Tracing Metacognitive Self-Regulation in an Introductory Physics Course

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Overview

- Introduction to Physics Education Research
- Background
    - Theoretical framework of self-regulation
- Method of Study
- Results and Analysis
- Implications for Instruction
- Conclusion and Future Work

Introduction

- Physics Education Research (PER)
  - The study of teaching and learning physics mostly at the college level
  - Want to identify student difficulties and improve instructional methods
  - Done by experts in the field

Background

- Motivation: students are exposed to a variety of information sources
- Self-regulation is one's awareness of and control over his or her learning environment

Metacognitive monitoring

<u>Self-Regulatory Behaviors</u>

- Setting appropriate goals
- Retaining intrinsic motivation
- Applying appropriate learning strategies

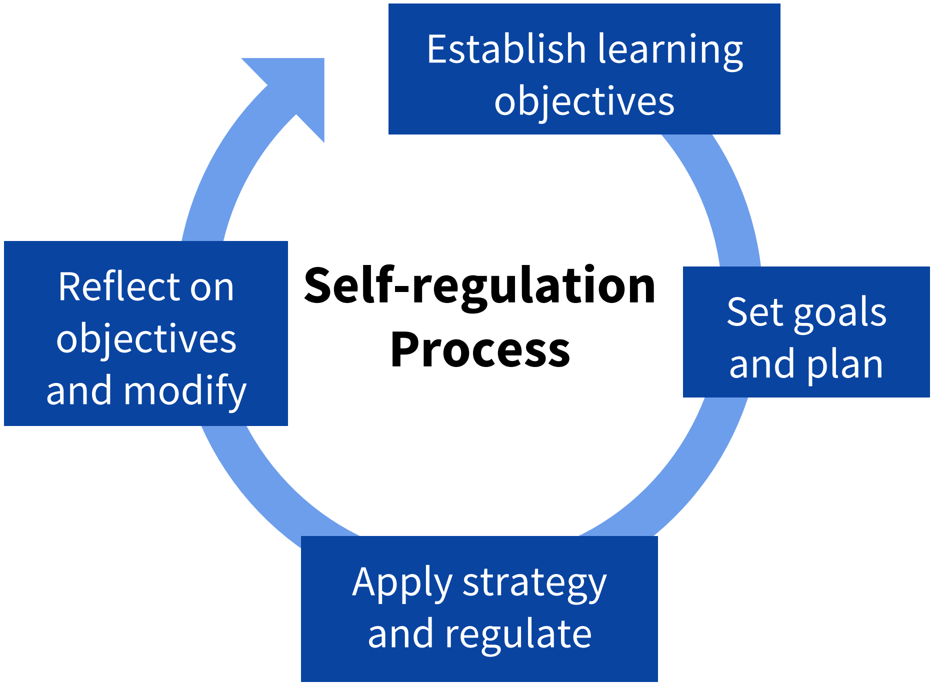
Our Project

Based on prior research:

- High performers practice more self-regulatory behaviors, indicated on reflections from an honors intro physics course (May & Etkina, 2002)
- Learning objectives help students organize information (Simon & Taylor, 2009)

Our study:

- Implement objective-based reflections to foster metacognition



Context/Method

- Setting
  - 2 sections of introductory, calculus-based physics course at UW (Mechanics)
  - Different instructors, same homework and learning objectives
  - Assumption: students in both sections are comparable (Heron, 2015)
- Experimental section: weekly reflections
- Control section: no reflections
- Data
  - Colorado Learning Attitudes about Science Survey (CLASS)
  - Weekly self-reflections from experimental section (9 weeks)
- My work
  - Analyze and interpret CLASS and reflections (~1800)
  - Determine implications for instruction

