# Online Data Collection and Analysis in Introductory Physics

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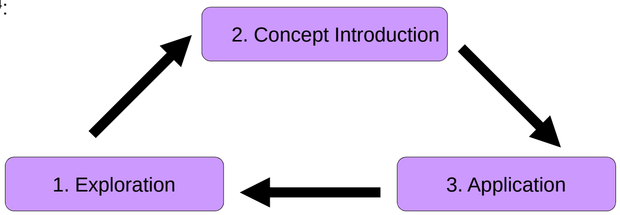
## I.Introduction

The Internet is already used to distribute learning materials[1]. It can also give us an opportunity to collect data about how students use those materials and about their conceptions of physics. There is interest in how students' epistemological beliefs, which depend on learning context, affect what students present about their understanding of physics[2,3]. Online data collection may also present an opportunity to study student learning in a different, natural environment of their own choosing

## II. Design

We designed three lessons on Newton's laws using the three-stage learning cycle[4]:




The lessons:

- Focus on making observations, measurements and explanations of video
- Are implemented online via survey response system
- Combine objective and subjective questions.
- Serve as a support structure for an online synthetic tutoring system

**The question is whether students will provide detailed answers to our questions that will give insight into their understanding of physics.**

## III. Analysis

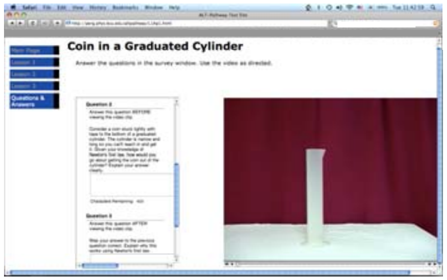
We looked at student responses to a pair of questions from one of the application activities.

- The activity focused on how to obtain a coin stuck lightly inside a graduated cylinder using Newton's first law.
- 96 college algebra-based physics students and 28 high school physics students responded to these questions.
- Student responses were assessed based on whether they contained a level of detail sufficient for qualitative analysis.
- The ideas expressed were analyzed phenomenologically.

The activity is shown to the right. The wording of the questions is:

Q1:*"Answer this question BEFORE viewing the video clip: Consider a coin stuck lightly with tape to the bottom of a graduated cylinder. The cylinder is narrow and long so you can't reach in and get it. Given your knowledge of Newton's first law, how would you go about getting the coin out of the cylinder? Explain your answer clearly."*

Q2:*"Answer this question AFTER viewing the video clip: Was your answer to the previous question correct? Explain why this works using Newton's first law."*




## IV.Preliminary Results

The majority of students provided detailed responses to one or both questions:

**Fraction of Students Providing Detailed Responses**

| | Question 1 | Question 2 |
|---|---|---|
| High School Students | 32% (9 responses) | 82% (23 responses) |
| College Students | 74% (71 responses) | 98% (94 responses) |

Sample Student Responses and Ideas Expressed:

**Applied force is needed:**

*"I would go about getting the coin by turning it upside down and hitting the cylinder on the table until the coin came out…to create a downward force on the coin causing it to go into motion." - College student, question 1*

**Applied force must exceed tape's force:**

*"I would probaly [sic] exerte [sic] a greater force on the opening in a downward motion…to overcome the tape's force" - High school student, question 1*

**Uses Newton's 1st law:**

*"…cylinder and the coin are moving at the same speed. Then the external force of the table stops the cylinder…the coin continues to move at the same speed…until it stops from the force of the table…" - College student, question 2*

**Uses physics terms incorrectly:**

*"…the acceleration was larger than the mass or the force holding the coin…"- College student, question 2*

**Inconsistency in a single student's two responses:**

*"Turn the cylinder upside down and thrust downward, then stop suddenly. The coin will want to keep moving, so it will release from the tape and fall…" - High School student on question 1*

*"…you wouldn't be able to stp [sic] thrusting downward enought [sic] to break the force of the tape on the coin, but by hitting it on the table, the froce [sic] would be great enought [sic] for the tape to release the coin…" - The same student on question 2*

## V. Conclusions and Future Work

These preliminary results are promising with regards to student willingness to provide detailed responses to free-response questions online, without a facilitator. More importantly there is evidence that those responses give insight into students' conceptions of physics. We will proceed with analysis of student responses to our lesson materials and work to combine them in our synthetic tutoring system.

## VI. References

1. For example PhET simulations: http://phet.colorado.edu/index.php
2. E. F. Redish, J. M. Saul, and R. N. Steinberg, *Am. J. Phys* **66**, 212-224 (1998).
3. R. E. Scherr and D. Hammer, *Cognition & Instruction* **27**, 147-174 (2009).
4. R. Karplus and D.P. Butts, *Research in Science Teaching* **14**, 169-175 (1977).