Large-enrollment Classes

Original research report:

DesLauriers, L., Schelew, E., and Wieman, C. 2012. Improved learning in a large-enrollment physics class. Science. 332: 862-864

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Abstract

This study compared the amount of study learning from two different teaching approaches in large-enrollment physics classes. They measured the amount of learning of a specific set of topics and objectives when taught as lectures by a highly rated instructor and by a trained but inexperienced instructor who used another approach. Learning in two large classes were compared (N = 267 and N = 271). The non-lecture teaching resulted in increased student attendance, more engagement, and more than twice the learning than in the lecture section.

Introduction

Even though research (eight papers cited) suggests that lecturing is less effective than certain other approaches to teaching, lecturing is still the main approach to teaching college courses. Prior studies (cited) of physics instruction practices indicated that evaluation of the teaching was typically comparing student learning when an instructor changes the approach from year to year.

The authors cited their previous work on the effectiveness of traditional lecturing or an interactive teaching approach in two full sessions of an advanced quantum mechanics class. Though the interactive approach produced better initial learning, the learning level 6 to 18 months later was about the same with both approaches.

In this present study, the authors wished to compare teaching methods in large introductory physics classes (second semester physics, calculus based). The control group was a class taught via lecture by a highly motivated faculty member with high student evaluations and many years of experience. The experimental group was taught by a physics post-doctoral fellow and a graduate student, whose only teaching experience had been as TAs (teaching assistants); they used the different approach based on educational research. These instructors were new to these students and had not taught this course before. The same learning content was presented to both groups over one week.

Methods

The experimental group was taught by a method known as "deliberate practice" (reference cited). This approach emphasized constructivism (students do things right after learning) and formative assessment (ongoing, real-time testing). The deliberate practice occurred in class, with a series of challenging questions and tasks that required students to practice physics-like reasoning and problem-solving, with frequent feedback from the instructor and fellow students (reference cited).

During the first 11 weeks, all students were taught by traditional lecture (3 hours per week) in a large theatre-style lecture hall with fixed chairs behind benches grouping up to five students. Students had weekly homework assignments, laboratory periods, and tutorial/recitation sections where they solved graded problems. All course content was the same, but there was a different lecturer for each section. Instructors had above-average student ratings in the past and many years of experience. They used PowerPoint slides to present content and also gave demonstrations, and students took notes. At the end of a given set of instruction, students were tested with "clickers," an automated personal response system (responses average 1.5 per class period, with a range of 0 to 5). Credit was given for submitting clicker responses.

At week 12 in the semester, two groups (267 and 271 students) were formed into the two test groups of this study.

Before the experiment began, various data were collected from the first 11 weeks. At this time, all students had completed two mid-term examinations. Data revealed that test scores, attendance, grades, and engagement scores did not differ statistically between the control and experimental groups. This was unexpected because one instructor was perceived as more animated and intense.

During the three lecture periods of week twelve both control and experimental sections were taught the same electromagnetic-wave topics and learning objectives. The control group was taught via lecture by the same instructor they had during the first 11 weeks. The experimental group was taught via the deliberate practice method by two different instructors who were new to the class. Instructors of both sections knew that this 12^{th} week of instruction constituted a competition to determine instructor effectiveness.

At the end of week 12 all instructors designed and agreed on a multiple-choice test that measured learning of the instruction, irrespective of how the topics were taught.

In the experimental class, no lecturing occurred, other than instructor-provided feedback. Features of the "deliberate practice" teaching, and the time allocation, included: 1) preclass reading assignments, 2) pre-class reading quizzes, 3) in-class clicker Q&A, followed by student discussion, 4) small-group active learning tasks, and 5) targeted instructor feedback. At the beginning of the first 50-min class, explanation of the rationale for this kind of teaching was given to the students in the experimental section.

A typical protocol in an experimental section class period consisted of an initial clicker Q&A session of 2 minutes, followed by an instructor feedback lasting 4 min. This was followed by a similar second period of Q&A and instructor feedback and a third such session of 3 minutes Q&A and 5 minutes of

feedback. Students then re-voted by clicker. This was followed by another Q&A session of 3 minutes and 6 minutes of feedback. A 6-minute group activity was followed by an instructor-delivered 6-minute demonstration, followed in turn by 4 more minutes of group activity and 3 minutes of feedback.

