Transforming the preparation of physics GTAs

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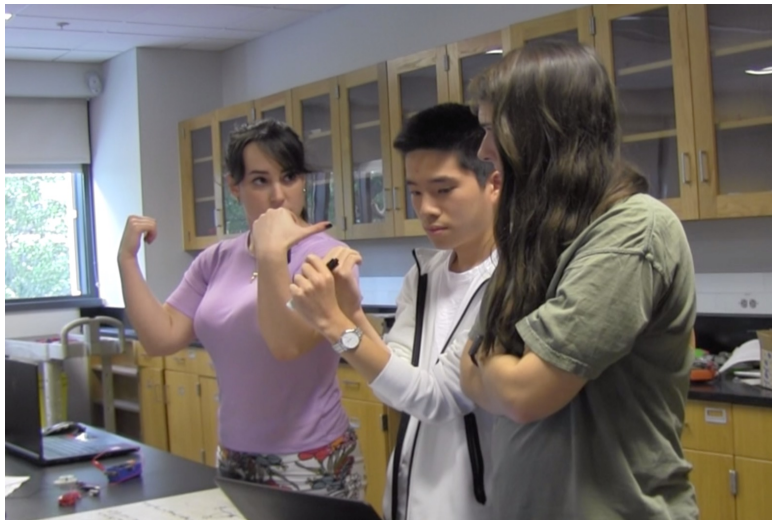
The need for TA preparation

- Undergrads in large-enrollment intro physics classes can spend up to half of their in-class contact hours supervised by TAs (labs, studios, tutoring…)
- TAs have the potential to have large impact on undergrad student learning
- TAs are novice teachers, many have zero prior teaching experience
- **TAs need preparation for teaching!**



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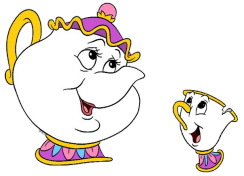
Tale as old as time…

"In his inaugural oration as first president of Johns Hopkins University in **1876**, Daniel Coit Gilman expressed the pious hope that graduate schools would help to develop the teaching ability of future professors. This hope has remained largely unfulfilled to date."

Charles Süsskind, American Journal of Physics, 25(3), **1957**



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1970 and earlier

Logistics for teaching labs, basics of pedagogy, peer observations, video recording

Ohio U
[AmJPhys, 39, 1971]

U Missouri
[AmJPhys, 42, 1974]

Kansas State
[AmJPhys, 42, 1974]

UC Berkeley
[AmJPhys, 43, 1974]

Temple U
[AmJPhys, 46, 1978]

1980

First meta-analyses of GTA prep research; calls for more systematic research

Carroll
[J Higher Ed, 51, 1980]

Abbott et al
[New Directions for Teaching and Learning, 39, 1989]

1990

PER, concept inventories, active learning; first long-lasting GTA prep programs

Lawrenz et al
[J College Science Teaching, 22, 1992]

Hestenes et al
[TPT, 30, 1992]

Hake
[AmJPhys, 66, 1998]

Redish & Steinberg
[Physics Today, 51, 1999]

2000 and beyond

[hundreds of references]

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TA preparation works!

- Research shows* that training improves TAs' **confidence** and **self-efficacy**, enhances TAs' **pedagogical content knowledge**, and can result in the adoption of **learner-centered** teaching strategies
- STEM TAs benefit from **discipline-specific preparation**, and teaching improves their **methodological research skills**
- TAs need to receive guidance on **logistics** such as classroom management and grading, and must have the opportunity to **practice** and **receive feedback** on their performance, both before and during their teaching

* Alicea-Muñoz, PhD Dissertation, Chapter 2; Georgia Tech (2020)
https://smartech.gatech.edu/handle/1853/62714

