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ALPhA
Advanced Laboratories

Beyond the First Year
Summer2021
(Virtual)

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Mentoring Professional Collaboration and Communication in the Physics Laboratory

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Charlotte Zimmerman

29 July 2021

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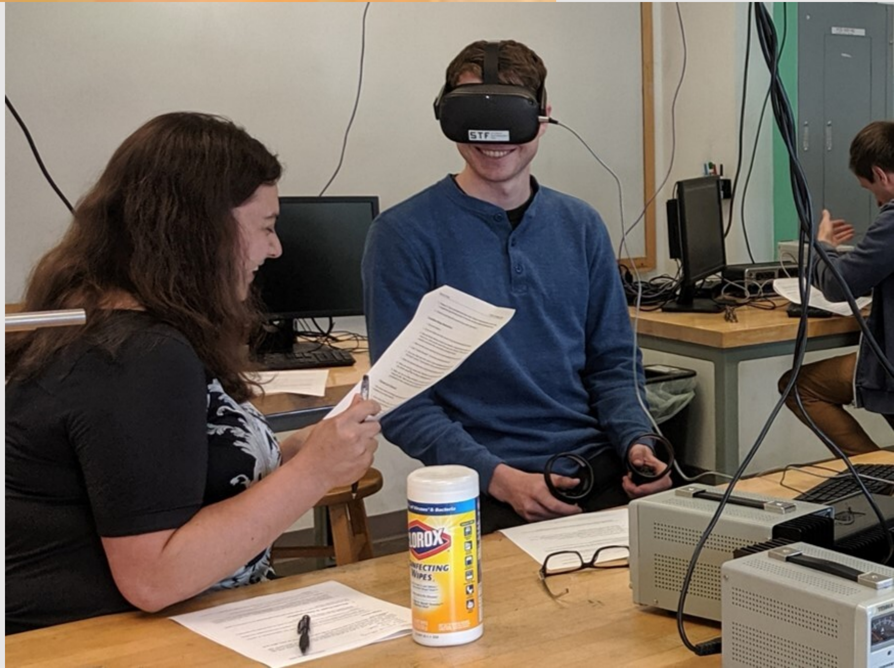
The team

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Acknowledgements and Support

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  - Student Technology Fee
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Roadmap

- What problem motivates this work?
- What does DBER research suggest?
- What are we doing?
- Are we having any success?

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Roadmap

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Solvay 1911 – the worlds first physics conference

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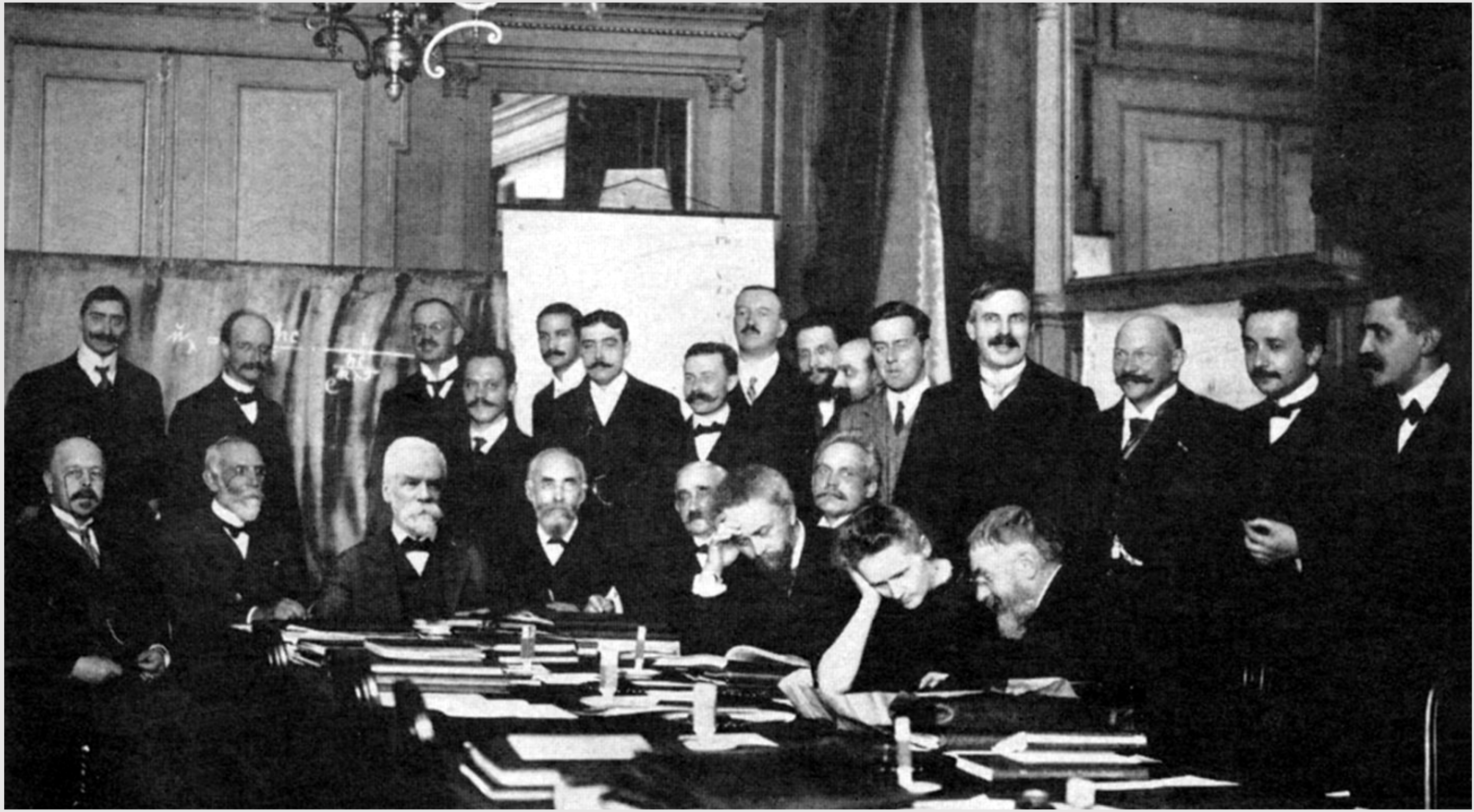

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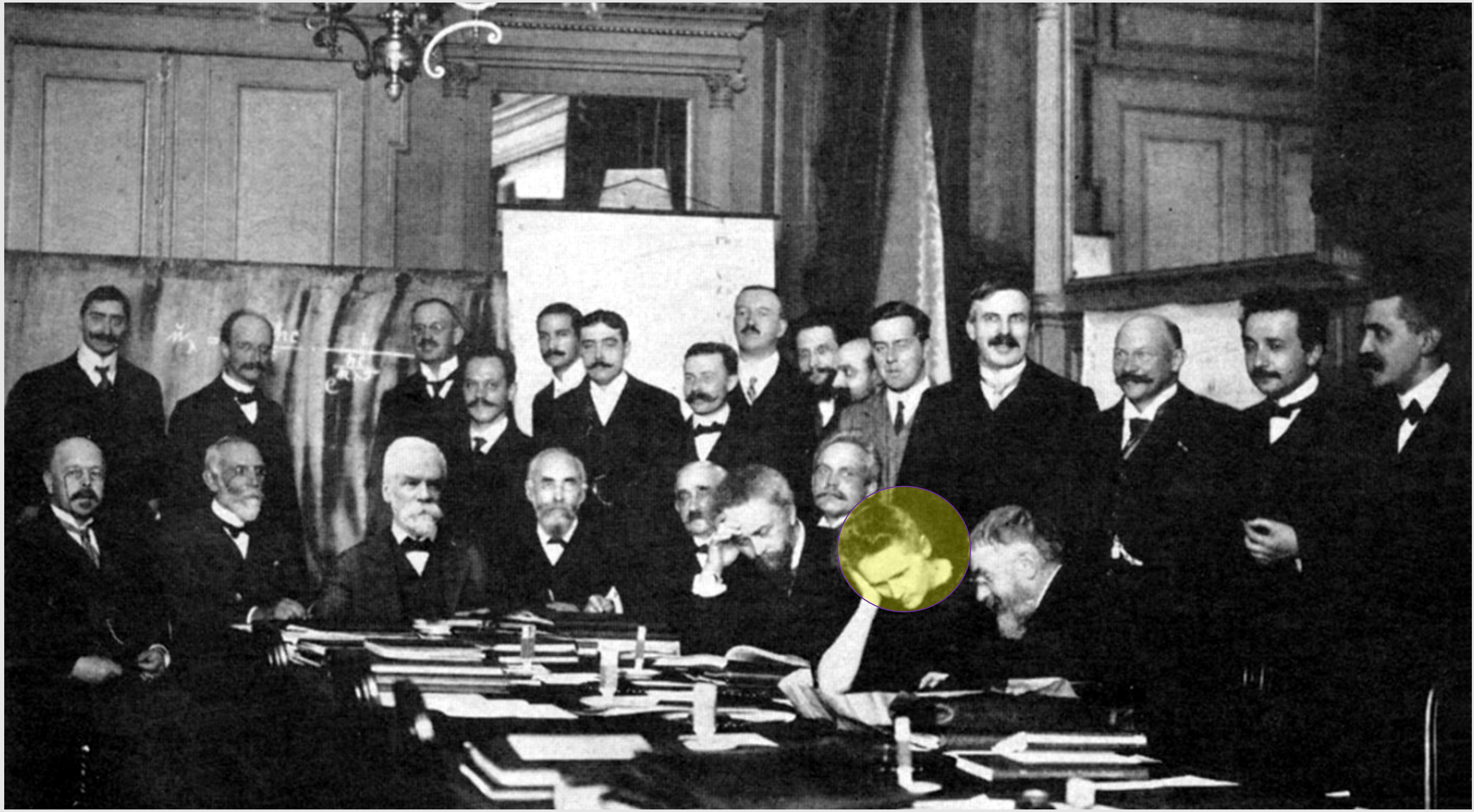

