Peer Instruction: Results from a Range of Classrooms

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Peer Instruction (PI) is a widely used pedagogy in which lectures are interspersed with short conceptual questions (ConcepTests) designed to reveal common misunderstandings and to actively engage students in lecture courses.[1–3] Correspondence and informal discussions indicate a user base of hundreds of instructors around the world who teach with PI, yet to date there has been no systematic study of PI implementation and effectiveness in the variety of settings in which it is used.

As a first step toward such a systematic study, we polled current and former PI users via a web-based survey to learn about their implementation of and experience with PI.[4] The survey collected data about how instructors learned about PI, courses in which PI was used, implementation details, course assessment, effectiveness, instructor evaluation, and the community of PI users.

In addition to posting the survey on the Project Galileo website,[4] we directly invited more than 2700 instructors by e-mail to complete the survey. More than 700 instructors completed the survey, 384 of whom we identify as using Peer Instruction.[1,2] The language of the survey was purposely broad in order to include instructors who had used a strategy similar to PI without being aware of our work; we therefore received responses from many instructors using other collaborative learning strategies. Respondents represent a broad array of institution types across the United States and around the world (Fig. 1). Most use PI to teach physics, although chemistry, life sciences, engineering, and astronomy courses are also represented.[5]

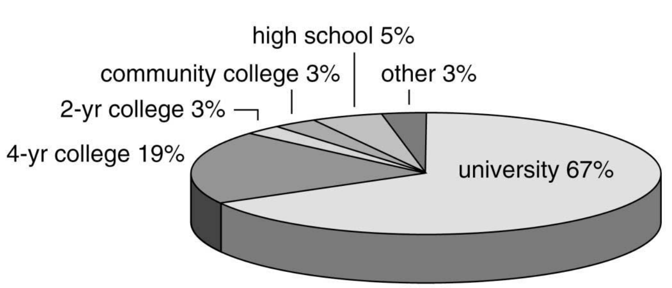

Fig. 1. Demographic breakdown of survey respondents using PI based upon institution type (*n* = 384).

Our survey probed two different measures of the success of PI in a course: data on student mastery of material, and instructors' evaluation of the success of PI use. More than 108 PI users responding to the survey reported collecting quantitative data on the effectiveness of PI, of whom 81% administered the Force Concept Inventory (FCI) in their courses.[1,6] Instructors at 11 colleges and universities provided us with matched sets of pre- and post-test FCI data, to assess the gain for individual students. From these data we determined the average normalized gain for each course[7]

$$g = \frac{S_f - S_i}{1 - S_i},$$

where S_i, S_f = initial, final score of students on the FCI in 30 courses taught with PI; the average for a given course is denoted g. These PI courses have a class average gain of 0.39 ± 0.09

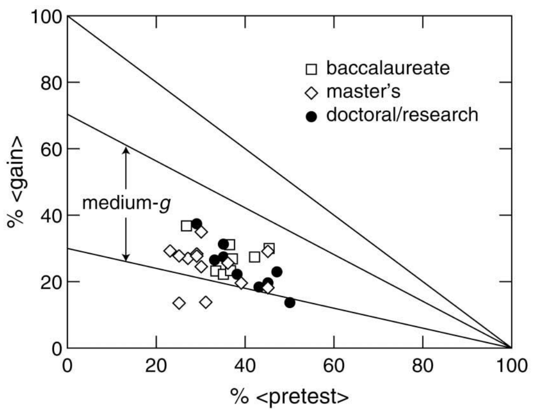

Fig. 2. Class-averaged normalized gain of introductory physics students in college courses taught using Peer Instruction. Symbols denote institution type according to the 2000 Carnegie Classification of Institutes of Higher Education. Data from Harvard courses is not included and has been reported separately.[1,2]

(Fig. 2). In his survey of FCI data, Hake[7] defines a "medium-*g*" range from $g = 0.3$ to 0.7 and finds that 85% of the interactive engagement courses included in his survey and none of the traditionally taught courses show gains in this range. We find that 27 of 30 (90%) PI courses in our survey fall in the medium-*g* range, with only three below $g = 0.3$ (Fig. 2). Data from Harvard courses are not included, as they have been reported separately elsewhere,[1,2] and the aim of this study is to investigate implementations of PI by instructors other than the developers.

To determine whether instructors consider the use of PI in their classes to be successful, we asked them if they were likely to use PI again in the future. Of the 384 identified PI users responding to the survey, 303 definitely planned to use PI again and 29 probably would. Only seven respondents expressed no plans to use PI again. Thus, the vast majority of instructors completing our survey consider their experiences with PI to be successful. These responses may not accurately represent the relative incidence of positive and negative experiences, as there may be a selection bias in who chose to complete the survey;[8] however, the responses do indicate that PI has been successfully implemented in a large number of classrooms.

