Student Perceptions of Structural Messaging in Physics Courses

Eric Kuo

2026 APS GPS – Denver, CO – 3/18/2026

UNIVERSITY OF
ILLINOIS
URBANA-CHAMPAIGN

The teacher says:
"You don't need to have taken physics in high school to be successful in this class."

...but students
feel that HS physics is essential for success.

The teacher says:
"You should always ask questions if you don't understand."

...but students
don't ask their questions.

The teacher says:
"Learning takes time. Don't worry if you don't understand everything right away. Keep working at it."

...but students
interpret early failures as indicating that they cannot succeed in physics.

Structural Messaging

Course structures (e.g., activities, assessments, course policies, etc.) communicate messages to students about how they should engage in learning physics.

Structurally:
The course is fast-paced and "assumed knowledge" is never explicitly taught.

students
feel that HS physics is essential for success.

Structurally:
Socio-emotional risks of asking questions in class.

students
don't ask their questions.

Structurally:
Failing early, one-shot, high-stakes assessments sets upper bound on one's course grade.

students
interpret early failures as indicating that they cannot succeed in physics.

How instructors convey messages about learning

Structural Messaging

- Curriculum
- Learning Activities
- Assessments
- Grading policies
- Physical Classroom Setup

Instructor Action Messaging

- Types of explanations given
- Types of questions asked
- Responses to students' ideas and Q's
- Facilitation of student/group work

Instructor's Explicit Communication

- "Don't memorize the equations. Apply the key principles describing the physical systems."
- "You can improve through hard work and effort.
- "Working with others is a great way to learn."

Research on Skills Building in Undergraduate Physics

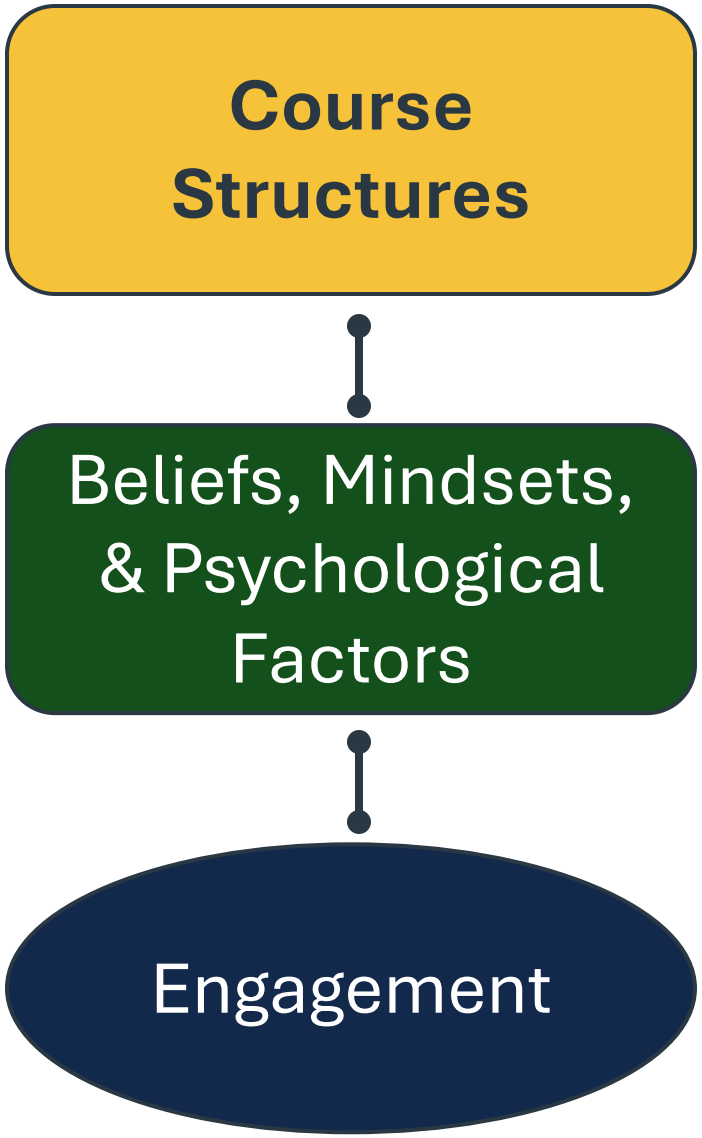
Wed. March 18, 1:15 — 3:03 p.m.

