Students' reasoning paths through the lens of Dual Process Theories

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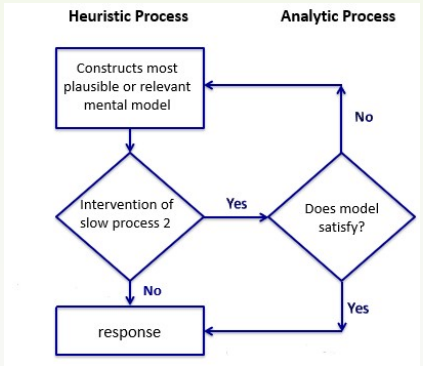
Abstract

When faced with unfamiliar situations, students are more likely to rely on intuitive reasoning rather than formal knowledge and skills developed during instruction. In order to pinpoint specific factors and instructional circumstances that lead to productive and unproductive reasoning strategies, we have been developing sequences of questions that allow for the disentanglement of student conceptual understanding, reasoning, and intuition. We used these sequences in introductory algebra-based and calculus-based Mechanics courses at a large research university. The Dual Process Theories (DPT) of reasoning are used to interpret students' responses. Written answers, explanations, and self-reflections (viewed through the lens of DPT) reveal student approaches to reasoning: reliance on intuition, development of heuristics, and use of confirmation bias.

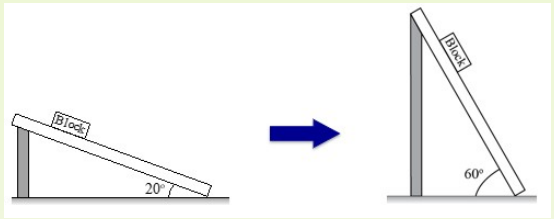
ual Process Theories (DPT)



DPT argues that there are two reasoning paths: System 1, which is intuitive and subconscious, and System 2, which is deliberate and time intensive. When a student approaches a problem, System 1 constructs a plausible model based on the student's prior knowledge. Then System 2 may or may not intervene before the student produces a final response.

Methods

- We asked 121 algebra-based and 50 calculus-based Physics I students a sequence of questions designed to elicit student reasoning patterns. Questions were given in a web-based format with participation credit awarded for completion.



- If this angle is increased to 60 deg, does the magnitude of the frictional force between the block and the ramp *increase*, *decrease*, or *remain the same*? Explain.
- What answer do you think people who applied intuitive thinking to the situation above chose? Explain.
- Did you apply intuitive reasoning/knowledge or formal reasoning/knowledge in your original response? Explain.

Results

- **Reliance on Intuition**: students tend to "visualize" the given situation and base their answers of this visualization

> "The frictional force would **decrease** because as you tilt the ramp higher, the block will have a **faster velocity** causing the block to have less friction." – Student 19

> "As the angle of the ramp increases, the block will **slide faster** down the ramp creating a **greater** frictional force." – Student 25

- **Development of Heuristics**: students developing "rules" for problems

> "**You always take the cos of the angle** multiplied times the force so I originally assumed that when the cos amount deceases the frictional force. This was the **first thought** that popped into my head." – Student 9

- **Confirmation Bias**: students using their physics knowledge to justify their intuitive model

> "I used some intuitive reasoning and some formal reasoning. I **used intuitive when I first read the question and picked an answer**. Before I moved to the next question I stopped and thought about why it would be that answer and if it could be a different answer." – Student 83

> "It **made sense** that the friction would decrease, so I **came up with a formal reason** for why that might be true." – Student 122

- **Reverting to Intuition**: students recognizing that there is a flaw with their intuition but unsure of how to proceed

> "I think I **mostly went about the problem in a intuitive way**…I **tried to formally** think it through by trying to remember the magnitude equations and by thinking of the different forces or anything that may be relevant to the problem. I was **uncertain with my formal thinking** attempt, so I went with my intuitive reasoning." – Student 54

> "I looked at my equation sheet and **tried to see how the equation would be used** to solve this. I'm a **bit unsure** if I'm right because the normal forces are going to be at different angles because the ramp angles are different." – Student 119

Implications

Through the lens of DPT we have examined student responses to a sequence of questions to better understand factors that lead to productive and unproductive reasoning strategies. Many of the students' answers to our first question would imply student difficulty with physics concepts or mathematical calculations. However, when asked to explain their reasoning process many of these students showed that, instead of using and struggling with formal knowledge, they were relying on intuition, heuristics, and confirmation bias.

An interesting result from the survey came from a few students who appeared to have the formal knowledge needed to solve the problem but remained unconvinced and reverted back to their intuition. This is different from relying on intuition because students are recognizing an inconsistency between their intuition and their formal knowledge but are unsure how to proceed. Future work should focus on how to better document this dissonance and help these students make the transition from their intuition to use of formal knowledge.

References

1. Evans, Jonathan St. B. T., "The heuristic-analytic theory of reasoning: extension and evaluation," Psychonomic bulletin review, 13(3), 378-395 (2006).

Acknowledgments

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