Peer Instruction Challenges and Solutions

Many successful users of Peer Instruction indicate that they had to overcome a number of challenges, which we describe here along with solutions suggested by the respondents. Thirteen percent of instructors cite the time and energy required to develop ConcepTests as an impediment to using PI. Developing good ConcepTests certainly takes a great deal of effort; to minimize duplication of this effort, and to make PI easier to implement, we and other developers of ConcepTests have made online databases of ConcepTests for introductory physics, chemistry, and astronomy freely available.[9] Consequently, for courses in these areas, ConcepTest development need not be a major obstacle.

Ten percent of respondents report that their colleagues are skeptical of the benefit of student discussions that take away lecture time. A third of these instructors report addressing this skepticism by collecting data on student learning gains. One particularly effective approach is to compare achievement of students taught with and without PI on identical exams.[10] Others suggest inviting skeptical colleagues to sit in on a class, sharing positive student feedback with them, or even giving the assessment tests to other faculty.

About 9% of respondents report that the quantity of material to cover in a semester often makes it difficult to devote class time to ConcepTests. One-tenth of these instructors reduce the amount of material covered by the course, but the majority do not have the freedom to do so. One option for those bound by a lengthy syllabus is to require students to learn some of the material on their own, especially by assigning reading of the text *before* class. Instructors report success with a number of strategies for providing the incentive for students to read ahead of time, including Just-in-Time Teaching.[11]

Another challenge is students' resistance to the method (7% of respondents). Because most students are unaccustomed to active participation in science classes, some feel uncomfortable participating in discussions, or initially consider the discussions a waste of time. Thus, respondents report that it is essential to thoroughly explain the use of PI to their students. Persistence in using Peer Instruction in the face of initial student resistance is important; 15 (4%) users report that, while their students were initially skeptical of PI, the students warmed up to it as they found the method helped them learn the material. Regularly presenting class-averaged data on student performance also shows students that the method is helping them and thus may also motivate students.

A related challenge is the difficulty in fully engaging students in class discussions (7% of respondents). In the words of one instructor, "some students were too cool, too alienated, or perhaps too lost to participate." Nearly half of those citing this challenge say it is important for the instructor to circulate through the classroom during the group discussion of the ConcepTest, helping to guide and encourage students in discussion. Other students may be motivated by receiving credit for participation and by the presence of ConcepTest-like conceptual questions on exams.[12]

Comments

In summary, the PI survey results indicate that most of the assessed PI courses produce learning gains commensurate with interactive engagement pedagogies, and more than 300 instructors (greater than 80%) consider their implementation of Peer Instruction to be successful. Over 90% of those using the method plan to continue or expand their use of PI.

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4. Adam P. Fagen, Tun-Kai Yang, Catherine H. Crouch, and Eric Mazur, "Factors That Make Peer Instruction Work: A 700-User Survey," presented at AAPT Winter Meeting, Kissimmee, FL, 2000. The "Peer Instruction Implementation Survey" is available on the web at http://galileo.harvard.edu/PIsurvey.html.
5. Eighty-two percent of instructors responding to the survey teach physics, 4% chemistry, 4% life sciences, 3% engineering, 2% astronomy, 2% mathematics, and 3% other.
6. Ibrahim Abou Halloun and David Hestenes, "The initial knowledge state of college physics students," *Am. J. Phys*. **53**, 1043–1055 (Nov. 1985).

7. Richard R. Hake, "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *Am. J. Phys.* **66**, 64–74 (Jan. 1998).

8. While the survey was designed to encourage instructors to provide feedback regardless of the effectiveness of their experience, we have no independent accounting of PI users to know whether satisfied users responded at the same rate as dissatisfied users. We encouraged instructors to report their experiences, positive and negative, and especially encouraged those with disappointing experiences to respond.

9. Project Galileo, http://galileo.harvard.edu/, contains an extensive database of ConcepTests in introductory physics and links to sites with chemistry ConcepTests (http://www.chem.wisc.edu/~concept/ and http://www.unet.brandeis.edu/~herzfeld/conceptests.html) and astronomy ConcepTests (http://hea-www.harvard.edu/~pgreen/educ/ConcepTests.html).

10. Such comparative data are reported in Linda R. Jones, Andrew G. Miller, and J. Fred Watts, "Conceptual teaching and quantitative problem solving: Friends or foes?" *J. Coop. Collabor. Coll. Teach.*, in press.

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