Research Questions

1. What differences are there in CLASS responses between the two sections and between the highest and lowest performers?

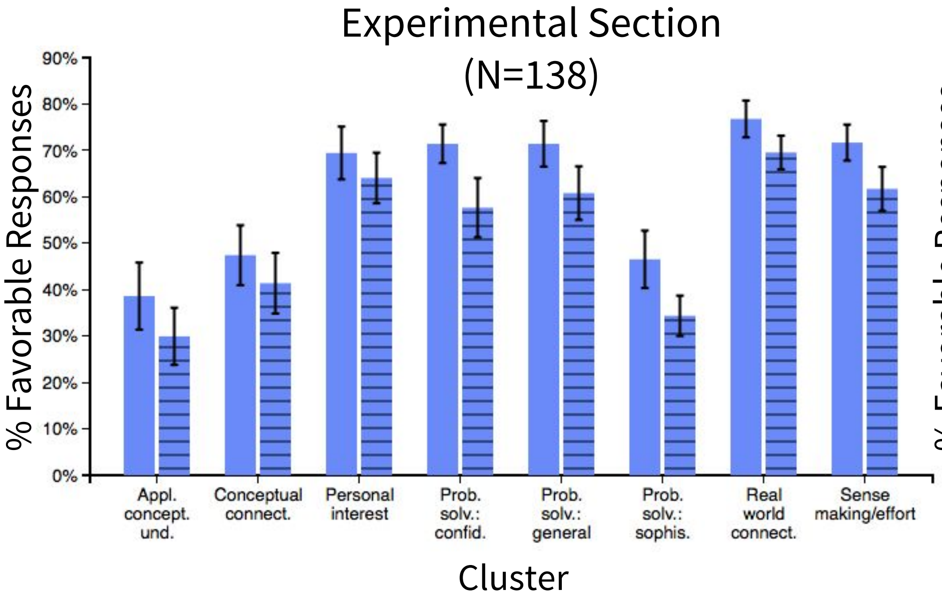
2. What metacognitive and self-regulatory thoughts are present in weekly reflections, and how do they change over the course of a ten week quarter?

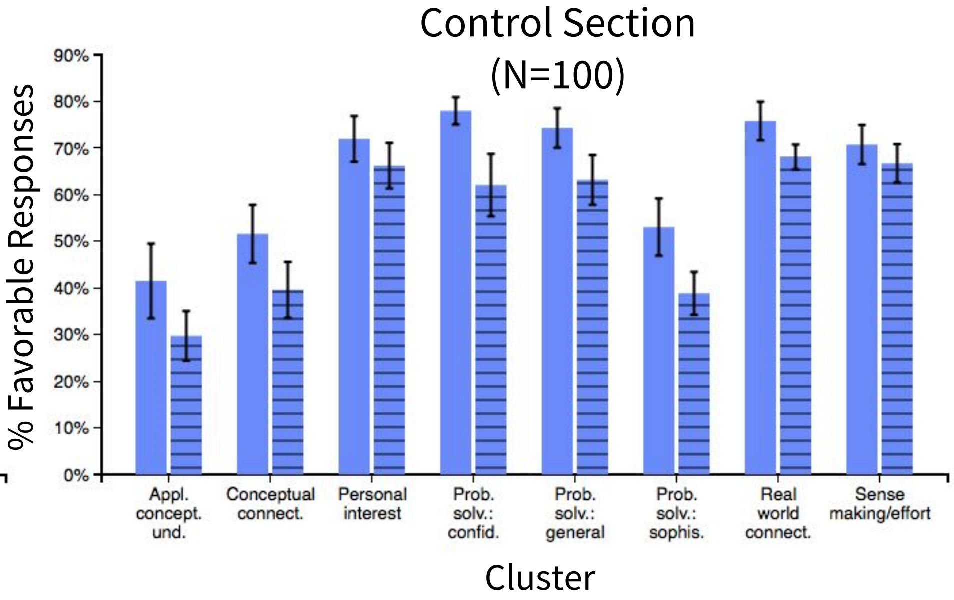
3. How can instructors integrate self-regulation into additional course components?

What is CLASS?

- Survey to measure students' general attitudes and beliefs toward physics (Adams et al. 2006)
- 42 Likert-scale statements
  - Example: "If I get stuck on a physics problem on my first try, I usually try to figure out a different way that works."
  - Answers indicate expert-like thinking (favorable) or novice-like thinking
- Instructors would like to improve students' attitudes (more expert-like thinking)
- However, it is *very* rare for students' beliefs to improve
  - National average for shift in favorable responses is about -4%