Hyatt Regency, Centennial G

Experimental scientific research skills

Computational thinking skills

This talk:
Engagement in physics learning as a “skill”



- Epistemological Beliefs
- Growth/Fixed Mindset
- Sense of Belonging/Community
- Psychological Safety
- and more!

Eric Kuo

Sarat Lewsirirat

Morten Lundsgaard

Ellen Ouellette

Christina Krist
(Stanford University)

Vidushi Adlakha
(Indiana University – Indianapolis)

StruM

Structural Messaging in Physics Courses

Students' perceptions and experiences of structural messaging and connections to (self-reported) engagement.

Students are attending to structural messaging

1) Structures imply instructor's intent/mindset.

2) Structures create opportunities for students to experience and believe in instructor's explicit messaging.

3) Structures support a sense of community (and engagement) among students.

Study Context: Phys A

("pre-physics for calc.-based Phys 1", ~375 students)

Many structural reforms, including:

- Exam improvement bonus points
- Collaborative homework office hours
- Collaborative whiteboard problem solving in discussion sections
- Etc…

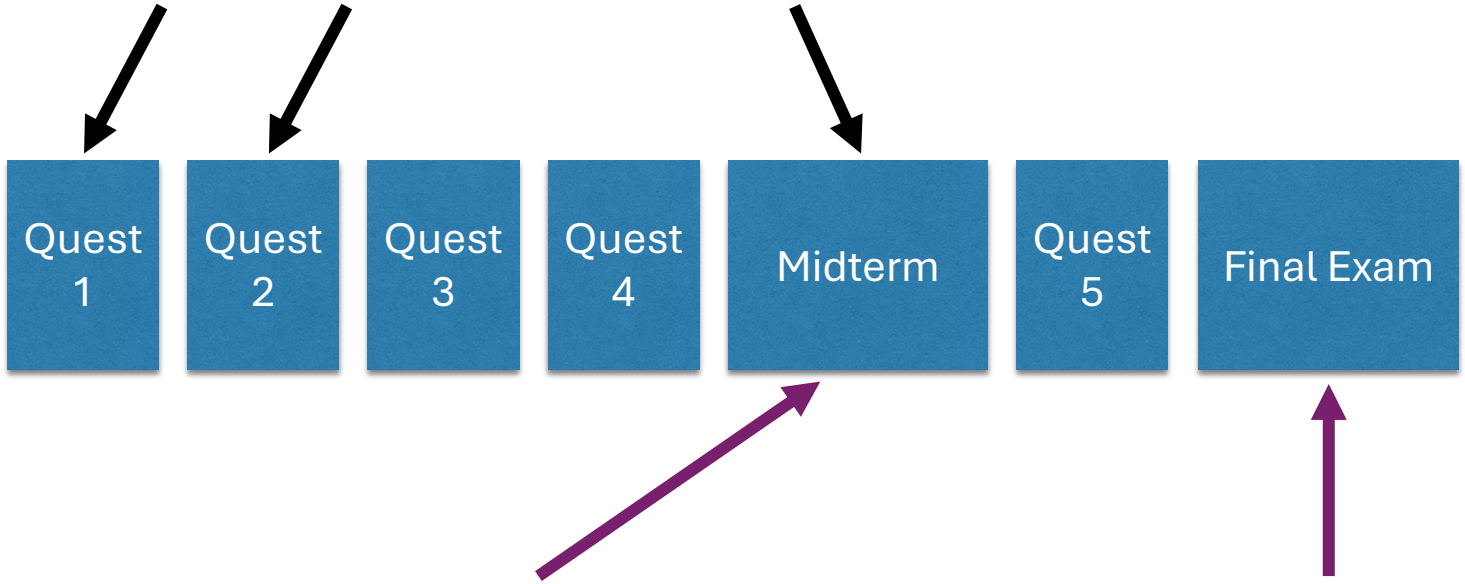
Conducted 59 semi-structured interviews

- Questions: Course structures and student experience

Exam improvement Bonus Points

Class discussion: Growth mindset messaging

"Recognize what you've learned already, where you can improve."



