Collaborative Learning vs. Lecture for Introductory Physics Students: A One-Year Longitudinal Study

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Abstract. A collaborative group-learning classroom was implemented on a pilot basis at ETH Zürich in the Spring 2017 semester. Data on conceptual understanding, problem-solving ability, and student feedback were collected from the class and compared to a parallel large lecture class. In addition, a comprehensive Final Exam was given in January 2018 to assess the overall learning achievements of the students in both sections. These comparative data will be presented in order to gauge the effectiveness of the collaborative pedagogical approach.

1 Background and Motivation

Studies of undergraduate STEM education have demonstrated that students need to be actively engaged in the learning process in order for it to be effective. A passive lecture environment ("teaching by telling") has been shown to be largely ineffective in developing students' skills in critical thinking and problem solving [1]. Despite the abundant data which indicate the shortcomings of the conventional lecture format, however, it continues to be the instructional mode that is prevalent in most institutions.

In the collaborative group-learning approach known as "studio physics" [2], students work together in small groups on conceptual and numerical problems, while the instructor serves as a facilitator or "coach" instead of a lecturer. By merging this collaborative methodology with the integration of a broad variety of pedagogical activities (including conceptual/numerical exercises, laboratory experiments, and possibly computer simulations), a dynamic collective learning environment is created which fully engages students.

2 The ETH Project

Last year, we reported on the preliminary results [3] for a pilot implementation of a collaborative learning environment in an introductory physics class at ETH Zürich (for the Physics 1 course in the Spring 2017 semester). A total of 54 students were organized into 18 groups of 3 students, with each triplet sharing a portable whiteboard for collective group activities and sitting around 9 hexagonal tables (with 2 groups per table). In the classroom, the instructor was aided by three Teaching Assistants who monitored the students' progress during the in-class exercises and intervened to guide the discussions or answer questions. Lecture was reduced to a minimum, so class preparation was critical for the students. To help students gauge their own understanding and motivate their preparation, optional online "Warmups" were assigned before each class. In addition, for developing problem-solving skills, numerical problems were offered as homework practice using the online *MasteringPhysics* system [4] and the Moodle course management software.

Comparative data were taken during that semester in both the collaborative section and a parallel large lecture section with ~300 students. Student performance was measured by the Force Concept Inventory [5-6] and a common mid-term exam which included both numerical and conceptual problems. In both cases, the performance of the collaborative section exceeded that of the lecture section. In addition, student feedback was obtained from the collaborative section via a mid-semester questionnaire, as well as the usual ETH end-of-semester course evaluation. The opinions of the students were extremely positive, even though the pedagogical methods employed in the collaborative class were radically different from the conventional lecture format to which they were typically accustomed.

3 New Longitudinal Data

At the end of the Spring 2017 semester, there was no comprehensive exam given to the Physics 1 students. The second half of the course (Physics 2) was taught in the Fall 2017 semester with only a standard lecture section (*i.e.* without a partner collaborative section). The Final Exam for the entire physics course was given in January 2018, at the end of the full-year sequence of Physics 1 (Spring 2017) and Physics 2 (Fall 2017). For the former, the Final Exam was essentially 7½ months after the end of the Physics 1 course, so the Physics 1 component of that exam constituted a longitudinal assessment of the physics knowledge and problem-solving skills of those students at the end of that time period.

In addition, it is also potentially interesting to examine the Final Exam results for the Physics 2 component. While the Physics 2 class in Fall 2017 was only taught in a lecture format, one could pose the question as to whether any problem-solving skills that were developed in the Physics 1 collaborative class were transferred to the Physics 2 portion.

Finally, we also now have student feedback survey data from both end-of-semester course evaluations, so we effectively have "snapshots" of student attitudes and impressions from two different time periods. These surveys include data related to class attendance, time spent on out-of-class preparation, level of intellectual challenge, and self-confidence in the comprehension of the course material.

4 Conclusion

In this talk, we will outline the details of our implementation of the collaborative class at ETH Zürich and present our data from the two concurrent class sections – both the previous data from Spring 2017 as well as the new data from the Final Exam in January 2018. Student feedback from the end of both courses (Physics 1 and Physics 2) will also be reviewed to see if any common themes emerge. This will allow us to compare student performance (and student attitudes) at two different points in time, which will help us determine the extent to which the positive effects of the collaborative pedagogical approach have been retained.

References

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