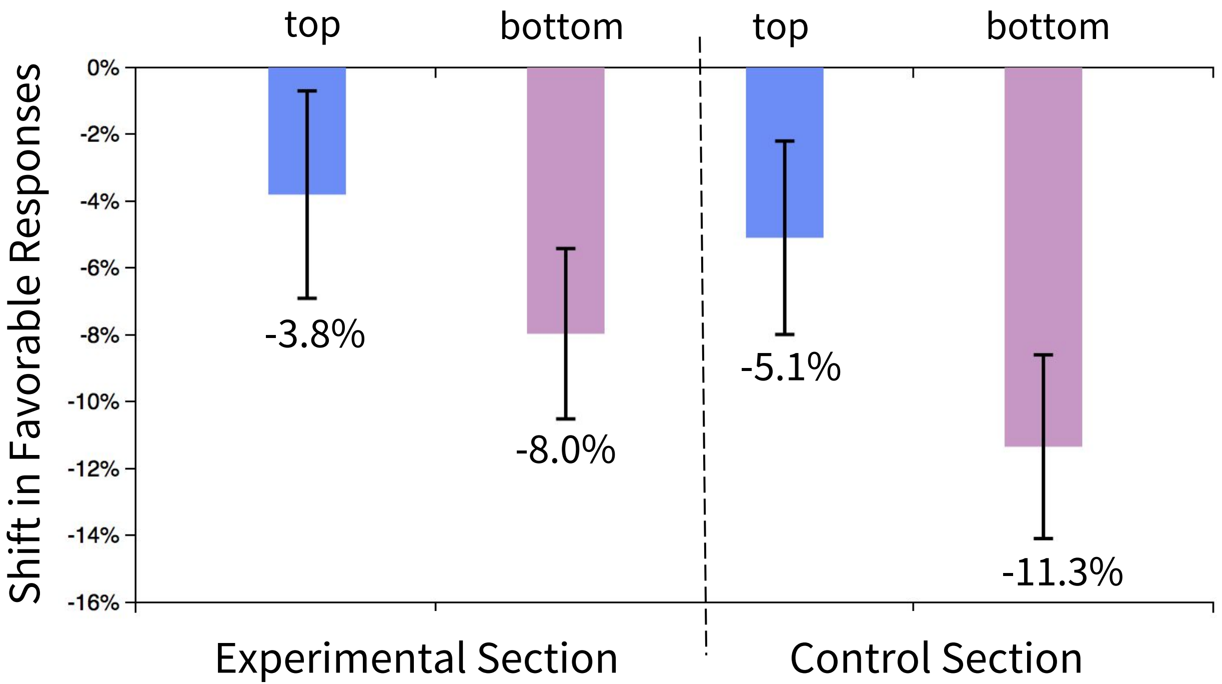
Results: CLASS





- Overall shift in percent of favorable responses: -6.9 ± 1.5% for experimental section, -5.9 ± 1.7% for control section
- Potential impact of instructor gender (male instructed section had -4.2% shift)

- CLASS overall shifts by quartile give more insight
- Top quartiles shift by an expected amount
- Bottom quartiles have much larger decreases in favorable responses
- Perhaps self-regulation can reduce negative shift of bottom quartile



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Results: Weekly Reflections

Prompt: “Select one course Weekly Objective on which you've made progress over the past week. Briefly describe an activity you engaged in over the past week during which you made progress on one of the Learning Objectives you selected. Finally, describe how your thinking changed as a result.”

- Intentionally open-ended
- Feedback provided
- Analysis
    - Identify metacognitive responses
    - Characterize patterns of metacognition over time
    - Develop coding scheme (qualitative data categorization)

Characteristics of metacognitive responses:

1. Description of prior misunderstanding
2. Statement of activity or problem that changed initial thinking
3. Description of new line of reasoning/formal knowledge

Example:

"When I was solving this problem, I initially thought that the quadrant of the graph the line was in showed which direction the car was headed in. After working through it and messing up a couple times, I learned that...if the slope at that point is in a negative direction, it is moving back, if it is positive, it is moving forward."

Next step: categorize how presence of these characteristics evolves over 9 weeks

Coding Scheme	
Code	Description
Improved	Student shows an increase in metacognition in his or her reflections from the beginning to the end of the course.
Flat (metacognitive)	Student begins with solid evidence of metacognition in his or her reflections, and this remains consistent throughout the course.
Flat (not metacognitive)	Student consistently does not demonstrate metacognition in his or her reflections throughout the course.
Decreased	Student begins the course with strong evidence of metacognition, but this decreases over time.

Example of "Improved" (student from bottom quartile)

Week 1: "In order to understand motion graphs, I have looked over book examples and have labeled out the meaning of different sections of the graphs to ensure that I understood what each change in the function meant."