Midterm Improvement Bonus Points
If (Midterm %) > (Quest 1 – 4 %),
gain bonus points prop. to % improvement

Final Improvement Bonus Points
If (Final %) > (Midterm & Quest 1 – 5 %),
gain bonus points prop. to % improvement

Ex #1) Structures imply Instructor's growth-oriented messaging

What are your thoughts about the exam improvement bonus points?

[The teacher is] encouraging you to study and rewarding you for doing better. The fact that [they're] giving bonus points is good, because it's like **[they want] to see you improve**, and I think that the way [they're] giving bonus points is a completely fair way…It's like rewarding someone for working hard.

Agree or Disagree: "If I don't learn something the first time, I'll never be confident in that topic."

Karina

Disagree. I think the [exam improvement bonus points help] back up what I'm saying. **[The teacher] wants you to improve** from Quest to Quest. So if I don't do well on a particular topic on a Quest, if I work hard, if I study, if I understand it later on the midterm and the final, [the teacher is] going to reward me learning that. So it's not like I'll never be confident if I don't learn it the first time. **There's always room to grow.**

Phys A Office Hours
(“HW Club”)

Ex #2) Structures create opportunities for students to experience and believe in instructor's belonging messaging.

Do you ever find yourself comparing yourself to others?

Yeah. You know, it's hard, because you think that you're the only one struggling in this class, but, you know, when you go into office hours, you're really not. And that's just really shocking, you know?

The professor told us this [on] the first day. He stood up there [and said,] "you're going to struggle in this class at times, and there are other people struggling with you." And, I'm like, "nah, I don't think that's true."

Tom

But, you know, going to office hours and meeting these people…I'm like "holy cow." It's just mind blowing how, you know, you're not the only one alone. You're not the only one struggling with this concept or this class. And so, it's not boosting [my] well-being or anything like that. But it's just like, okay, it's a different feeling, that you're not the only one struggling.

Ex. #3) Structures support a sense of community and engagement among students in discussion sections

Q: In Phys A discussion sections, do you feel comfortable sharing your ideas and asking questions in your group?

Counts of high- and low-comfort ratings by course (N = 29 students).

	PhysA	Math	Chemistry	Engn.	Latin	Total
High-Comfort Course-Instances	28	11	7	1	1	48
Low-Comfort Course-Instances	1	9	4	0	0	14

Ouellette et al., under review

Ex. #3) Structures support a sense of community and engagement among students in discussion sections