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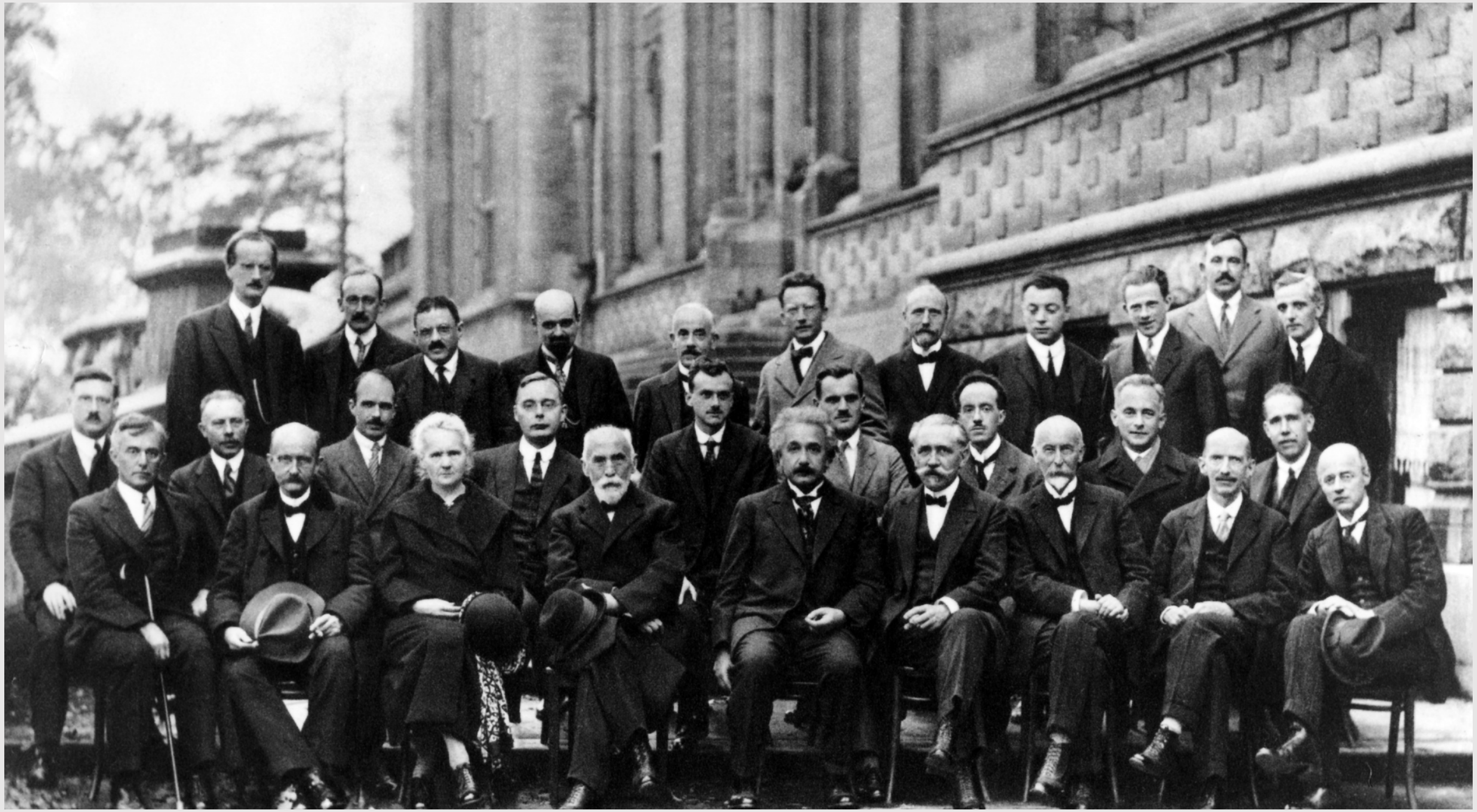
Solvay 1927



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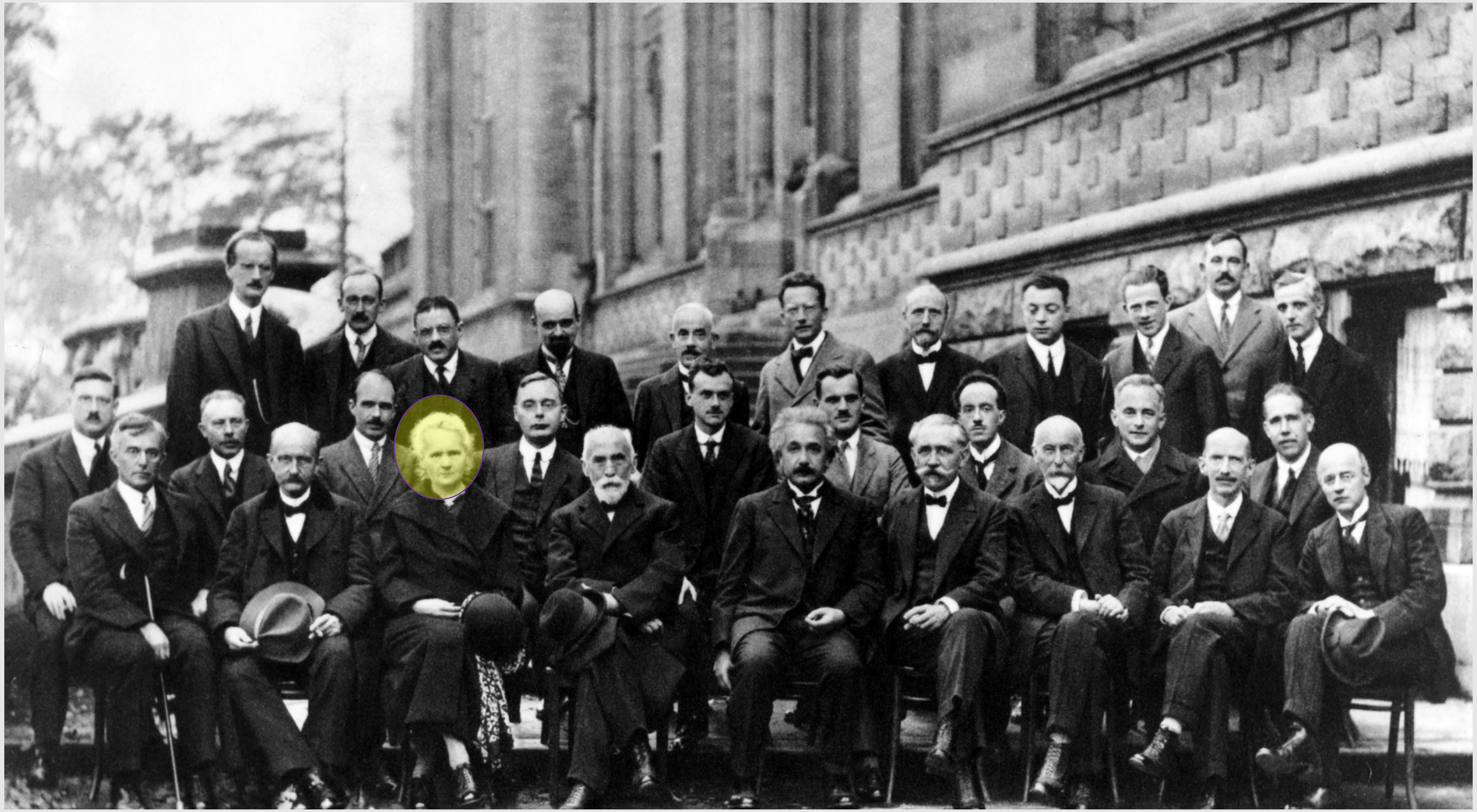
Solvay 1927



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Solvay 1933

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Solvay 1933

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Solvay 2011 – the centennial of the worlds first physics conference

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Solvay 2011 – the centennial of the worlds first physics conference

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Viewpoints

(Hazari & Potvin 2005)

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- Perhaps there is a biological foundation.
- Perhaps, as a subject, physics just naturally appeals to its current practitioners only.
- Perhaps there is an (unintended) bias in the culture of the physics community that favors the current majority by repelling the minority.

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Viewpoints

(Hazari & Potvin 2005)

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Characteristics - SES

	Top 20% (n_{sample}=98)	The rest (n_{sample}=363)
SAT_M	710	670
FCI % pre/change	65/+9	42/+9
Math Reasoning % pre/change	51/+4	43/-2
CLASS Problem Solving (Gen) % pre/change	71/-2	62/-10
CLASS Personal Interest % pre/change	73/0	65/-9
Average of the Median MHI High School	*Q*	0.9**Q* *p-value < .015*

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NJ school math and socioeconomics

(J.Anyon 1980)

MHI Quintile	Socioeconomic Status	Schoolwork culture
2nd	Working class	Work is evaluated for obedience to procedure. Students learn to imitate the teacher in math class.
3rd-4th	Middle class	Work is getting the right answer. Creative activities are occasional, for fun but not part of learning. Students are given some choice in math on which of two procedures to use to get an answer.
4th-5th	Affluent professional	Work is a creative activity carried out independently. The products of work should show individuality. Students gather data and use it to learn about mathematical processes.
Top 1%	Executive elite	Work is developing one' s intellectual powers; students invent ways to measure and calculate in math class.