The clicker questioning epochs consisted in dividing the class in two at the beginning of class. After a clicker question was posed, students were divided into small groups of 2 or more to discuss possible answers and then voted by clicker. The instructor then presented the voting results and discussed them.

Small-group learning activities required written answers to problems or questions. Students developed ideas as a group, but answered questions individually. Meanwhile, the instructor of the control group observed student responses and discussion of questions, and used most of them not for feedback to his section but as summative evaluation.

Two days prior to testing over the material presented in week 12, all students were reminded of the upcoming test and given on-line access to all material (readings, clicker questions, answers, and group tasks and answers). Both control and experimental groups were told that the test grade would not count on their final grade but that the tests would be useful practice for the final exam.

On the test of instruction given to both groups during week 12, both groups had received instruction on the same material, except the experimental group had not received any instruction on one of the 12 test questions.

Results

During the week of the experiment, engagement and attendance remained unchanged from levels in the first 11 weeks in the control group (45 $\pm$ 5% for engagement and 53 $\pm$ 3% for attendance). Marked improvements occurred in the experimental group: engagement increased to 85 $\pm$ 5%, while attendance increased to 75 $\pm$ 5%.

Few students finished the 12-question test over the week 12 material in less than 15 minutes. The average time taken was about 20 minutes.

Test results are shown in Fig. 1. In the control group, showed up to take the test, whereas 211 students in the experimental group showed up.

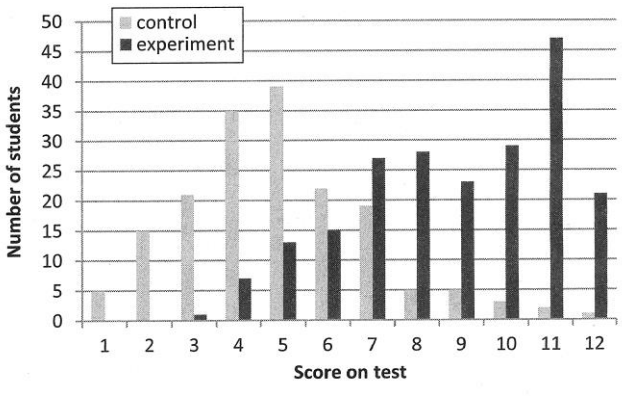

Fig. 1. Histogram of test scores for the two sections for each of the 12 questions on the test given on week 12 instruction.

Test results indicate that students in the experimental group scored on average at a 74 $\pm$ 1% correct level, whereas control students performed at a level of 41 $\pm$ 1% correct level. Random guessing would have produced an average score of 23%.

Discussion

The authors speculated that the reason for increased attendance in the experimental group was that these students found classes more interesting.

The authors noted that the test results (Fig. 1) revealed a "ceiling effect" in the experimental group. They also note there was little overlap in results from the two groups, indicating that the learning difference in the two groups applied to the whole student population in each group.

They attribute the better success in this present study than in their previous work to a more effective teaching protocol, with special credit given to the clicker questions and group tasks. Another factor could have been the former study had used an end-of-term exam that reflected all of the learning over the semester, whereas this test was focused on just the one week were the different teaching method of deliberate practice was used.

Authors also point out that this was a low-stakes test that measured what was learned in class itself in the absence of subsequent study.

Authors also discussed the possibility that students might object to this kind of teaching because it is different from what they have normally experienced. However, a survey of students in the experimental group at the end of the intervention week revealed that the approach was well-received. Ninety percent agreed with the statement that they "enjoyed the interactive teaching" and 77% agreed they would have "learned more if the whole course had been taught in this interactive style."

The conclusion was that deliberate practice teaching produces better results, both in terms of student participation and learning, than occurs with traditional lecturing, even when provided by a stellar professor. The authors see no reason why these findings cannot be generalized to other college courses.
