

Case Studies in Introductory Physics Course for Science Programs: Example of Intervention

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Abstract. Case Studies are a valuable teaching tool that allows us to bring real-world scenarios, introduce a process of authentic scientific inquiry to undergraduate physics courses, and promote a genuine collaboration among the students. Contrary to a common belief, they can be effectively used in a large-enrolment introductory physics classes. The example of Case Studies developed for the introductory physics courses for science programs will be demonstrated. The methods of measuring the impact of the case studies on students' learning will be discussed.

Introduction

Several decades of Physics Education Research (PER) have demonstrated that an active learning environment is associated with much-improved learning outcomes when compared with the traditional instructor-centered lectures. The flipped classroom, with Peer Instruction, (PI) [1] is known to improve both the course retention rate and student grades. However, the success of PI rests heavily on the quality of the multiple-choice questions, with the conceptual ones being much more effective than the factual (recall) questions. An additional drawback of multiple-choice format questions is that they do not provide the students with the incentive to formulate their own ideas. Using Case Studies instead of, or in addition to, the multiple-choice questions, reduces the overall reliance on the multiple-choice format, while providing the students with the opportunity to analyze more open-ended and, often more realistic scenarios. The Case Studies are under-utilized in an undergraduate physics education, probably, because of a common belief that they are difficult and time-consuming to use. However, they can be effectively used for group work even in the large-enrollment introductory physics classes. The current project has built on our own earlier work in which the collaborative class discussions based on real-life scenarios were proposed as an alternative to the PI protocol [2].

Case Studies Methodology

A set of Case Studies was developed for a large-enrollment introductory physics classes for students in science programs. The scenarios target fundamental concepts of introductory physics curriculum (predominantly classical mechanics content). Whenever possible, the Case Studies are intended to bring a real-life context to the classroom. An example of Case Studies will be featured in the presentation. The "Designing a Roller Coaster" Case Study provides the students with the requirements for the sequence of specific elements (such as vertical and horizontal, loops, various hills, and inclines) to be included in the newly designed attraction. The students are given a set of guidelines and assumptions that need to be considered in order to check the feasibility of the proposed design. The students' task is to perform basic calculations and determine what dimensions are possible for the required elements. Each group will have to answer a subset of questions regarding each element to be included in the design. For example, one of the questions reads: "The ride must have a large vertical circular loop of 25 meters in radius, with the lower point of the loop touching the ground level. What would be the minimum height of the initial elevation so that the cart remains in contact with the track and the passengers do not fall out while

going through the upper portion of the loop?” If used for evaluations, the same Case Study can be customized for different groups by using different sequence and/or sizes of the required elements. While the Case Studies can be used for summative evaluations, we believe that the case studies main role is providing additional learning opportunities.

Research Questions: Measuring the Impact of the Case Studies on Students’ Learning

We are interested in finding the answers for the following research questions:

- 1) Does using Case Studies as a basis for students’ collaborative discussions further improve students’ conceptual understanding beyond what is achievable while relying only on multiple choice questions and standard end-of-chapter problems?
- 2) What use of the Case Studies is more effective: as a written homework group assignment, or as a live in-class collaborative discussion exercise?

Results and Conclusion

This is a work in progress. While it is already clear that Case Studies based on real-life scenarios can captivate students’ imaginations and increase the engagement with the material, the impact on conceptual learning needs to be evaluated in a formal study, with several students’ cohorts, and preferably, beyond a single institution. The effectiveness evaluation methodologies will be discussed.

References

- [1] E. Mazur, *Peer Instruction: A User's Manual*, Prentice Hall, NJ, 1997.
- [2] C. Kalman, M. Milner-Bolotin and T. Antimirova, Comparison of the Effectiveness of Collaborative Groups and Peer Instruction in a Large Introductory Physics Course for Science Majors, *Canadian Journal of Physics* **88**(5) (2010) 325-332.