Assessment of a Flipped Physics Course

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Dr. Nero received a dB-SERC Course Transformation Award to flip a large enrollment introductory physics course for physics majors and engineers. He developed the materials for the course (lecture videos, assessments, etc.) during the summer of 2014 and implemented it in the fall of 2014. He taught two sections of this course, one in which he used the flipped approach and the other in which he used the traditional approach. He assessed the effectiveness of the flipped course by comparing student learning in the flipped course with the traditional one, for which he used various measures.

Brief background on flipped course (for more detailed information see the lunch discussion on October 20, 2014 on implementation of flipped/just-in-time teaching courses on our journal club, pizza lunch meetings page).

- ~200 students in the class
- Class is broken up in two groups, with each group of students attending a class for two hours (instead of four hours). Instructor still has to teach four hours a week, two hours with each group.
- Before class, students watch video lectures, read assigned material from the book, and take a short (10 question) conceptual quiz which is due at midnight before class. The conceptual quiz also has an open-ended question regarding what students found difficult to understand in the reading/video lecture.
- The video lectures are recorded by David
    - A chemistry professor mentioned that some time ago, one of his colleagues flipped his course and used online lectures given by someone else. He ended up getting horrible teaching evaluations that semester, much lower than usual (partly because it was perceived that he was 'outsourcing' his teaching load), and as a result decided to never do it again.
- During class, David reviews material based on the results of the quiz (focuses on concepts more challenging for students), uses demonstrations and clicker questions, has students engage in problem solving, and once a week has students work in groups to solve a challenging concept-rich problem

Results

Exams:

- Students in flipped class are performing statistically significantly better on all exams (three midterms and a final), and on the most difficult midterm (related to rotational motion), the discrepancy was largest.

Conceptual assessments

- To ensure students take these assessments seriously, David gives extra credit for taking them and tells students that if they do take them, they should be sincere
    - He also went over the completed surveys and looked for various obvious signs of guessing (e.g., student picking all C's or ABCDE ABCDE after some point etc.) and removed those from the analysis.
- Force Concept Inventory (FCI): students in the flipped class had higher pre-test scores (may be partly due to the fact that the traditional class was in the evening, and historically, students in evening courses show decreased performance).
- David used an established approach in educational research to take into account the pretest scores by comparing ***average normalized gain*** which is defined to be $\langle g \rangle = \frac{\%_{post} - \%_{pre}}{100\% - \%_{pre}}$
    - The normalized gain is a measure of how much students learned (as measured by a conceptual assessment) as a percentage of the maximum that they could have learned.
- For FCI, students in the flipped class got normalized gains 5% higher. While this difference is not statistically significant, it is in the right direction (flipped>traditional)
- Similar results are seen when students are binned by pretest scores, especially for students in the middle (flipped>traditional)
- For a survey on rotational motion (one of the most challenging topics taught in the course), the Rotational and Rolling Motion Conceptual Survey (RRMCS) students in the flipped class received statistically significant higher normalized learning gains, and on the average, they learned 10% more (with respect to what they could have learned) compared to the traditionally taught students.
- Similar results to the FCI are obtained when binning students by pre-test scores.
- On another survey of thermodynamics, STPFASL, there doesn't seem to be much difference, but this is a very challenging survey (even for graduate students) and thermodynamics is taught in the last week of the course.

A note about these surveys: development of the items on these surveys is a painstaking process which includes performing statistical analyses to ensure that the items discriminate between students who know and students who don't know the concepts involved (reliability – point biserial coefficients, KR-20 etc.) and that the surveys are measuring what they are supposed to (validity – student and expert interviews). While some students may be guessing on the pre-test, they are very few, because these surveys have been written using everyday language and are geared to elicit student misconceptions (students are answering using their common sense and neglect to use physics principles and concepts).

Attitudinal survey

- David also gave the CLASS (Colorado Learning Attitudes about Science Survey) which is a survey of student attitudes about science as they pertain to physics (things like how connected physics is to real life, whether learning physics entails making sense of concepts for yourself or memorization etc.)
- He found no differences on the survey overall between the flipped and traditional classes, except when looking at a particular sub-category of the survey, problem solving confidence:

students in the flipped course started higher but ended at the same level as students in the traditional course.

- One possible explanation is the difference between the courses: students in the flipped section had to solve problems on their own before seeing the instructor present a solution, whereas students in the traditional course just saw the instructor solving example problems. Seeing someone else solve a problem and doing it yourself are very different things. Students in the traditional course may see the instructor solve problems and think they can do it themselves (overconfidence) whereas students in the flipped course, since they have to solve problems on their own in class before being show solutions, may realize how difficult the problem solving process really is (and be more realistic in their self-assessments).
- It is worthwhile pointing out that students in the flipped course outperformed students in the traditional course on the final exam, and therefore had better problem solving ability despite similar self-assessments of problems solving ability.

Teaching evaluations:

- Students in the flipped class overwhelmingly thought that the flipped format worked for them, and also would be interested in taking a future physics course in a flipped format as well.
- David also carried out focus group discussions with a subset of the students and found that about 1/3 of them had taken a flipped class before and had either negative or neutral experiences. It is therefore encouraging that they had positive attitudes about David's flipped course.
- Students in the two courses seemed to spend about the same amount of time on the course (including in-class and out-of-class time)
- Students in the flipped course spent less time reading the textbook than students in the traditional course, partly because they reported liking the lecture videos a lot more.

Also interesting is that more than 50% of students reported using Khan Academy as an external resource. This suggests that they should be open to a flipped format since the videos on Khan Academy are very similar to what is generally recommended for online lecture videos (relatively short, focused around one concept or principle).

Overall, David is encouraged by these results and has decided to teach a flipped introductory course again for which, based on the feedback, he is planning to make incremental improvements.

Improvements

- In the previous semester, as time passed, he noticed that he had less class time than he wanted to use for group work on concept-rich problems. As a consequence, later in the semester, he used fewer and fewer of them. Therefore, this semester, he decided to move these problems to the recitation.

- He decided to increase the difficulty of the example problems
- The platform for videos was changed to Classroom Salon (free) because blackboard was not a very good one
    - Classroom salon allows students to make marks at various points in the video post questions and answers
    - So far in the semester (3 weeks) there are over 1000 comments (questions/answers/comments) posted on the online videos.
    - David gives students some credit (very little) for posting questions.