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"The biggest obstacle to success is NOT limitation with math skills or knowing the definition of density···Its the institutional suppression of thinking."

-Richard Steinberg 2011

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Problem

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Most physics students,

and especially students from low SES high schools,

struggle to assimilate the habits of mind we model.

Many leave our courses with even less expert-like quantitative attitudes and habits than when they started.

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Roadmap

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- What problem motivates this work?
- **What does DBER research suggest?**
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Transmission mechanisms of cultural norms

(adapted from Hazari & Potvin 2005)

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- **Pedagogically:** through instructional practices, conveying what it means to do physics
- **Socially:** encouraging/discouraging through the structure, interactions, and treatment in the physics community

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Target characteristics of physicists

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- **Physics Identity:** Physics identity is important characteristics of all successful students. Reward and praise are essential to its development. *(Potvin & Hazari 2013, Hazari et. al. 2010, Stout et. al. 2012)*

how a person is viewed by self and others,

and how they want to be viewed

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how a person is viewed by self and others,

and how they want to be viewed

A strong physics identity is less likely for students from underrepresented groups (gender, race, ethnicity, socioeconomic status)

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how a person is viewed by self and others,

and how they want to be viewed

- **Self-efficacy:** Self efficacy is a significant predictor of success for all students. *(Sawtelle 2011)*

the extent or strength of one's belief

in one's own ability to succeed

at physics-related tasks

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First steps

(Hazari & Potvin 2005)

- change the social climate towards collaboration instead of competition
- rethinking physics curriculum and culture to include broad and diverse worldviews

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Theoretical framework: community of practice

(Wegner et. al. 1998, 2002)

- is a group of people who are active practitioners.
- made up of domain, community, and practices
- provides a way for practitioners to share tips and best practices, ask questions of their colleagues, and provide support for each other.

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Theoretical framework: community of practice

(Wegner et. al. 1998, 2002)

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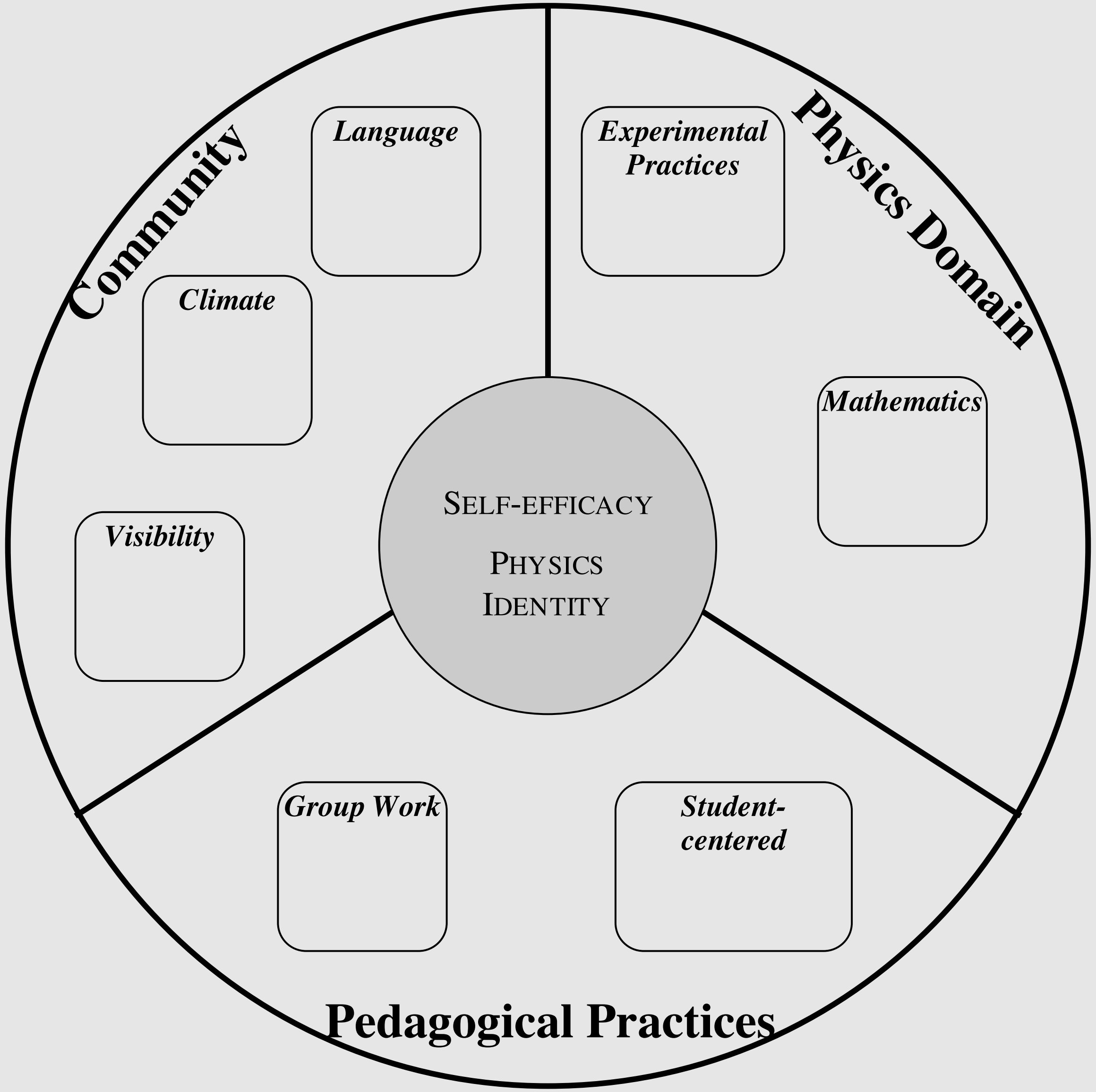

COMMUNITY OF PRACTICE

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micro aggressions and micro validations

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- aggressions: brief, everyday exchanges that send (unintended) denigrating messages to certain individuals because of their group membership
- validations: just the opposite
- no one event will make or break, but the accumulation can make a difference one way or another.

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Theoretical framework: community of practice

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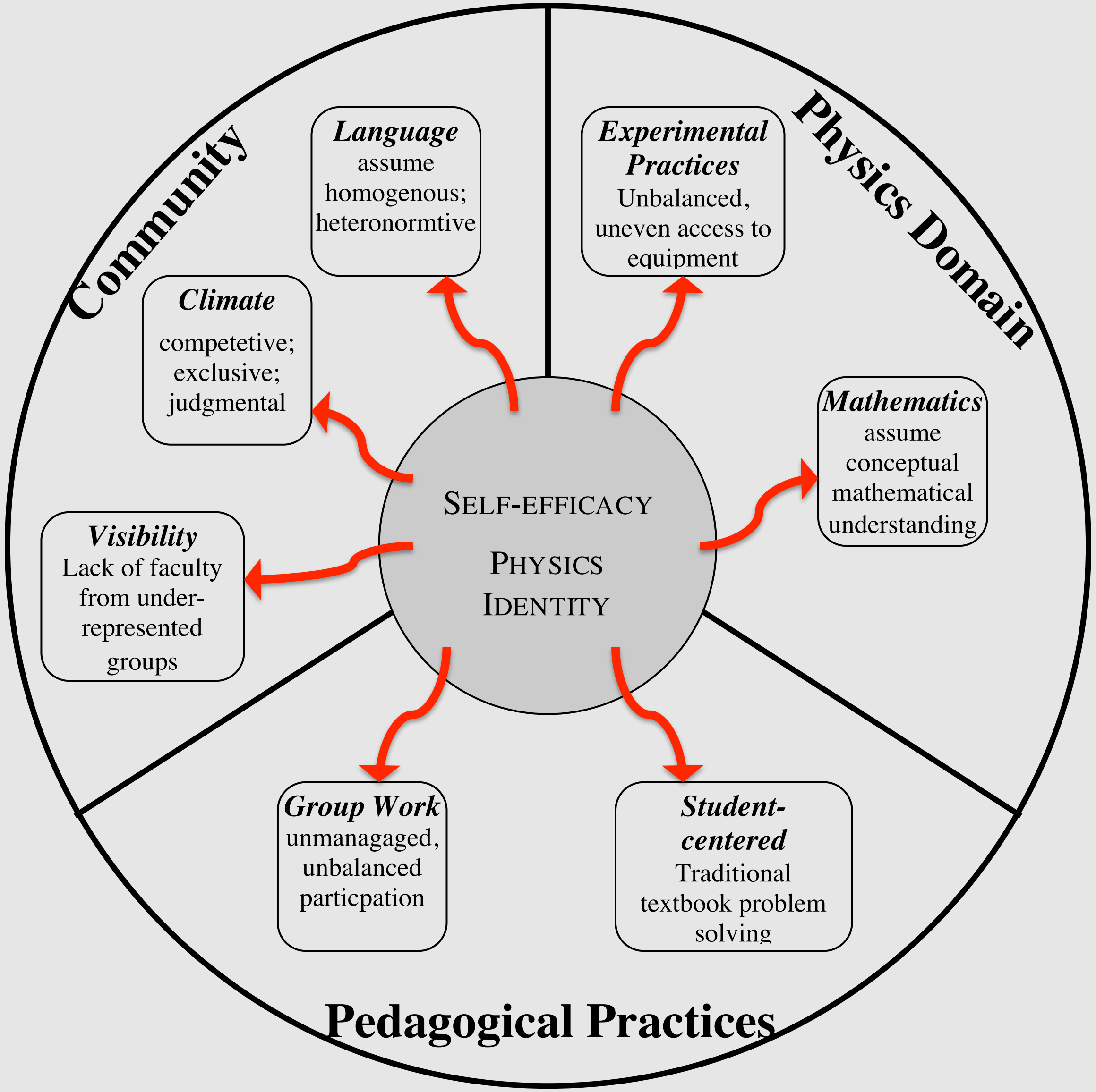

