Evaluative sensemaking: frequency of student strategies and variance among instructors

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July 23, 2019

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Evaluative Physics Sensemaking

Seeking meaning or coherence, at the end of a problem, between representations of physics knowledge

– Dimensions, limiting case, special-case analysis, functional behavior, *etc*.

[1] B. A. Danielak, A. Gupta, and A. Elby, Marginalized identities of sense-makers: Reframing engineering student retention: Marginalized identities of sense-makers, Journal of Engineering Education

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Motivation

Professional physicists use these sensemaking strategies [2]

Instructors **implicitly** expect students to use them as well [3]

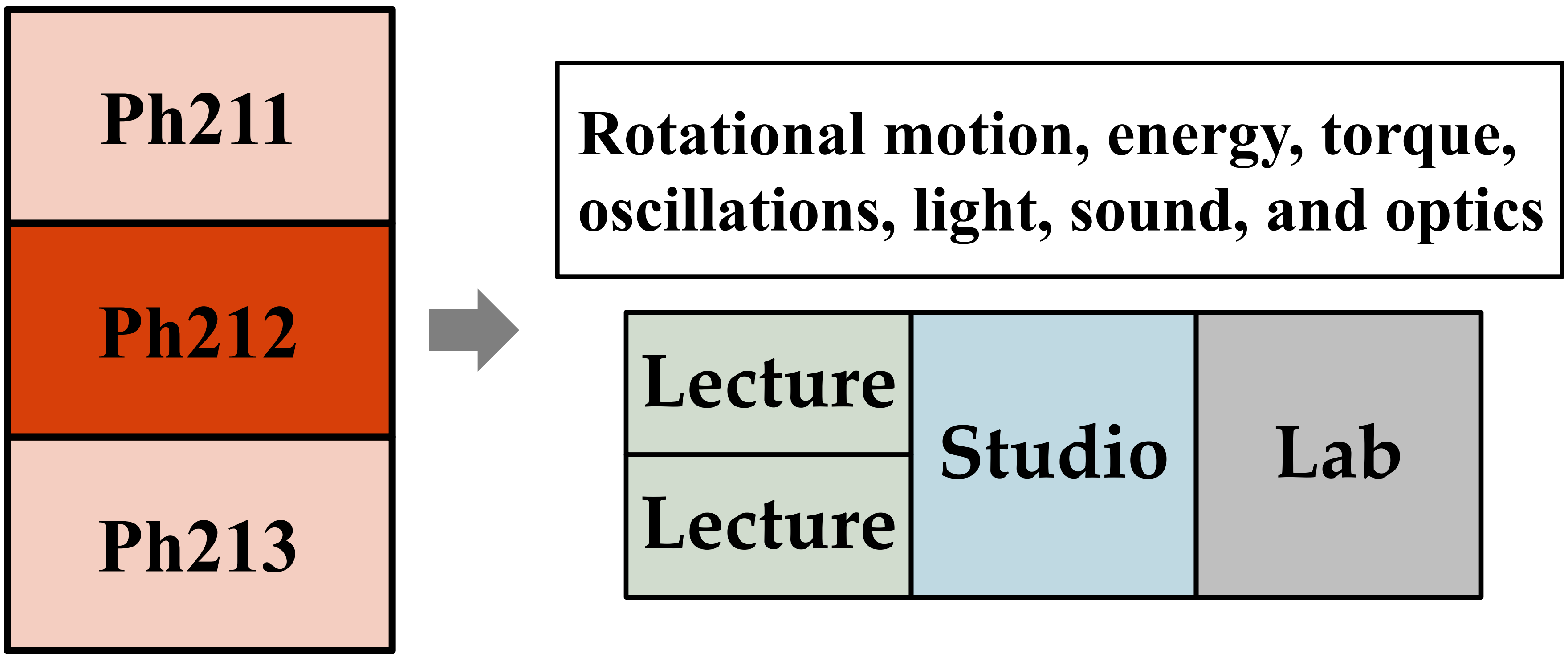
[2] C. Singh, When physical intuition fails, Am. J. Phys. **70** (2002).
[3] M. Lenz and E. Gire, Faculty views of and expectations for dimensional analysis, PERC Proceedings (2016)

