Case Studies for Small-Group Student Collaboration in Large-Enrollment Introductory Physics Classes

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Goals

- Improve students' conceptual learning in large-enrollment introductory physics courses for science and engineering programs using Case Studies format for small-group collaborative activities
- Develop Case Studies that explore the fundamental physics principles through realistic physics scenarios
- Increase students’ engagement
Motivation

- The benefits of peer collaborations in large courses are well-documented [1,2], but typical Peer Instruction often rely on using oversimplified questions presented in a multiple-choice format.
- The main disadvantages of multiple choice format are not giving the students an opportunity to formulate their own ideas and the questions not being open-ended.
- We aimed at creating more open-ended study materials that would also present more realistic physics scenarios thus reducing the reliance on multiple choice questions.
Fostering Students Collaborations

● This project was envisioned before the COVID-19 pandemic and was intended for use during regular on-campus courses.

● However, the switch to remote teaching during the pandemic, and the resulting students’ isolation created even more pressing need for student collaboration and community-building.
This proposal is based on some earlier work [3, 4].

It involved introducing stand-alone collaborative group activities based on cognitive conflict that replaced the Peer Instruction activities for a limited number of topics [3].

The analysis of Fall 2007 class intervention demonstrated the high effectiveness of small-group discussions, but at that time, the ability to collect responses to non-multiple choice inquiries was limited, as well as the ability to collaborate was also restricted to the nearest neighbors in the classroom.
Case Studies Development

- The instructional materials in the form of Case Studies were prepared with the assistance of an upper year student and a recent graduate from Medical Physics program.

- **Case Studies assignments (worksheets), discussion items, plausible solutions and answers set, as well as grading rubrics** were developed.

- Each of the Case Studies targets common student misconceptions.

- Each Case Study presents a realistic, plausible scenario, and as such, often introduces more than one concept.
Case Studies for Mechanics Content

- Free Fall: Dropping a sandbag from a vertically moving balloon
- Projectile motion: Throwing a sandbag from a vertically moving balloon
- Air resistance: A record-setting jump from a stratosphere
- Conservation of energy, normal force, dynamics of circular motion
- Conservation of a linear momentum: an investigation of a collision
For example, a case study on air resistance and terminal velocity is based on the data log from a record 2011 jump from the stratosphere.
Sample Questions

● When and at which altitude did his motion stop being a near unobstructed free fall (evidence of air resistance becomes apparent)?

● When and at which altitude did he break the sound barrier? Did this occur after he opened his parachute or before?

● When did he reach terminal velocity with his parachute still closed?

● For how long and at which altitudes was he in a true free fall?
Sample Questions (Continued)

- When he broke the sound barrier, was he still in a free fall or already experiencing the air resistance that cannot be neglected?
- What was his vertical speed when he landed?
- Calculate his terminal velocity before he opened his parachute.
- Calculate his terminal velocity after he opened his parachute.
Implementation

- Two Case Studies were piloted during 2021/2022 academic year as small-group assignments.
- Completed outside of the class hours and submitted by the small groups via D2L.
- The full set of materials will be used during the 2022/2023 academic year.
Research Questions

● Does providing the students with opportunities to collaborate on analyzing realistic physics scenarios and formulating their own ideas increase students’ engagement and fosters active learning?

● Will using these open-ended scenarios/activities as a basis for students’ discussions/collaboration further improve students’ conceptual understanding beyond what is achievable while relying only on multiple choice questions and standard end-of-chapter problems?

● This is a work in progress. The full impact of students collaborations on Case Studies will be analyzed after a complete implementation during the next academic year.
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References


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Thank you!
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