MICRO AGGRESSIONS

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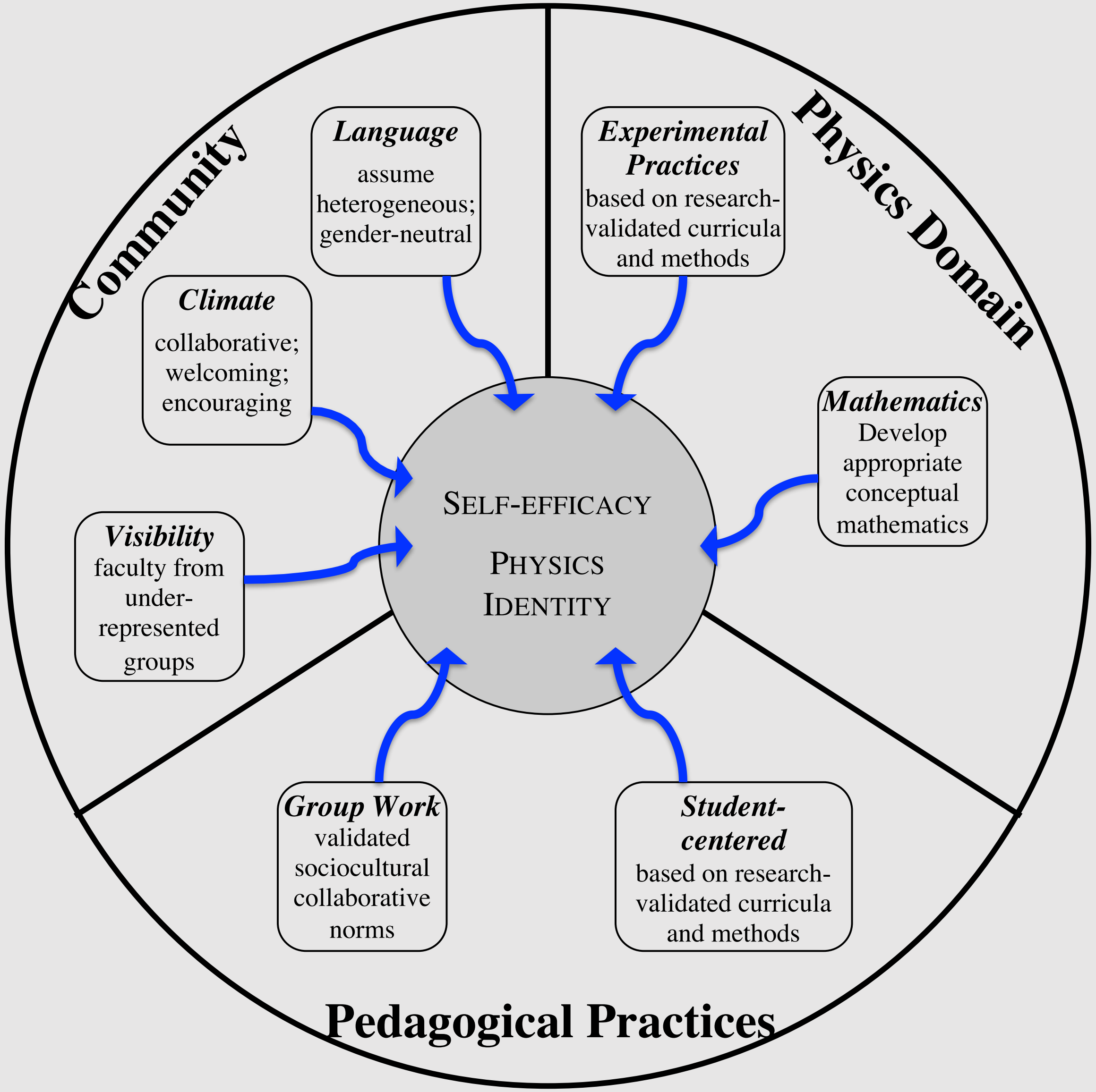
Theoretical framework: community of practice



MICRO VALIDATIONS

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Summary: Some suggested Practices

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- Group norms (code of conduct)
- Effective collaboration as a learning objective
- Authentic intellectual challenge
- Student-centered community of practice

Developing a community of practice

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Laboratory courses can:

- Foster self-efficacy in physics practices
- Enrich beliefs about the scientific practice
- Model a welcoming and inclusive community
- Help students develop professionalism

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Roadmap

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One attempt a reframing "successful" in the physics laboratory

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Context is a 200-level lab course: *Introduction to Experimentation*

- Learn to work on a team
- Ask scientific questions and design and conduct experiments to answer them
- Develop own methods for data reduction, modeling, error propagation
- Communicate through reports and presentations
- **There is no designated physics context associated with this lab**

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One attempt a reframing ”successful” in the physics laboratory

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I. Shift in learning objectives and assessment from individual to Collective Intelligence

- independent of the average IQ of its members
- depends on equitable #words spoken per member, and average social intelligence of group members

(Woolley, Chabris, Pentland, Hashmi, Malone in Science 2010)

II. Develop self-efficacy through engagement in a community of experimental physics practices

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Mentoring and Managing Collaboration

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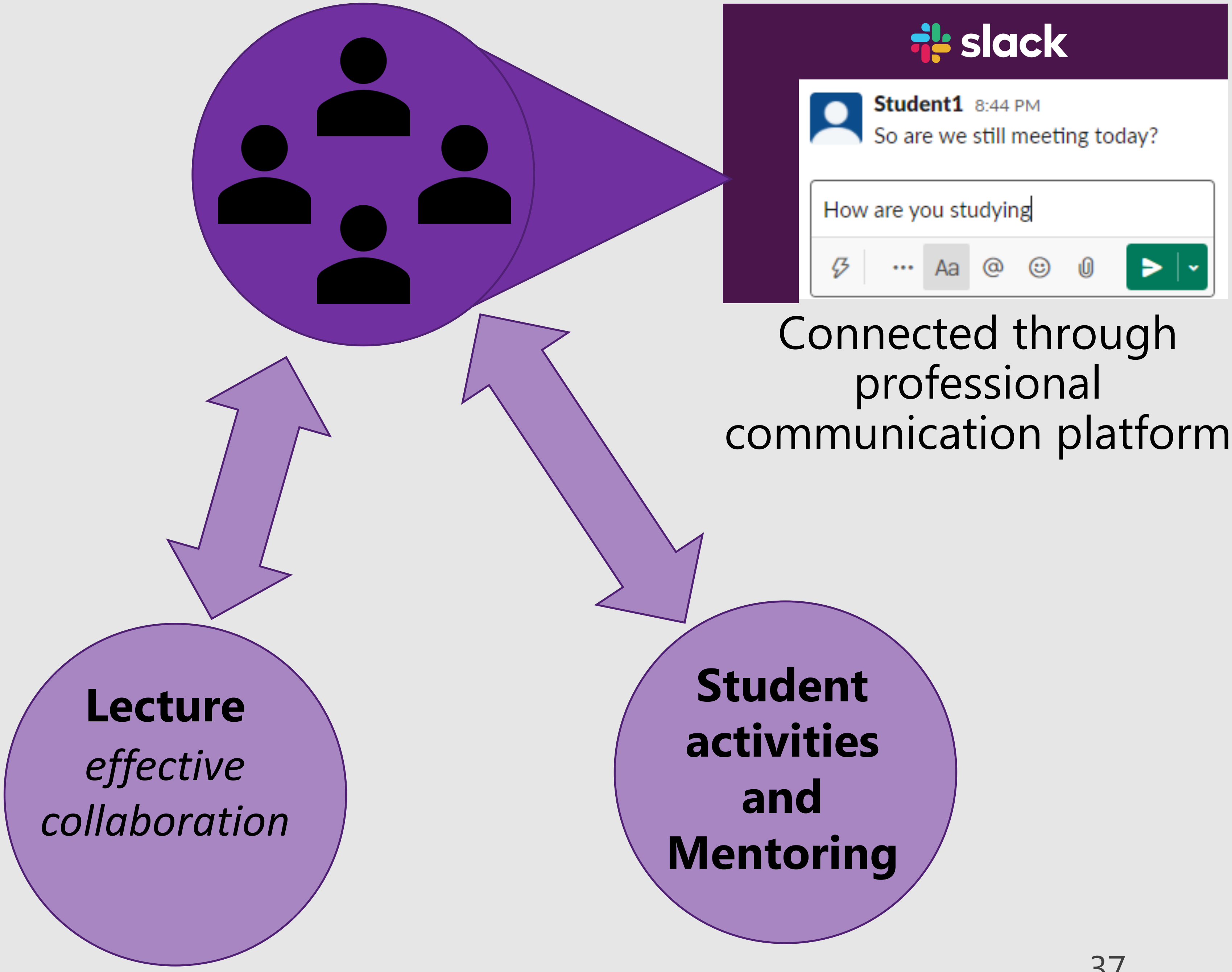
I. Fostering CI through Community of Practice