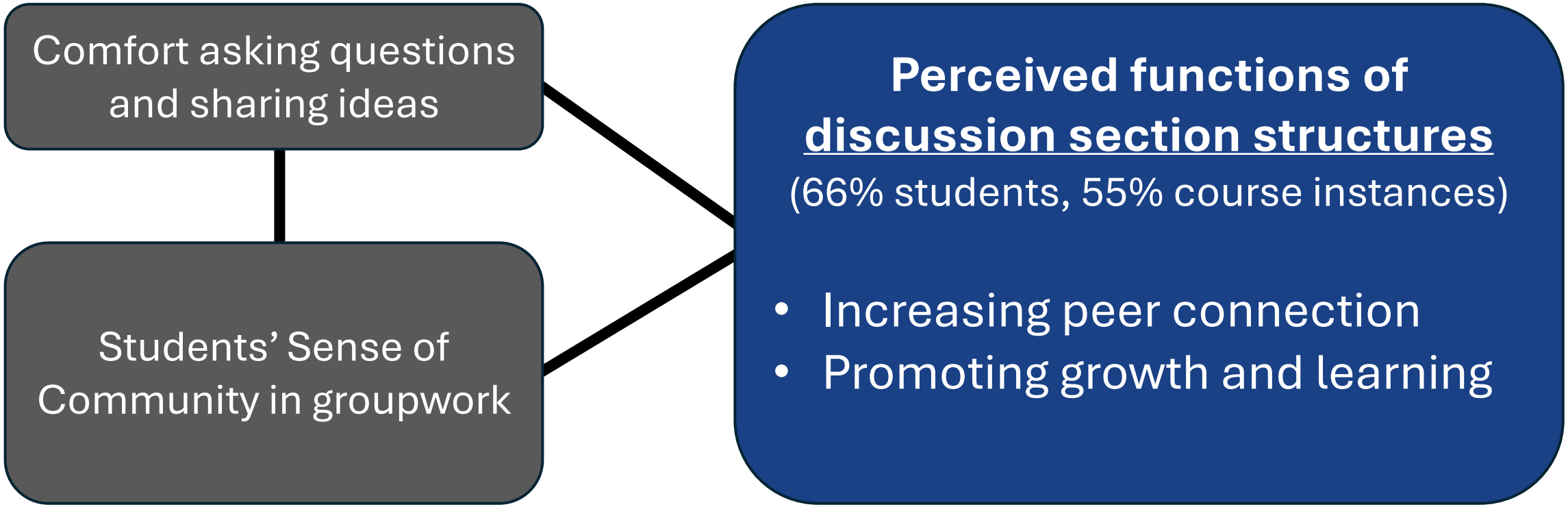
Comfort asking questions and sharing ideas

Students' Sense of Community (Sarason, 1974; McMillan & Chavis, 1986) **in groupwork**

- Personal connections with others
- Sense of "working together" collectively
- Expectation that others will help
- Low threat of judgment from others

Ouellette et al., under review

Ex. #3) Structures support a sense of community and engagement among students in discussion sections



Ouellette et al., under review

Sample of structures/functions

	Course Structure(s)	Perceived Function(s)
Supporting Peer Connection	Sitting at Tables; Working on Shared Whiteboards	Increase Peer Interaction
	Consistent, small groups	Decreased social cost; increased familiarity with peers
Promoting Growth and Learning	Course grading for improvement	Interpreting Errors as room for improvement
	Discussion grading: 90% participation, 10% correctness	Decreasing pressure incentivizes learning

Ouellette et al., under review

“Nexus” Structures

	Course Structure(s)	Perceived Function(s)
Supporting Peer Connection	Activities to explicitly discuss (fictional) students’ incorrect explanations.	Decrease Social Cost
		Increase Peer Interaction
		Decrease Competition/Hierarchy
Promoting Growth and Learning		Interpreting Errors as room for improvement
		Decreasing pressure incentivizes learning

Ouellette et al., under review

Intermediate Classical Mechanics

(114 students, mostly Physics/Astro majors)

- 13 student interviews, ~7 months after completing the course

3 key interview questions

- What was most helpful for your learning?
- What is something you'd like to see implemented in other courses?
- What advice would you give to someone about to take the course?

Intermediate Classical Mechanics

(114 students, mostly Physics/Astro majors)

Structure of office hours supports sense of community and engagement

Everyone from that class went [to office hours], so I made a lot of friends…If you were trying, there was no sense that you're dumb for asking a question.

Rishi

…in office hours, when someone understood something, they would write it on the board and explain it to whoever cares. That way you don't have to go and approach people, and that was helpful. [Office hours was] an environment where everyone wants to learn, and everyone was willing to help everyone learn. That was a big part of succeeding in that class.

Nevin

Structure of office hours supports sense of community and engagement

Office hours felt like a community, because we all had the same struggles, so we're all working together and getting to know each other.

There was a mutual understanding: "we're all in this together." We didn't hide things; we tried to help each other out…we had mutual respect with students in office hours, because you see the same students each week working hard, and you know that other students aren't just trying to get the answers from you. They also want to learn the best they can.

