Research-Based Implementation of Peer Instruction: A Literature Review

Trisha Vickrey, Kaitlyn Rosploch, Reihaneh Rahmanian, Matthew Pilarz, and Marilyne Stains*

Submitted November 6, 2014. Revised December 7, 2014. Accepted December 10, 2014.

Abstract

Current instructional reforms in undergraduate science, technology, engineering, and mathematics (STEM) courses have focused on enhancing adoption of evidence-based instructional practices among STEM faculty members. These practices have been empirically demonstrated to enhance student learning and attitudes.

However, research indicates that instructors often adapt rather than adopt practices, unknowingly compromising their effectiveness. Thus, there is a need to raise awareness of the research-based implementation of these practices, develop fidelity of implementation protocols to understand adaptations being made, and ultimately characterize the true impact of reform efforts based on these practices.

Peer instruction (PI) is an example of an evidence-based instructional practice that consists of asking students conceptual questions during class time and collecting their answers via clickers or response cards. Extensive research has been conducted by physics and biology education researchers to evaluate the effectiveness of this practice and to better understand the intricacies of its implementation. PI has also been investigated in other disciplines, such as chemistry and computer science. This article reviews and summarizes these various bodies of research and provides instructors and researchers with a research-based model for the effective implementation of PI. Limitations of current studies and recommendations for future empirical inquiries are also provided.

INTRODUCTION AND BACKGROUND

These research-based pedagogies significantly increase both student learning and attitudes toward science (NRC, 2011, 2012). **Peer instruction** (*PI*), which was first introduced by Eric Mazur in 1991 (Mazur, 1997), is an example of a research-based pedagogy.

In *PI*, traditional lecture is intermixed with conceptual questions targeting student misconceptions.

1.) Following a mini-lecture, students are asked to answer a conceptual question individually and vote using either a flash card or a personal response system commonly called a “clicker.”
2.) If a majority of students respond incorrectly, the instructor then asks students to convince their neighbors that they have the right answer.

3.) Following peer discussion, students are asked to vote again.
4.) Finally, the instructor explains the correct and incorrect answers (Mazur, 1997; Crouch and Mazur, 2001).

It is important to note that, although *PI* is commonly associated with clickers and there have been helpful reviews on best practices for clicker use (Caldwell, 2007; MacArthur *et al.*, 2011), this article is focused on *PI*, a specific, evidence-based pedagogy that can be effectively implemented with or without clickers.

Discipline-based education researchers have responded to calls (President's Council of Advisors on Science and Technology [PCAST], 2010, 2012) **for instructional reforms** at the postsecondary level by **developing and testing new instructional pedagogies grounded in research on the science of learning** (Handelsman *et al.*, 2004; National Research Council [NRC], 2011, 2012).

Are There Measurable Learning Gains with the Use of *PI*?

The **impact of *PI*** on student learning has been most commonly measured in physics through the calculation of *normalized learning gains*.

Normalized learning gains were first introduced by Hake (1998) in a widely cited study demonstrating the positive impact of **active-learning instruction** in comparison with traditional lecture. *Normalized learning gains* are calculated when a conceptual test, typically a concept inventory (Richardson, 2005), is implemented both at the beginning and end of a semester/unit/chapter. The actual gain in a student's score is divided by the maximal possible gain, ((posttest – pretest)/(100 – pretest) × 100), which allows a valid comparison of gains between students with different pretest scores.

In a *longitudinal study*, Crouch and Mazur (2001) explored **the impact of PI** compared with *traditional lecture* on student learning in algebra- and calculus-based introductory physics courses at Harvard University. At the beginning and end of a semester, they administered a conceptual test, the Force Concept Inventory (FCI; Hestenes *et al.*, 1992), to measure changes in normalized learning gains as they implemented either the PI pedagogy alone or a combination of PI and just-in-time teaching (Novak, 1999; Simkins and Maler, 2009) pedagogies. During the 10 yr of data collection, Crouch and Mazur (2001) observed normalized learning gains that were regularly twice as large as those observed with traditional lecture, even when implementing PI alone.