Experiences and outcomes in flipped classroom teaching of a large undergraduate physics-engineering class

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Phys 222 (Core curriculum): Modern Physics covers Relativity, Models of the Atom, an Introduction to Quantum Mechanics, Atomic Physics, and Nuclear Physics. Conceptual student learning outcomes: (1) Understanding of the physical laws of the topics described above. (2) Learning about the historic context of the physical developments and their implications for science and technology today. (3) Learning to think critically/scientifically and developing the skills needed to attack complex problems. Textbook is Modern Physics for Scientists and Engineers (Fourth Edition) by Thornton and Rex.

Grading: Grading: 3 exams 60%; Final (comprehensive) 30%; Homework (WebAssign) 10%. If a grade on the Final Exam is higher than the lowest grade on one of the three exams during the semester, that lowest grade will be replaced by its average with the Final in computing the course grade.

Goals: Mastering advanced physics skills, understanding of terms, notions, and facts as well as learning concepts and theories, developing problem-solving and mathematical skills, the ability to apply principles and generalizations already learned to new problems and situations, fostering the ability to think creatively, learning to concentrate on major factors and to disregard insignificant ones; understanding the concept of accuracy of measurements and importance of correct estimates, in learning of landmark laboratory work and research, how to draw reasonable inferences from observations, and becoming adept at turning the physical quantities into symbolic variables, translating the problems into equations.

Main targeted difficulties: (1) Students have different backgrounds, and therefore identification of points of weakness of each student early in the course is of utmost importance. (2) The concepts are well learned when they are used and actively applied in problem solving, however attempts to memorize formulas instead of applying analysis and critical thinking often prevail. (3) Rather often scientific discoveries made in the 18th and 19th centuries (which make the basis for this course) remain disconnected from the realities of the modern science and technology, and therefore the task is to relate the concepts of the course with the contemporary physics and the state-of-the-art engineering applications and discuss these modern developments in the classroom.

Approaches:

Used
First, all students took a mathematics diagnostics test.
Second, the elements of the flipped classroom setting were used. Video lectures were uploaded a week before the class lectures. After studying instructional materials, students were given the opportunity to ask questions and express their opinions.
Third, a library of video recordings of lectures and problem-solving tutorials. These recordings produced with Camtasia software were uploaded to the MediaMatrix video sharing website of our university.
In progress,
Fourth, the development of an interactive site on the Internet with a physics forum for instructors and students. The existing website for the course http://www.oipo.physics.tamu.edu, presented the current course materials (syllabus, announcements, lecture notes and slides). For assignments, WebAssign website (https://www.webassign.net/) was used.
Fifth, students were allowed to earn extra course credit by making a short power point presentation on a listed research topic. To be implemented,
Sixth, for real time interactive teaching Google Forms will be used. This free online software is interactive in real time and allows students to ask written questions which can be viewed by the instructor who can select questions for discussion with the students.
Seventh, work of students in groups. As a future extra credit opportunity, students will form small groups and create a presentation or report on a landmark experimental discovery in a physics journal format. In the group projects students will develop interpersonal communication skills, effective solving skills, and the abilities to approach non-traditional problems and to relate different topics of the course and intrinsic motivation learning skills.

Impact of time spent on homework on semester grade

Impact of time spent on homework on homework grade

As an example of a group project, they are asked to apply concepts of stress and strain, expansion, and static strain to designing the foundation of the Burj Khalifa. How many pillars of steel and concrete must be in the foundation? What should its dimensions be so it can be constructed on desert sand? What friction forces must be present, so it does not sink in the desert sand?

This is an indication that the homework is an important contributor to learning.

The hump in the center-left of the graph indicates students who either understood the material well, or received help.

Conclusions

• We aimed at improving effectiveness of teaching introductory physics courses by implementing different approaches: using Internet WebAssign homework assignments, giving extra credit for presentations, providing pre-recorded videos of lecture presentations.
• With these approaches also elements of the flipped class setting were introduced.
• The evaluation of outcomes was done in two ways qualitatively through an anonymous student survey and quantitatively by statistical measures.

• The significant cultural, educational and ethical diversity of the class required also to address individual qualities and preferences of the students, and providing a wide range of educational materials helped in this respect.
• In the future it is important to develop additional quantitative statistical characteristics which can serve as metrics for the efficiency of different course components. In particular, the assessment of development of critical thinking throughout the course can be performed by giving a Critical Thinking Skills Test (Wieman, C. E.) at the beginning, at midterm, and at the end of the semester to demonstrate the students’ progress in this dimension.

References


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