- Dedicated lecture time throughout the course to learning about effective collaboration
- Professional communication platform (Slack)
- Student activities:
  - Code of conduct
  - Teamwork agreements
  - Group roles with scripts
- Mentoring: management and guidance

Student driven community of practice



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GROUP ROLES AND ACTIONS	WHAT IT SOUNDS LIKE
Meeting Manager •Direct the sequence of steps. •Keep your group "on-track." •Make sure all group members participate. •Watch the time spent on each step.	"Let's come back to this later if we have time." "We need to move on to the next step." "What do you think about this idea?"
Recorder/checker •Act as a scribe for your group. •Check that all group members are able to effectively use Slack and Zoom •Check for understanding of all members. •Make sure all members of your group agree on plans and actions. •Make sure names are on group products.	"Do we all understand this diagram?" "Are we in agreement on this?"
Skeptic •Help your group avoid coming to agreement too quickly. •Make sure all possibilities are explored. •Suggest alternative ideas.	"What other possibilities are there?" "Let's try to look at this another way." "I'm not sure we're on the right track."

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Scripts!

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Learning as a Sociocultural Outcome

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II. Community of experimental physics practices

- processes of experimental physics, including **student designed experiments** (Etkina et al, 2007)
- Data reduction/modelling **constructed** through invention activities (Schwartz et al 2011, Day et. al 2010)
- **.Collaborative Report writing**

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Model Creation Curriculum

(Etkina, E. 2015)

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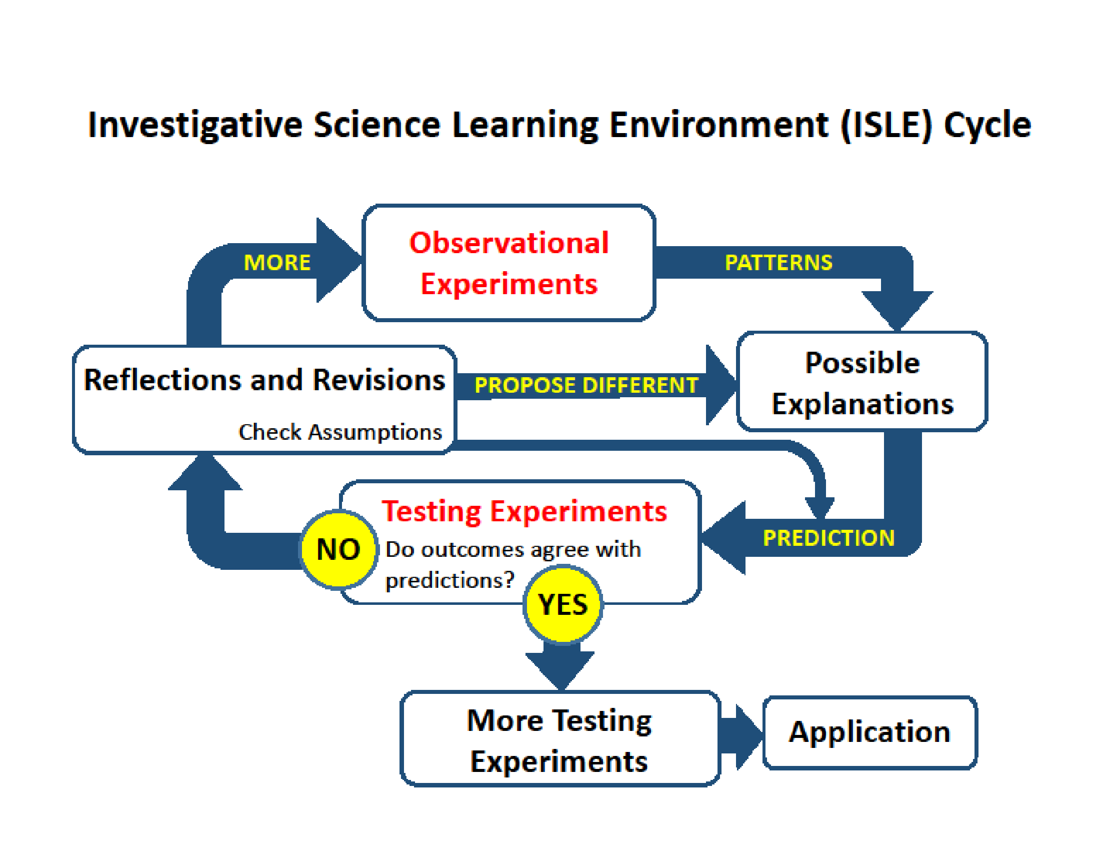
- Under the ISLE framework, **observational experiments** are a place for open-minded exploration and creation of a model



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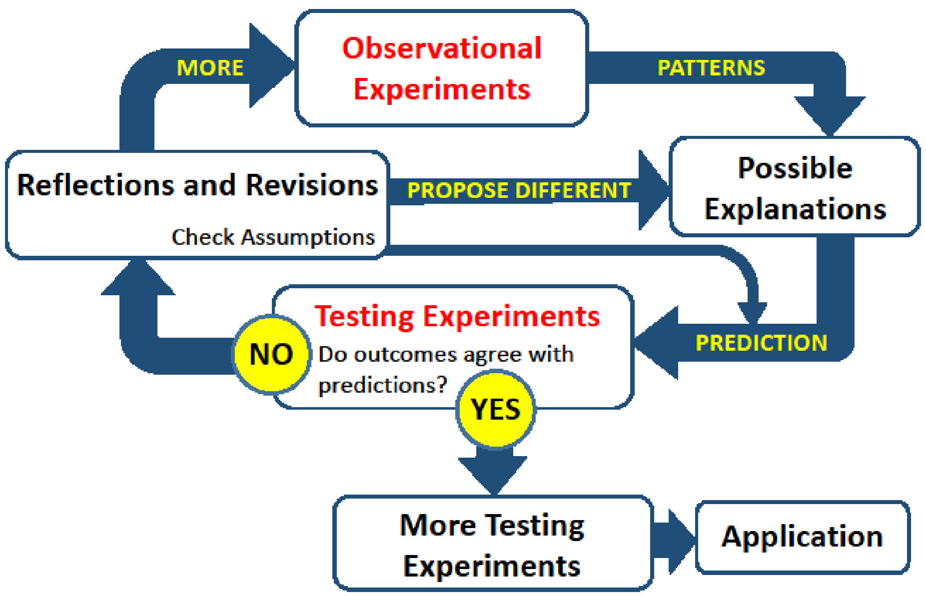
Model Creation Curriculum

- Observational experiment activities are hard to design
- Anything accessible is a known phenomenon with known answers

Investigative Science Learning Environment (ISLE) Cycle



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Model Creation Curriculum

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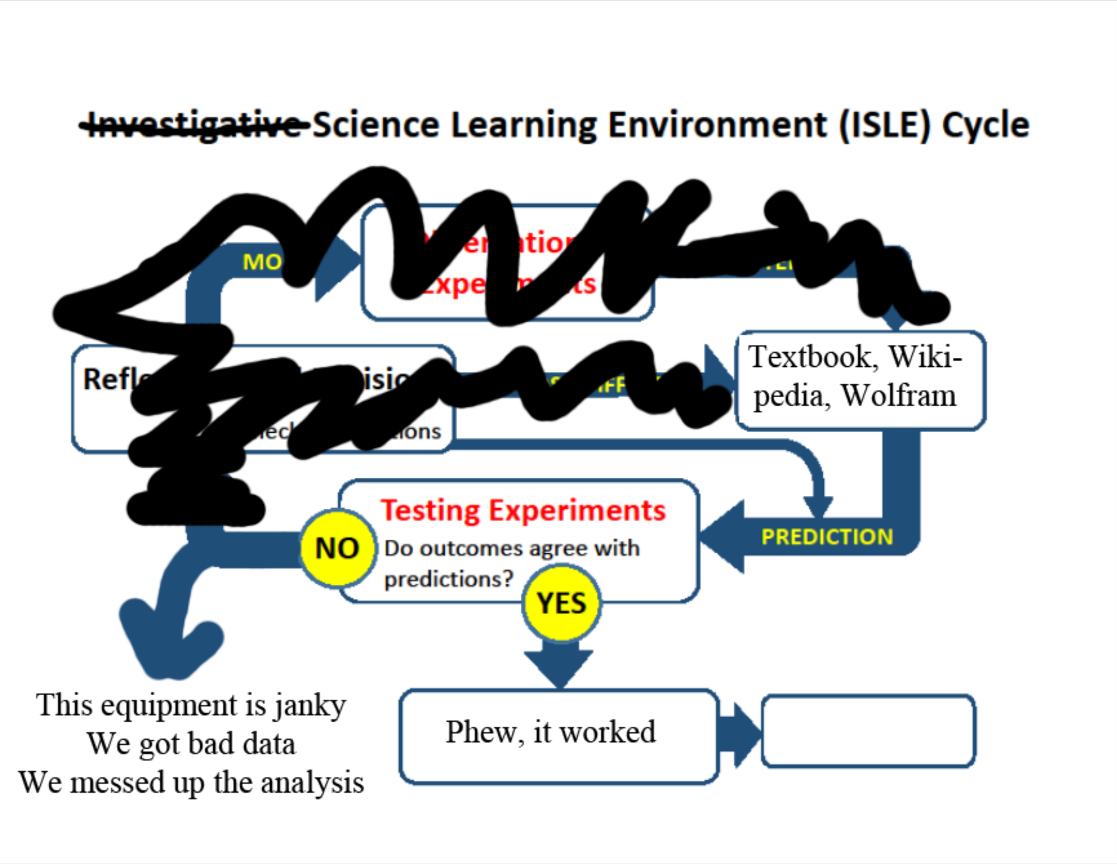
- Observational experiment activities are hard to design
- Anything accessible is a known phenomenon with known answers
- Students are conditioned to confirm known answers in science labs