Week 6: "I have done <u>practice problems</u> that <u>allow me to determine whether or not I understand the motion of an object</u> and what it does to the components. As a result, this has let me better visualize and begin problems that move in more than one direction."

Week 8: "To better understand torque I have … [practiced] some of the <u>problems</u> out on a whiteboard... This changed my thinking by letting me <u>learn how to draw extended free body diagrams, it was initially tricky for me to see where all the forces went</u> now that they weren't all centered on one spot."

Example of "Decreased" (student from bottom quartile)

Week 1: "Before, it [was] hard for me to interpret graphs ... However, after practicing with professor in class, I [got] to know how to read graphs in terms of slowing down and speeding up in the velocity versus time graph."

Week 4: "For this week, I [learned] how to draw the free body diagrams. Before, I thought the net force should be drawn from the same origin. However, after the lecture, I figured out that different types of forces are not all from the same origin."

Week 8: "This week I [learned] that the angular momentum is conserved the same way the momentum we [learned] previously is conserved, which can be calculated using formula $L=I\omega$."

Summary So Far

- CLASS provides a general overlook of student perceptions; reflections offer richer insights
- The tentative coding scheme needs to be finalized and applied to all reflections to continue analysis
- Next step: apply findings from reflections to develop curriculum

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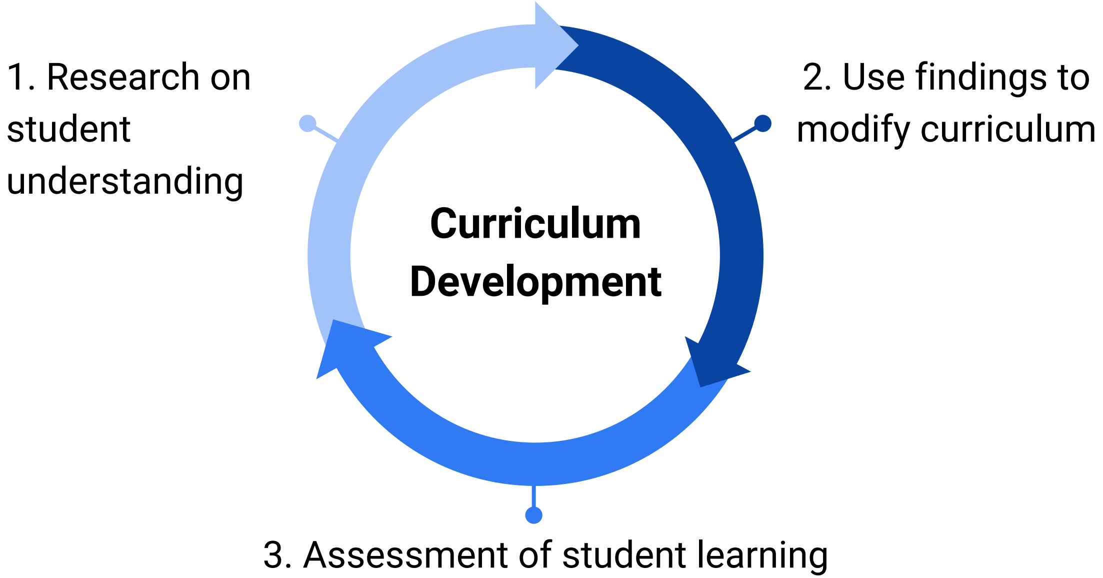
Implications for Instruction

- Reflections from both top and bottom quartiles talk about Tutorials
- Tutorials are interactive sessions that supplement lecture and lab
- They are meant for students to use reasoning and inquiry skills to build concepts

"At first, I didn't fully understand why the velocity of a point in contact with the ground was zero, but after completing about a page of the tutorial I soon realized that the velocity was a sum of the center of mass velocity AND tangential velocity, not just tangential velocity. "

Curriculum Development



- Tutorial components: **pre-test**, worksheet, homework, post-test
- Pre-tests are not returned to students!
- Proposition: provide feedback on pre-test performance to enhance self-monitoring

Conclusion

Progress toward research questions:

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Future work:

- Relate metacognition to academic performance
- Implement, assess, and modify Tutorial development (pre-test feedback)
- Collect reflections over longer time period

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