Educational Advances in Artificial Intelligence

■ *The Educational Advances in Artificial Intelligence column discusses and shares innovative educational approaches that teach or leverage AI and its many subfields at all levels of education (K-12, undergraduate, and graduate levels).*

Cynthia Bailey Lee

Active Learning in Lecture with Peer Instruction

Have you ever been surprised by poor class performance on a midterm question, and wondered why you were met with silence each time you asked "Any questions?" during the lecture on that topic? Do your students sometimes feel like they understood everything that was said in lecture, only to go home, start the homework, and immediately get stuck? Do you find that you only really learn something when you have to explain it to others?

Peer instruction is an active learning pedagogy that addresses these challenges and opportunities. Peer instruction is easily integrated into existing course designs and meeting schedules, because the change is largely limited to modifying the manner in which "lectures" are delivered. In peer instruction classrooms, students are presented with a series of multiple-choice questions. Students first respond to a question individually (often using a "clicker" device or phone app), then discuss the question in groups of three for 3–4 minutes, then respond again. The instructor can then show students instantly tallied results histograms, ask groups to report on their discussions, and provide additional clarification or expansion of the topic in response to the class' performance on the question. These question-response-discuss-response sequences may be inserted every 5–10 minutes to punctuate a traditional lecture, or a class may consist almost entirely of peer instruction questions.

Key factors for success with peer instruction include designing discussion-provoking questions, ensuring adequate preclass preparation by administering reading quizzes, and grading participation in questions but — crucially — not correctness of the response. Of course the heart of any question-driven approach to learning is the quality of the questions. Peer instruction questions may be used to verify student understanding of what was just said in lecture, or to highlight difficult corner cases in the reading material. My favorite questions are those that anticipate the next topic of lecture. A well-crafted question of this type can light a fire of motivation within students to hear what the instructor will teach next, because they have been confronted by a scenario that illustrates the need for it and have spent several minutes grappling with the issue.

Originally developed in physics classes by Eric Mazur, a Harvard physics professor, peer instruction's strong, multidecade track record of success there (Crouch and Mazur 2013) has launched it into other disciplines and, increasingly, into computer science classrooms. Peer instruction has been successful in a variety of computer science courses including introductory programming (in a variety of languages), Data Structures, Discrete Math, Introduction to Artificial Intelligence, Theory of Computation, Operating Systems, Programming Languages, and Architecture.[1] Potential adopters of these materials should be encouraged by reports that adopters of materials experience success matching that of the instructor who created the materials (Lee, Garcia, and Porter 2013).

Research on use of peer instruction in computer science has created a compelling case in several dimensions. Experiments using a follow-up question verified that students learn from discussing with peers and are not simply "copying" a perceived strong groupmate (Porter, Lee, Simon, and Zingaro 2011). In a study of more than 20 peer instruction classes taught by 7 different faculty, and compared to over 100 standard instruction versions of the same courses, use of peer instruction halved fail rates (Porter, Lee, and Simon 2013). Use of peer instruction in the introductory course, together with pair programming and media computation, retained 18 to 30 percent more majors in subsequent years (Porter and Simon 2013). Peer instruction is effective in engaging groups of hundreds of students (Lee, Garcia, and Porter 2013), and guiding groups of 10 or fewer in liberal arts college settings (Porter, Garcia, Glick, Matusiewicz, and Taylor 2013). Perhaps most importantly, students enjoy peer instruction and believe it to be beneficial. In standardized student surveys of classes using peer instruction, it is common for about 90 percent of students to say they recommend that other instructors adopt use of clickers and peer discussion (Lee, Garcia, and Porter 2013).

Note

1. Complete materials for many of these are available to faculty without cost at peerinstruction4cs.org.

References

Crouch, C. H., and Mazur, E. 2001. Peer instruction: Ten Years of Experience and Results. *American Journal of Physics* 69(970). dx.doi.org/10.1119/1.1374249.

Lee, C. B; Garcia, S.; and Porter, L. 2013. Can Peer Instruction Be Effective in Upper-Division Computer Science Courses? *ACM Transactions on Computing Education* 13(3): 12. dx.doi.org/10.1145/2499947.2499949

Porter, L., and Simon, B. Retaining 18–30% More Majors with a Trio of Instructional Best Practices in CS1. Paper presented at the 44th ACM Technical Symposium on Computer Science Education (SIGCSE '13), Denver, CO, 6–9 March.

Porter, L.; Garcia, S.; Glick, J.; Matusiewicz, A.; and Taylor, C. 2013. Peer Instruction in Computer Science at Small Liberal Arts Colleges. In *Proceedings of the Innovation and Technology in Computer Science Education Conference* (ITiCSE 2013). New York: Association for Computing Machinery.

Porter, L.; Lee, C. B.; and Simon, B. 2013. Halving Fail Rates Using Peer Instruction: A Study of Four Computer Science Courses. In *Proceeding of the 44th ACM Technical Symposium on Computer Science Education* (SIGCSE '13). dx.doi.org/10.1145/2445196.2445250.

Porter, L.; Lee, C. B.; Simon, B.; and Zingaro, D. 2011. Peer Instruction: Do Students Really Learn from Peer Discussion in Computing? In *Proceedings of the 7th International Workshop on Computing Education Research.* New York: Association for Computing Machinery, 2011. dx.doi.org/10.1145/2016911.2016923

Cynthia Bailey Lee is a lecturer in the Computer Science Department at Stanford University. She has a Ph.D. in computer science (University of California, San Diego) in the area of high-performance computing. Her currently research is in computer science education, with an emphasis on the use of peer instruction pedagogy in lecture.