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NOMR: Novel Observations in Mixed Reality

Intervention: NOMR Labs

(Canright et al., 2020)

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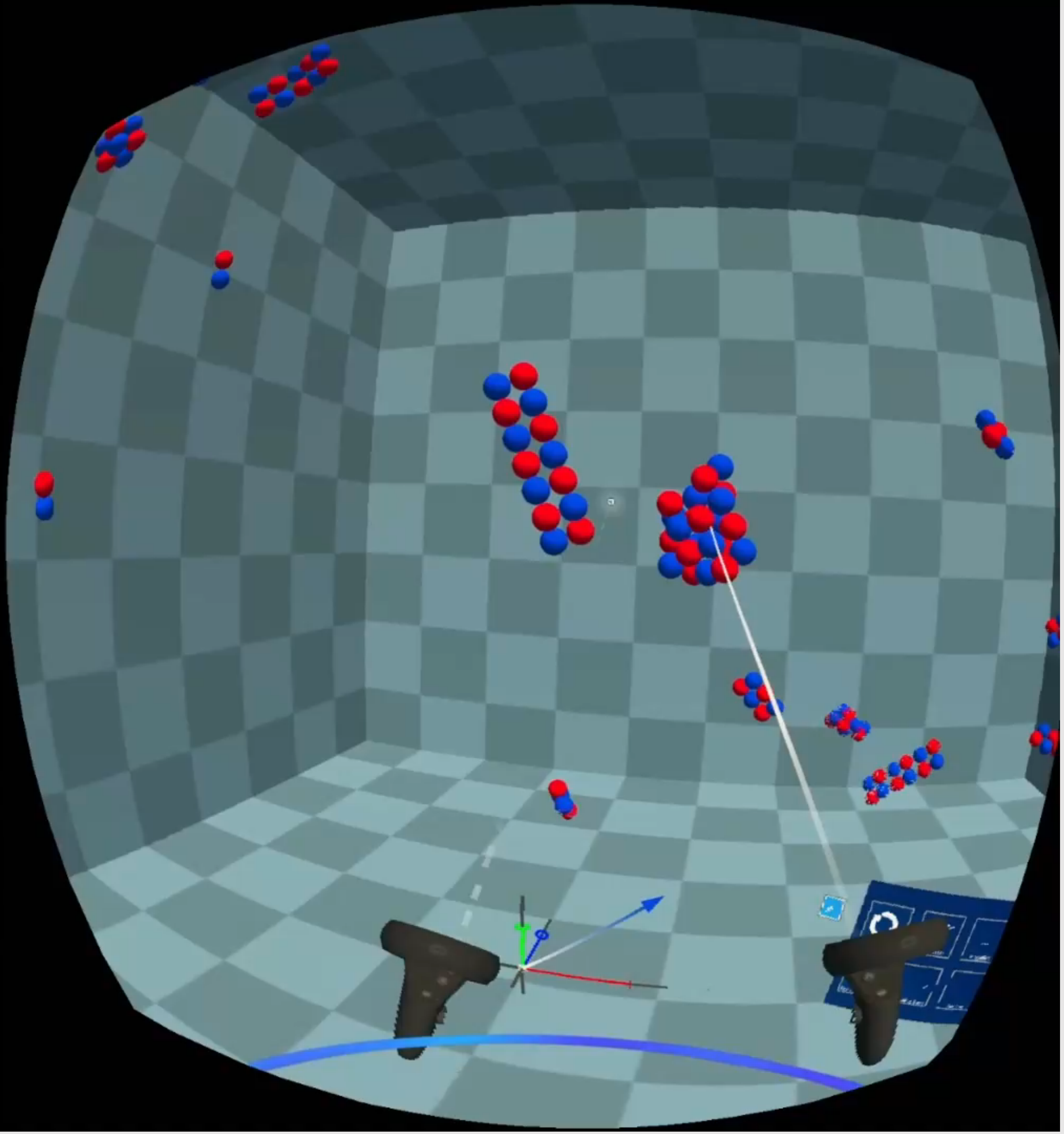
- Students explore fictitious physical phenomena in an immersive 3D environment
  - Hands-on
  - Experimental uncertainty present
  - "Answers" never shared
  - Phenomena consistent with known physics



Roadmap

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Early indications of some success: *Measures of some effects of collaboration*

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Engagement

(Wilson, 2020)

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Engagement With TAs

- Mitigates anxiety
  - related to lower success in engineering
  - correlated with being from underrepresented group
- Reward and praise are important to development of **strong physics identity**

Student-to-student engagement

- Sharing experiences mastering material can build **self efficacy**, particularly for women

(Sawtelle, Brewe, Goertzen, Kramer, 2012)

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Measuring Engagement

(El Hady et al., 2020)

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1. Messaging activity in Slack → Student-to-student engagement

Average messaging activity per week per person

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Measuring Engagement

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1. Messaging activity in Slack → Student-to-student engagement

Average messaging activity per week per person

- Activity over 10 ; nearly three times the activity as the comparison intro mechanics course
- We attribute this difference to collaborative graded reports and presentation

Measuring Engagement

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1. Messaging activity in Slack → Student-to-student engagement

Average messaging activity per week per person

2. Survey Items

5-point Likert Scale questions:

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
Interpreted value	-2	-1	0	+1	+2

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Survey Items: Engagement

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Engagement with TAs :

- At least one TA in this class cares about how much I learn.

Student-to-student Engagement

- I have found students in this class with whom I am comfortable working.
- I feel comfortable sharing ideas with other students I’ve worked with, even if I'm not sure my ideas are fully correct.

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Engagement Item results

Item (emphasis added)	Intro Mechanics ±(0.04)	Intro to Experiment ± (0.09)
At least one TA in this class cares about how much I learn.	+1.31	+1.31
I have found students in this class with whom I am ***comfortable*** *working.*	+0.86	+1.21
I feel ***comfortable*** *sharing ideas with other students I've worked with, even if I'm not sure my ideas are fully correct.*	+0.92	+1.25

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Early indications of some success: *Impact of science practices focus*

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Study Details

Instructional Context:

- 100-level honors electromagnetism lab, Winter quarter 2021
- Groups of 3-4 students
- 37 students, mostly freshmen

Software: *NOMR software developed in Unity in-house*

Hardware: *Oculus Quests lent to 1 student per group, streamed over Zoom*

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Understanding Student Lab Work Epistemology

(Hu and Zwickl 2017)

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- Hu and Zwickl developed a student epistemology assessment consisting of four free-response questions:

1. Why are experiments a common part of physics classes?

1. Supplemental learning
2. Theory testing
3. Foundation of physics
4. Scientific abilities
5. Science appreciation
6. Career preparation

2. Why do scientists do experiments for their research?

1. Theory testing
2. Discovery
3. Theory development
4. Technology advancement

3. What defines a scientific theory?

1. Evidence supported
2. Explanatory and predictive power
3. Quantitative aspect

4. How do theory and experiment relate?

1. Experiment tests theory
2. Theory explains experiments
3. Experiment inspires theory
4. Theory guides experiment

Results

(Canright et al., 2021)