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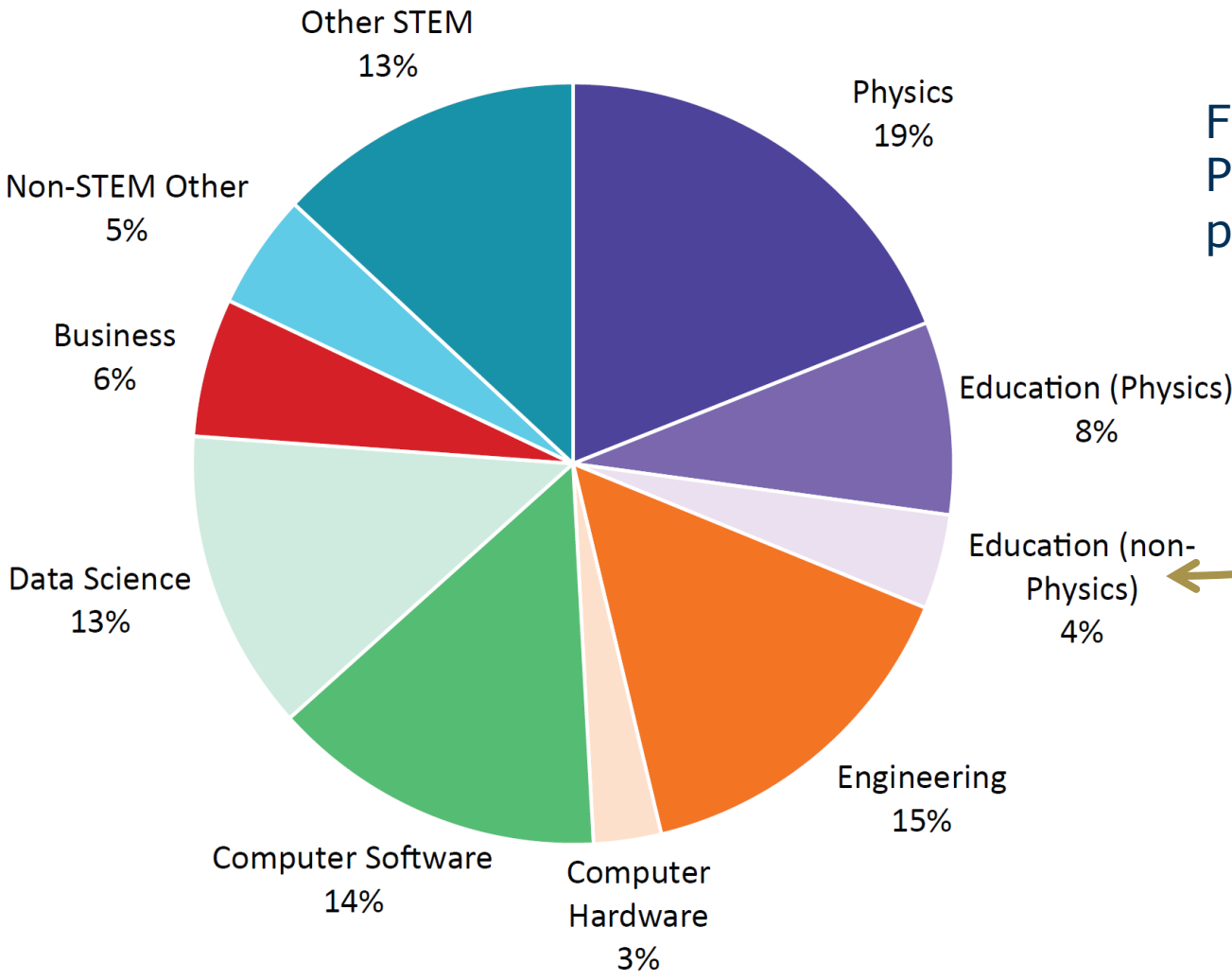
A majority of physics PhDs leave academia



Field of employment for new physics PhDs in potentially permanent positions, classes of 2016 to 2020

academic positions are only **12%** of all new physics PhDs

https://www.aip.org/statistics/whos-hiring-physics-phds

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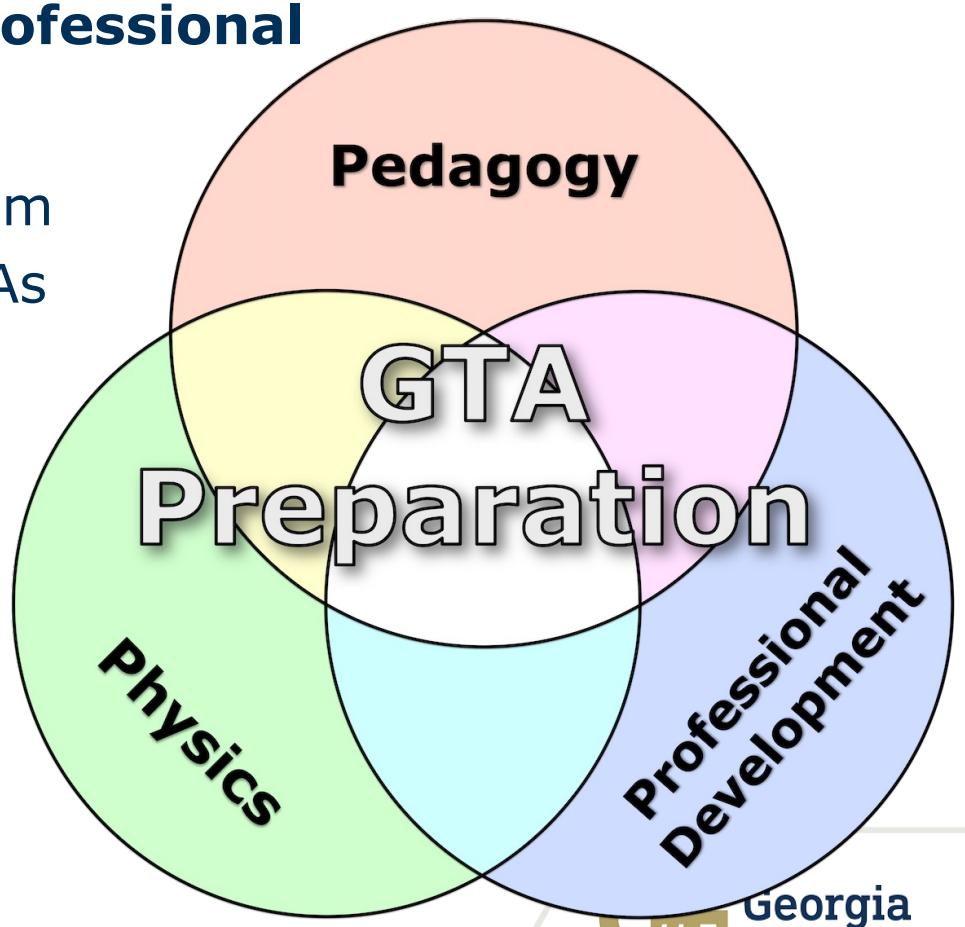
New Perspective on GTA Preparation