Anonymous

I’m excited about the prospects for structural messaging in PER.

1) Language for explicating instructional design considerations.

2) Research framework for studying (mis)alignments between teacher messaging and structural messaging.

3) Connections galore(!) to past/ongoing educational research.

Student attitudes/expectations/ personal epistemologies

"**If students are told** at the beginning of their first college course: 'In high school, you may have gotten away with memorizing equations without understanding them, but here that won't be enough' and if that mandate is **followed through in both assignments and grading**, students are more likely to be willing to put in the effort to change and grow."

- Redish, Saul, & Steinberg (1998). Student expectations in introductory physics. Am. J. Phys., 66(3), p. 222.

Complement to "out-of-curriculum" belief interventions

(see Walton & Wilson, 2018, *Psych. Rev.* on WISE interventions)

Research Article

aps ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

Psychological Science
1–12

DOI: 10.1177/0956797620929984
www.psychologicalscience.org/PS
SAGE

Changing Social Contexts to Foster Equity in College Science Courses: An Ecological-Belonging Intervention

Kevin R. Binning[1,2], Nancy Kaufmann[3], Erica M. McGreevy[3], Omid Fotuhi[1], Susie Chen[2], Emily Marshman[4], Z. Yasemin Kalender[5], Lisa B. Limeri[6], Laura Betancur[2], and Chandralekha Singh[7]

[1]Learning Research and Development Center, University of Pittsburgh; [2]Department of Psychology, University of Pittsburgh; [3]Department of Biological Sciences, University of Pittsburgh; [4]Department of Physics, Community College of Allegheny County; [5]Department of Physics, Cornell University; [6]Department of Biochemistry and Molecular Biology, University of Georgia; and [7]Department of Physics and Astronomy, University of Pittsburgh

Finding from Binning et al. (2020)

1-hr. activity improved avg. course grade for women in calc-based physics

ILLINOIS

Complement to "out-of-curriculum" belief interventions

(see Walton & Wilson, 2018, *Psych. Rev.* on WISE interventions)

<u>A need to change both mindsets and environments</u>

"…Sustained change may…require both a high-quality seed (an adaptive belief system conveyed by a compelling intervention) and conductive soil in which that seed can grow (a context congruent with the proffered belief system)."

Yeager et al. (2019). A national experiment reveals where a growth mindset improves achievement. *Nature*, 573(7774), 364-369.

Shifting conversations from student deficits to course deficits

(in)equitable performance outcomes can be mitigated by changing instruction/assessment structures (“course deficits”).

(e.g., Cotner & Ballen, 2017, *PLoS One;* Webb & Paul, 2023, *PRPER*)

Tue. March 17, 8:00 — 9:48 a.m.
Convention Center, Meeting Room 103
Education

Contributed Session | APR-G93

Research on Active Learning and Classroom Instruction

Topics: Physics Education Research, Education, Learning, General Physics, Data Analysis, Physics & Society, Biological Physics, Social Systems, Network Theory, Biophysics

- Catherine Crouch:
  What features of the course ecosystem (e.g., messaging, pedagogy, curricular choices) support IPLS student confidence and interest?

- Daria-Teodora Harabor:
  Overcoming social risks of asking questions in class using AI summaries of questions.

- Bruna Ribeiro:
  Correlation between social network connections and sense of belonging, suggested ”learning communities, collaborative study spaces.”

Where to go with structural messaging

- What new questions/models can it help us generate for research?
- Is this an “obvious” point or is it implicit/hidden knowledge?
- In what ways are we already investigating it?

Eric Kuo

Sarat Lewsirirat

Morten Lundsgaard

StruM

Structural Messaging in Physics Courses

Ellen Ouellette

Christina Krist
(Stanford University)

Vidushi Adlakha
(Indiana University – Indianapolis)

Thanks for Listening!

Questions?

This material is based upon work supported by the National Science Foundation under Grant Nos. 2100081 and 2235516.

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.