Engaging reflective thinking during exam-like situations: Slowing students down on short-answer questions increases performance

Joss Ives and Jared Stang

University of British Columbia, 2329 West Mall, Vancouver, BC, Canada, V6T 1Z4

Abstract. In a series of experiments designed to engage students in reflective thinking in exam-like situations, we test the effectiveness of two different interventions in improving student performance on specific short-answer questions. These interventions (1) ask students to explain their answer after answering a short-answer question, or (2) pair questions together for concepts that students frequently confuse for each other. For both interventions we demonstrate that we are able to increase student performance on those specific questions. These results have implications for the design of short-answer physics questions in learning and assessment situations.

1 Overview

This study seeks to answer the question: "Can engaging students in reflective thinking during exam-like situations increase their performance?" In two different sets of crossover-design experiments, run across a variety of first-year introductory Physics courses at the University of British Columbia, we used interventions designed to have students think more carefully about their answers to short-answer questions.

Previous work has shown that automatic cognitive processes can play a role in how students answer questions. Heckler [1] showed that imposing a time-delay for answer entry in carefully constructed multiple-choice questions could improve performance on that question. In that paper, it is hypothesized that students tend to choose their answer based on the plausibly-relevant details that are processed the fastest (e.g., the greatest height when asked about the greatest velocity from a position-time graph). Using a complementary lens, we consider how dual processing theory [2] (System 1: unconscious, intuitive judgements vs System 2: deliberate, conscious mental effort) can provide a possible framework to describe these results. In addition to our intervention designed to have students think more carefully about their answers, we deployed the Cognitive Reflection Test (CRT) [3], which measures the tendency for people to engage in System 2 thinking.

In the first set of experiments, performed across multiple different academic terms ($N_{students}$ > 600 each term), we asked students to explain their answer after answering a short-answer question on an exam. In the first term, we measured a statistically significant improvement in question performance on only one of six questions used, which still resulted in improved performance across all six questions combined, an effect size (Cohen's d) of 0.14 (95% CI = 0.05, 0.23). In later academic terms, we refined our design of the test questions and were able to observe statistically significant improvement in question performance on the majority of the questions deployed for the study.

In the second set of experiments, we used question pairs to ask about concepts that students frequently confuse for each other. In the intervention branch, students were asked both questions in the pair using the same question stem. In the control branch, students were asked only one of the questions in the pair. A net effect size (Cohen's d) of 0.23 (95% Confidence Interval = 0.17, 0.30) was observed in favour of the intervention.

We show that both interventions result in improved student performance. However, in contrast to our hypothesis that engaging students in reflective thinking should benefit students with low CRT scores the most, we do not see differences in how these interventions interact with

those students. Our results also suggest that the interventions may have greater benefit for students that performed well in the course as compared to those that performed poorly.

References

[1] Heckler, A. F. (2011). The Role of Automatic, Bottom-Up Processes: In the Ubiquitous Patterns of Incorrect Answers to Science Questions. In *Psychology of Learning and Motivation*(Vol. 55, pp. 227-267). Academic Press.

[2] Kahneman, D. (2011). *Thinking, fast and slow*. Macmillan.

[3] Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic perspectives*, *19*(4), 25-42.