- We want to produce GTAs who are **motivated** and **effective** teachers
- We also want to help GTAs develop **transferable professional skills** they can use outside the classroom
- **3P Framework*** – to have a comprehensive program for GTA preparation that is useful and valuable for TAs in the classroom and beyond there must be full integration between:
  - **Pedagogy** – the methodology of teaching
  - **Physics** – content and PCK
  - **Professional Development** – transferable skills useful inside and outside academia



* Alicea-Muñoz et al, Phys. Rev. Phys. Educ. Res. 17, 020125 (2021)

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Research Questions

1. What elements of a formal GTA preparation program do GTAs perceive as the **most useful** or beneficial for their professional development?

2. What effect does a formal GTA preparation program have on graduate students' **teaching self-efficacy** and **attitudes** about teaching?

3. Does a formal GTA preparation program have an effect on graduate students' **teaching effectiveness**?

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At GT Physics before 2013…

- TA training before semester:
  - General GTA Orientation (policies)
  - Meeting with GTA Supervisors (logistics)
- TA training during semester:
  - Weekly lab meetings and/or communication email (content)
  - Pedagogy seminars (outsourced)

Problems!

- Disconnect between pedagogy and content
- Lack of pedagogical reinforcement
- Lots and lots of complaining
- GTAs provided with no motivation
- No apparent relevance for professional goals

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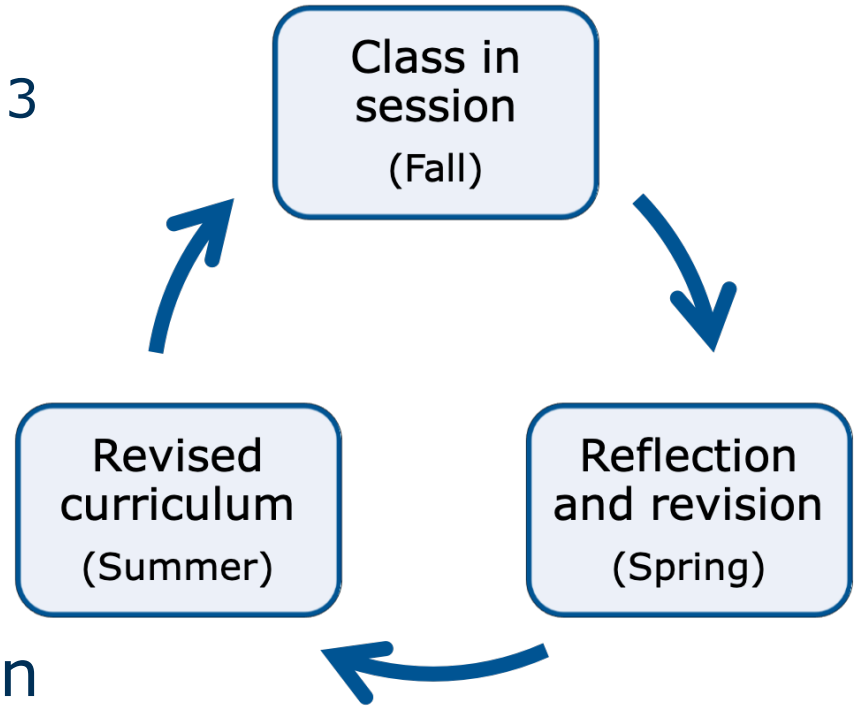
Physics GTA Preparation Course