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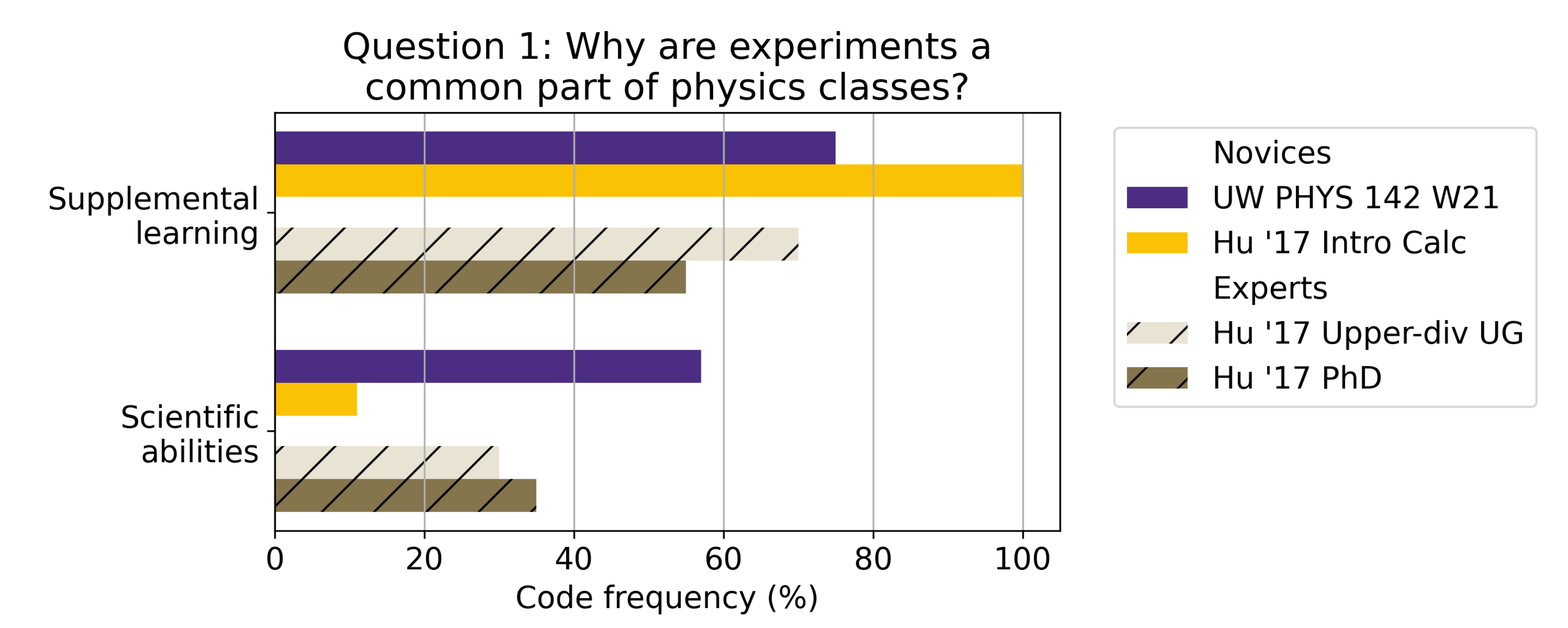
Compared to Hu and Zwickl and Zwickl '17, study participants:

1. See the role of instructional labs more to teach scientific abilities and less as a supplement to lecture learning



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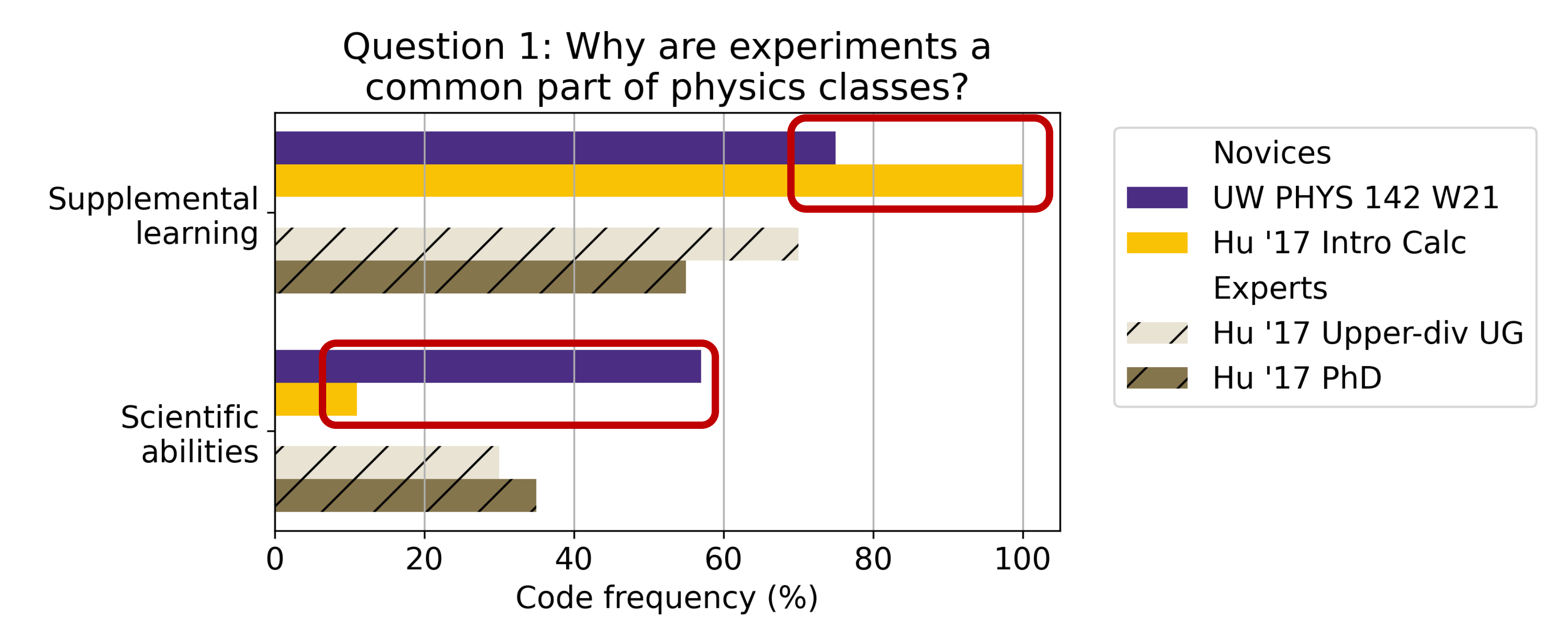

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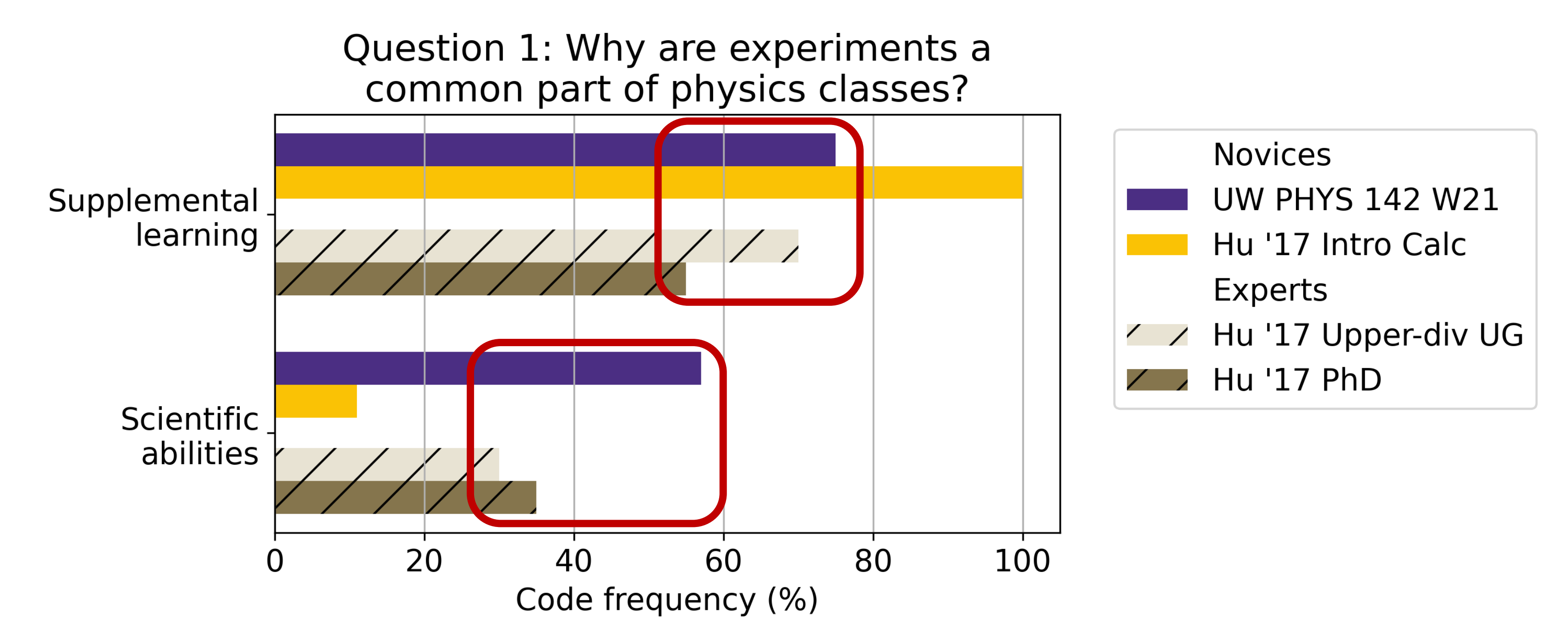

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Compared to Hu and Zwickl '17, study participants:

