A Student Led Whole Class Discussion Reconciles Friction with the System Schema

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Introduction

- Modeling Instruction is a pedagogical approach developed at Arizona State University [1,2].
- A key feature is the introduction of, and then coordination and translation between, multiple representations [3].
- A second key feature is Modeling Discourse Management [4], a learning-community approach that explicitly focuses on the epistemology of science.
- There are many curricula that utilize multiple representations, but there is little in the literature about how this is accomplished with Modeling Discourse Management.
- This poster presents a brief case study, through written work and transcript data, showing how a student led whole class discussion helps them use and coordinate system schema [5,6,7] and force diagram representations.

Modeling Discourse Management

- Collaborative groups of 4-5 students create a solution to a given problem on a 2'x3' whiteboard.
- Groups circle up and through presentation and discussion pursue a whole class consensus. The instructor is outside the circle and discussion.

- This is often called a student "Board Meeting".
- A key goal is to help students deeply realize that...
  - science is tentative and evolving,
  - knowledge and meaning are constructed and shared through dialogue.

Classroom Context

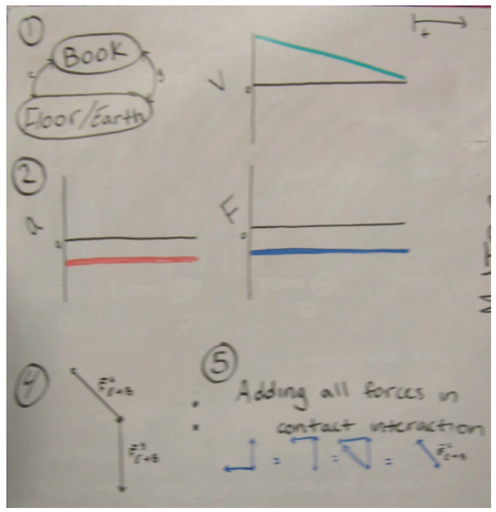
- Small, private, liberal arts university (1611 students).
- Calculus-based physics (27 students).
- Science majors (FCI pre-test: 9.7 ± 4.1)
- Modeling Instruction
- Near the end of the first semester.
- Physics concepts studied so far:
  - kinematics, energy [7], Newton's laws.
- Representations students are familiar with:
  - graphs, schema,1d force diagrams, 2d vectors.

The Sliding Box Problem[8]

You walk into a room and see a book sliding across the floor and slowing down. The book then comes to rest. You did not see what caused the book to start moving in the first place and do not care.

1) **Make a system schema for this situation.**
2) Define an appropriate coordinate system and make graphs of velocity and acceleration.
3) What would a graph of Force Total look like? Sketch it.
4) **Now using your system schema from one, make a force diagram for the box. Remember you can only have the same number of forces as interactions!**
5) What is the hard part about doing question four? Explain.
6) How would your write Newton's second law for this situation? Try.
7) Put your ideas and conclusions on a whiteboard.

Group #5's (mostly) correct solution



Problem Context

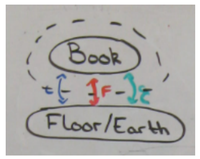
- Sliding book seen twice previously:
  - kinematics, energy [7]
- Deliberately designed to promote coordination of multiple representations.
- It's hard for students because they'd done...
  - friction with energy, but not yet with force
  - 1-d force diagrams, but not yet "tilted" forces
- Only group #3 asked for and received extensive "help" [9].

Board Meeting

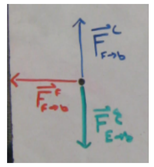
- Sixteen minute discussion
  - 7.5 minutes sharing whiteboards
  - 8.5 minutes of continuous, wide ranging, whole class discussion
- 14 students made substantive contributions
- Instructor interjected only twice

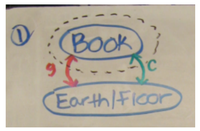
Group Whiteboards

system schema | force diagram

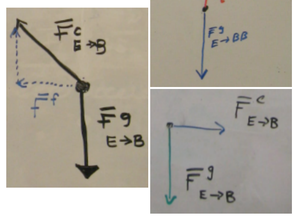


#1, #2





#3, #4, (#5), #6



- All system schema are consistent with past practice.
- **But** there are two different system schema answers.
- All groups have the same # of forces as interactions.
- **But** there are four very different force diagrams.
- Friction appears as a new interaction, as part of the contact interaction, or not at all.
- All but two force diagrams are consistent with graphs.

