and therefore it was particularly challenging to find time for students to complete even short experiments. In addition to class time, set-up time was a challenge as well.

To address these challenges, we have re-developed our activities in the following ways:

- Web-based computer simulation of the activity
- Thought experiment replication of the activity

These specifically remove the expense of laboratory equipment, and the second removes the expense of web-accessible computers/phones.

We are testing these activities through several implementation approaches:

- Faculty-led demonstration
- Student completion
- Student group studio work

These reduce or eliminate the class / laboratory time to complete the experiments. At this point, all versions of the activity packets (the instructions and handouts required to implement the activities) have been completed.

Ongoing Work

In the coming semesters, the modified activities will be tested at six institutions. Data on educational effectiveness of the activities will be gathered from pre- and post- administration of the Heat and Energy Concept Inventory (Prince, Vigeant, & Nottis, 2009b; Prince, Vigeant, & Nottis, 2012b; Prince, Vigeant, & Nottis, 2010), as well as student answers to post-activity reflection questions. Faculty using these activities will be surveyed both for the amount of time they spent on each particular topic as well as about their sense of how much they liked the approach they were testing.

Acknowledgement

Funded through TUES NSF-1225031

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