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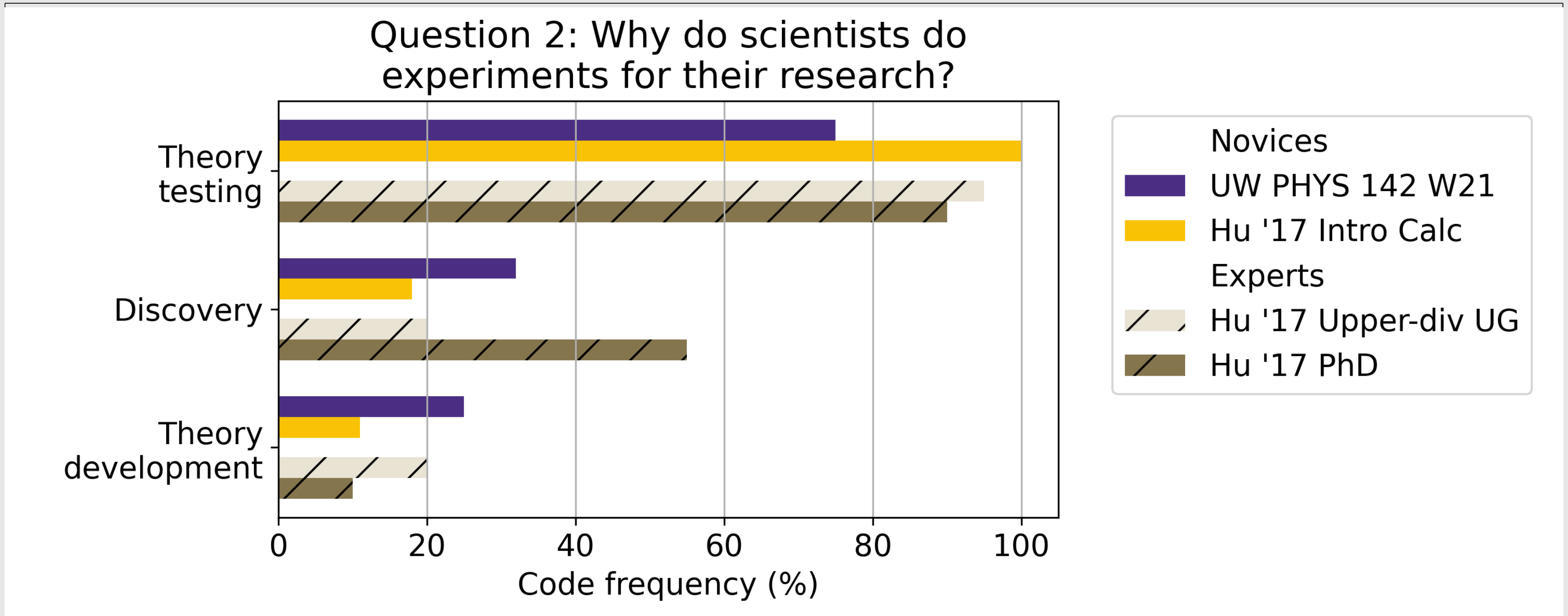
2. See experimentation in science not just as a means to test theories, but also to discover and develop them



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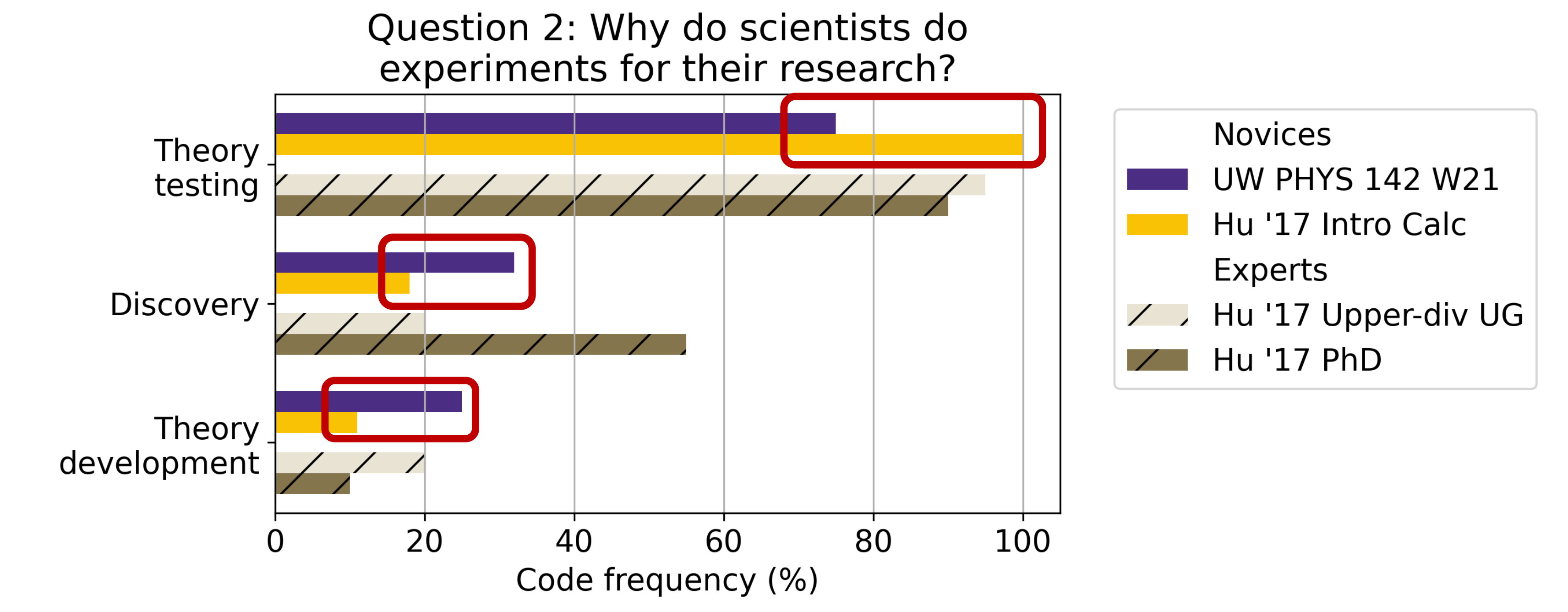

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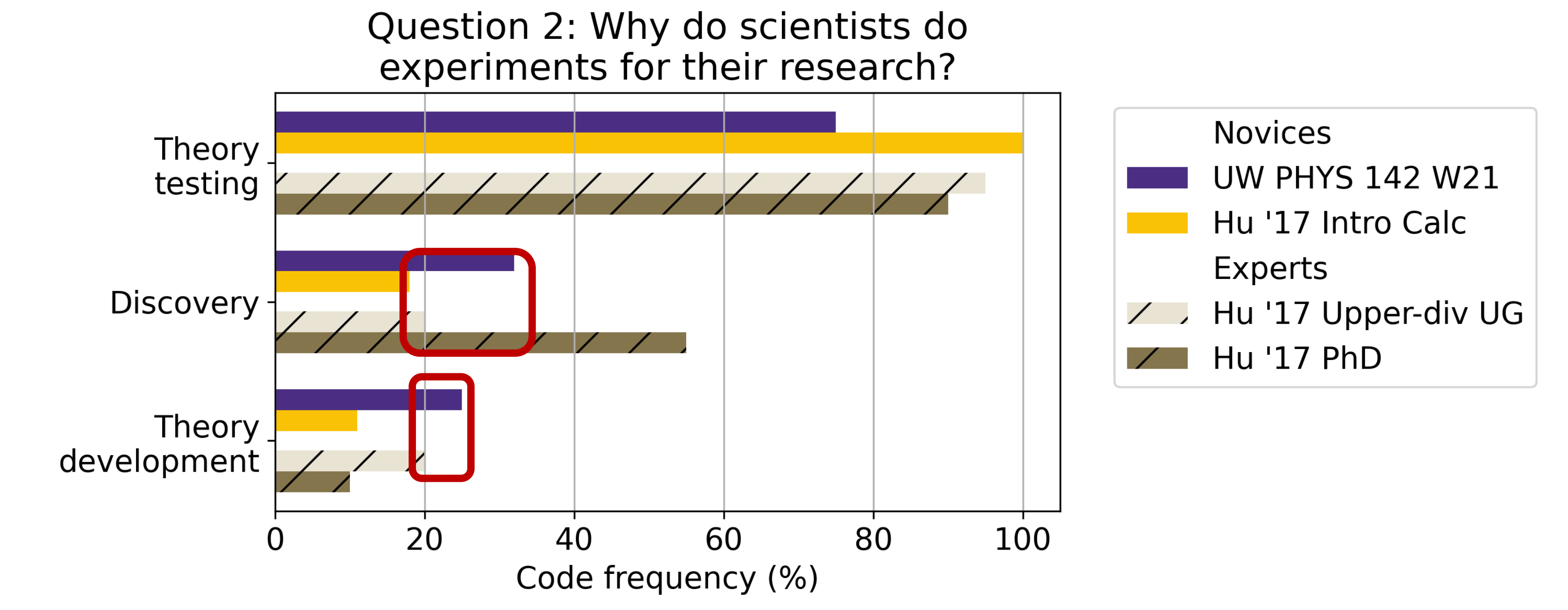

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Summary of findings

Contact: *brahmia@uw.edu*

- **Pedagogically:** through instructional practices, conveying what it means to do physics

- **Socially:** encouraging/discouraging through the structure, interactions, and treatment in the physics community

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Summary of findings

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- **Pedagogically:** through instructional practices, conveying what it means to do physics
  - *Creative practices of authentic science shows evidence of shifting epistemology*
- **Socially:** encouraging/discouraging through the structure, interactions, and treatment in the physics community

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  - ➢Creative practices of authentic science shows evidence of shifting epistemology
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  - ➢*Student mediated community of practice shows promise of fostering engagement*

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Summary of findings

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- **Pedagogically:** through instructional practices, conveying what it means to do physics
  - Creative practices of authentic science shows evidence of shifting epistemology
- **Socially:** encouraging/discouraging through the structure, interactions, and treatment in the physics community
  - *Student mediated community of practice shows promise of fostering engagement*

Effective collaboration needs ongoing management. TAs need training in group management

Closing thoughts

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- The laboratory is an excellent space for broadening our message of "successful in physics."
- Creating professional spaces in which it is normal to experience both hardship and success serves a more diverse group of students in physics.
- Mentoring students in being generous and adaptive to a variety of collaborative challenges helps prepare them for success in the workplace.

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"Making Physics More Inclusive and Eliminating Exclusionary Practices in Physics"

https://www.compadre.org/per/conferences/2021/