Research Questions

1. What sensemaking strategies do students use?
   - How frequently do students these strategies?

2. Do students with different instructors use different sensemaking strategies?

Instructional Context



Instructors' Pedagogies

Empower Eric

Pedagogy: Mathematical sensemaking

Sensemaking gives students power over learning

In-my-head Isaac

Pedagogy: Mathematical and conceptual sensemaking

Sensemaking can be done entirely in your head

Concept Carl

Pedagogy: Conceptual sensemaking

Sensemaking connects physics to math

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Homework Format

Required solution format

4. Reflect. Is the answer reasonable? Does it make physical sense?

a. **Evaluate the result.** Is the answer reasonable? Are the units correct? Does the answer make sense in limiting cases? Does the answer make physical sense? *Include a written explanation for why the answer makes sense and what it implies about the physical system.*

Grading rubric

Points:	0	1	2	3
4 a. Evaluate the result	No evaluation is given.	Very little information is given to evaluate the result.	A partial explanation is given for why the result makes sense (or does not make sense if the incorrect answer was reached), and what it tells us about the physics of the situation.	A clear and complete explanation is given for why the result makes sense (or does not make sense if the incorrect answer was reached), and what it tells us about the physics of the situation.

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Methods

- Six written HW assignments collected from all participating students (avg. N = 99*)
  - Two problems per assignment

Instructor	Participating Students	Avg Students
Empower Eric	51	47
In-my-head Isaac	34	27
Concept Carl	28	25
Total	113	99*

Results: Codes

We found a total of 21 codes

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Results: Codes

We found a total of 21 codes

Codes	**Type**	**Freq.**
Units Mentioned	Mathematical	46%

this is reasonable because the units work as expected

Results: Codes

We found a total of 21 codes

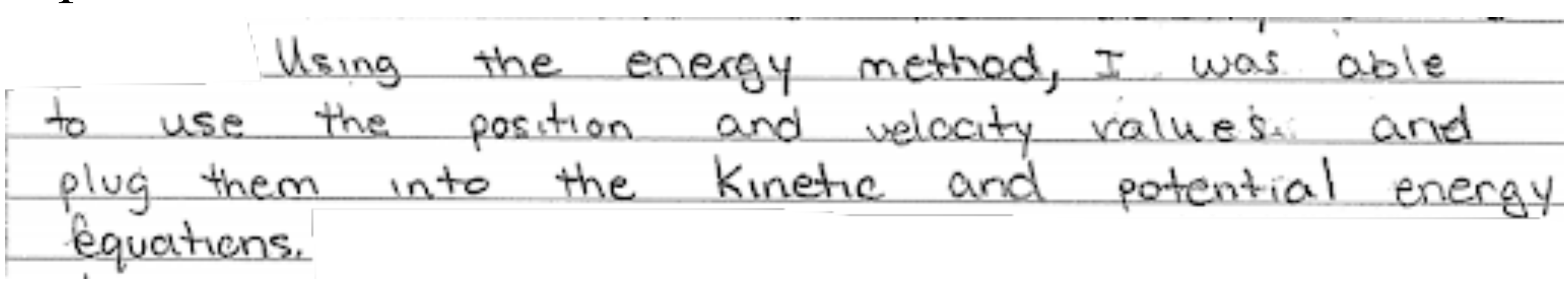
Codes	Type	Freq.
Units Mentioned	Mathematical	46%
Argument based on physical system	Conceptual	30%

The velocity at the end of the tube makes sense as well, given the long tube, the low weight of the ball, and the strong force of air upon the ball.

Results: Codes

We found a total of 21 codes

Codes	Type	Freq.
Units Mentioned	Mathematical	46%
Argument based on physical system	Conceptual	30%
Assumes correct reasoning or process	Mathematical/Conceptual	15%


Using the energy method, I was able to use the position and velocity values and plug them into the kinetic and potential energy equations.

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Results: Instructors

In-my-head Isaac

Pedagogy	*Codes*	Freq.
Balanced		
	Mentions appropriate units	41%
	Argument based on physical system	21%
	References non-physics prior knowledge	19%

Conclusions

- Students engaged in many types of sensemaking strategies
- Instructor pedagogy impacts student sensemaking
- Align pedagogy with desired student sensemaking outcomes

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Thank You!

Student Participants and OSU PER Group

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Methods

- Thematic analysis approach
- Elaboratively coded
  - Codebook from MacKenzie Lenz
- Inter-rater reliability tests conducted
  - 7 HW problems, > 95% agreement