Whole Class Discussion

At least two members of groups #1 and #2 clearly state they think of friction as a new type of interaction. They also explicitly discuss what this implies for the schema. For example:

[Sam,1] 01:25 *We were asked to begin. And...we set up a schema that had a third interaction in it, it had friction in it,*
[Andy,2] 11:30 *Don't we have to account for that (friction) in our schema somehow?...I think you have to.*

In fact, Kim wonders about the angled vector in group #5's force diagram, which is constructed from a vertical and horizontal (friction) vector:

[Kim,1] 09:17 *I just wanna know why you can... say there's a vector for friction if it's not an interaction within your schema.*

After the 7.5min mark, three students gradually help focus the discussion by identifying key differences amongst the boards that need to be resolved:

[Min,2] 08:28 *So essentially...you have to figure out whether or not there is a third interaction, which is friction, whether it's its own interaction, or whether it's a part of the contact interaction.*
[Sam,1] 09:36 *So, basically, the major difference between... our group consensuses are...centered around whether or not friction is an interaction and if friction isn't an interaction then it has to be a part of the contact*
[Ralph,5] 11:59 *Well... it basically comes down to is friction an interaction by itself or is friction part of the contact interaction already there?*

Then Karen chimes in, and her statement gets the class very excited:

[Karen,6] 12:18 *I have a problem saying friction is an interaction though because friction is defined as.. a.., like, caused by a contact, like caused by an interaction, so like how can friction be an interaction if it's caused by another interaction*

Many try to speak at this point. Here are a few:

[Stan,1] 12:38 *Isn't friction, like, due to contact, it's a product of it so is it, is it possible to label it as its own interaction or is it due to the contact?*
[Jim,4] 12:52 *It's part of the contact interaction.*
[Min,2] 13:05 *because...it it, I mean it's created by the contact*

The only sustained pause in the 16min then occurs at 13:33. After ten seconds, Jim breaks the silence:

[Jim,4] 13:43 *I think that friction is inherent to contact, so we need to have it as con, part of the contact interaction.*

Finally, Stan comes up with two questions that seem to seal the deal for many in the class:

[Stan,1] 14:09 *I think it's good idea to look at it, as as whether or not it's an interaction, can you have a friction interaction without a contact interaction?*
[many] *No*
[Stan,1] *Sooo, can you have friction as its own interaction?*
[many] *No*

After a diversion into a question about air resistance, the class comes to a final consensus:

[Stan, 1] 15:27 *Sooo, how do we label...friction, with, on the contact interaction, on the system schema. That's the next question. If we're agreeing that friction can't be another interaction. It's due to, it's a product of the contact.*
[Sue, 6] *I think we'll leave it out of the schema and put it in the assumptions.*
[Jim, 4] *I like the way, I like the way they (group #5) did it where they just showed the two different types of contact interaction, um, and then showed the resulting vector, as the contact interaction, so I thought that was good.*
[Min, 2] *Yeah,*
[Sam, 1] *Nice,*
[Stan, 1] *Alright*
[others] *Laughs of satisfaction*

What Facilitates Consensus?

- There is a strong vocal advocate in each group.
- It's clear there are very different answers with very different assumptions - unmissable initial controversy!
- It's near the end of the semester, so
  - they're socially comfortable...
    - with small groups
    - in large group
    - being "wrong" in front of everyone
  - many discourse norms are now regularly practiced...
    - negotiate meaning & knowledge through peer dialogue
    - violate reciprocal perspectives [10]
    - seek consensus
- The instructor has 10 years experience with Modeling.
- Group #1, which was vocal and initially incorrect, proposes reasoning that satisfies the rest of the class.

Acknowledgements

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References

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[7] E. Brew, "Energy as a substance-like quantity that flows: Theoretical considerations and pedagogical consequences", *Phys. Rev. Special Topics, PER* **7**, 020106 (2011).
[8] © Dwain Desbien, all rights reserved, used by permission.
[9] J. Durden, "Seeding: Understanding Discourse Management", 2011 AAPT Winter Meeting.
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