- One credit, pass/fail, required for first-time GTAs (mostly first-year PhD students), offered every Fall semester
  - Over 200 grad students have participated since 2013
- Course design follows best practices for GTA preparation found in research literature
- Curriculum development follows a yearly cycle of implementation and revision, based on assessment data and self-reflection



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Course Structure and Content

Orientation
(before semester starts)

1. Introduction & GT Policies
2. Teaching Physics
3. Classroom Management
4. Lab Simulation
5. Microteaching

(~15 hrs)

Follow-Up Meetings
(during Fall semester)

1. Grading
2. Midterm Evaluations & Time Management
3. Teaching Videos
4. Teaching and Research
5. Concluding Remarks

(~5 hrs)

Out of class activities: Classroom Observations, Workload Surveys, Mentoring Meetings

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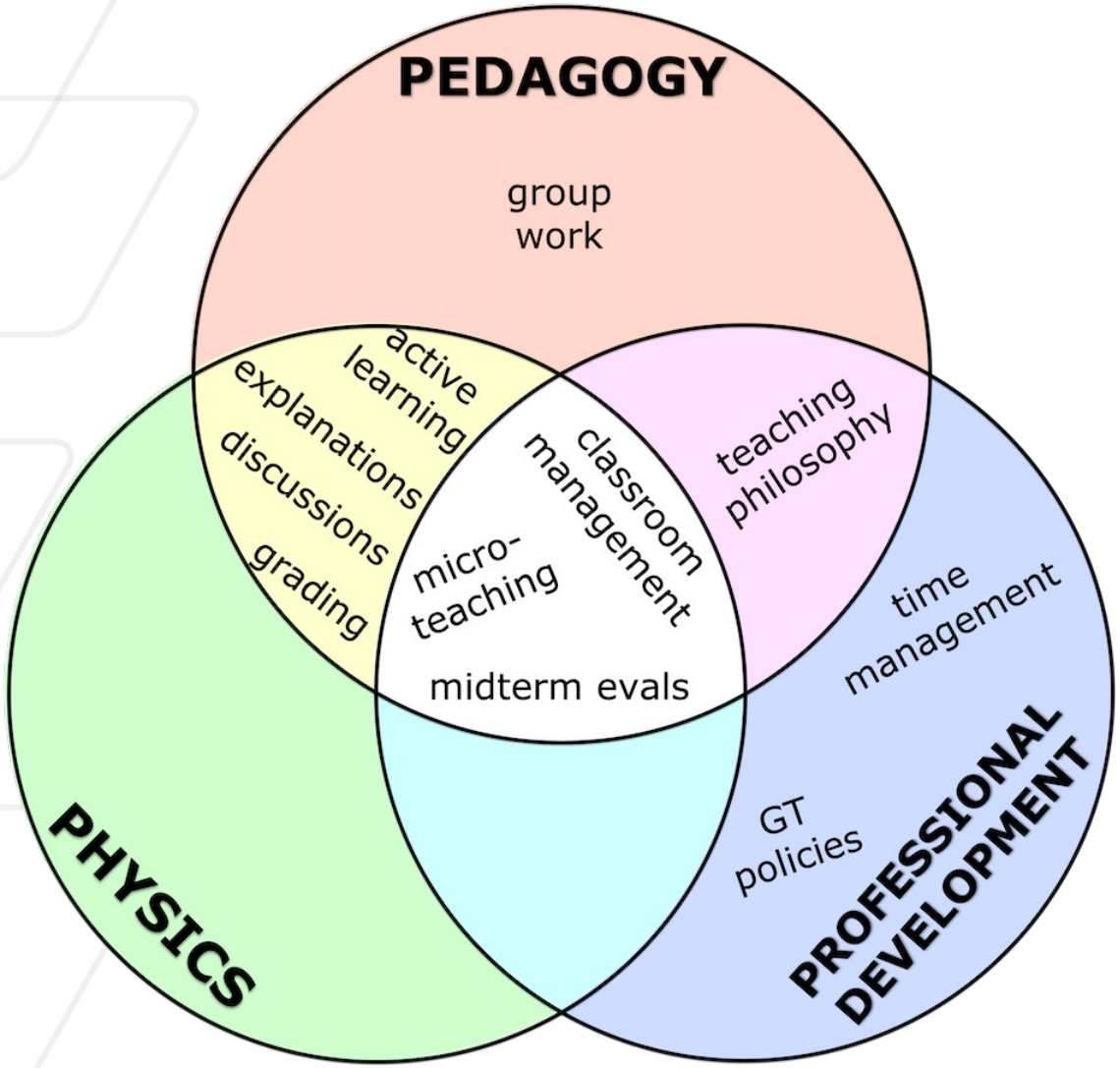
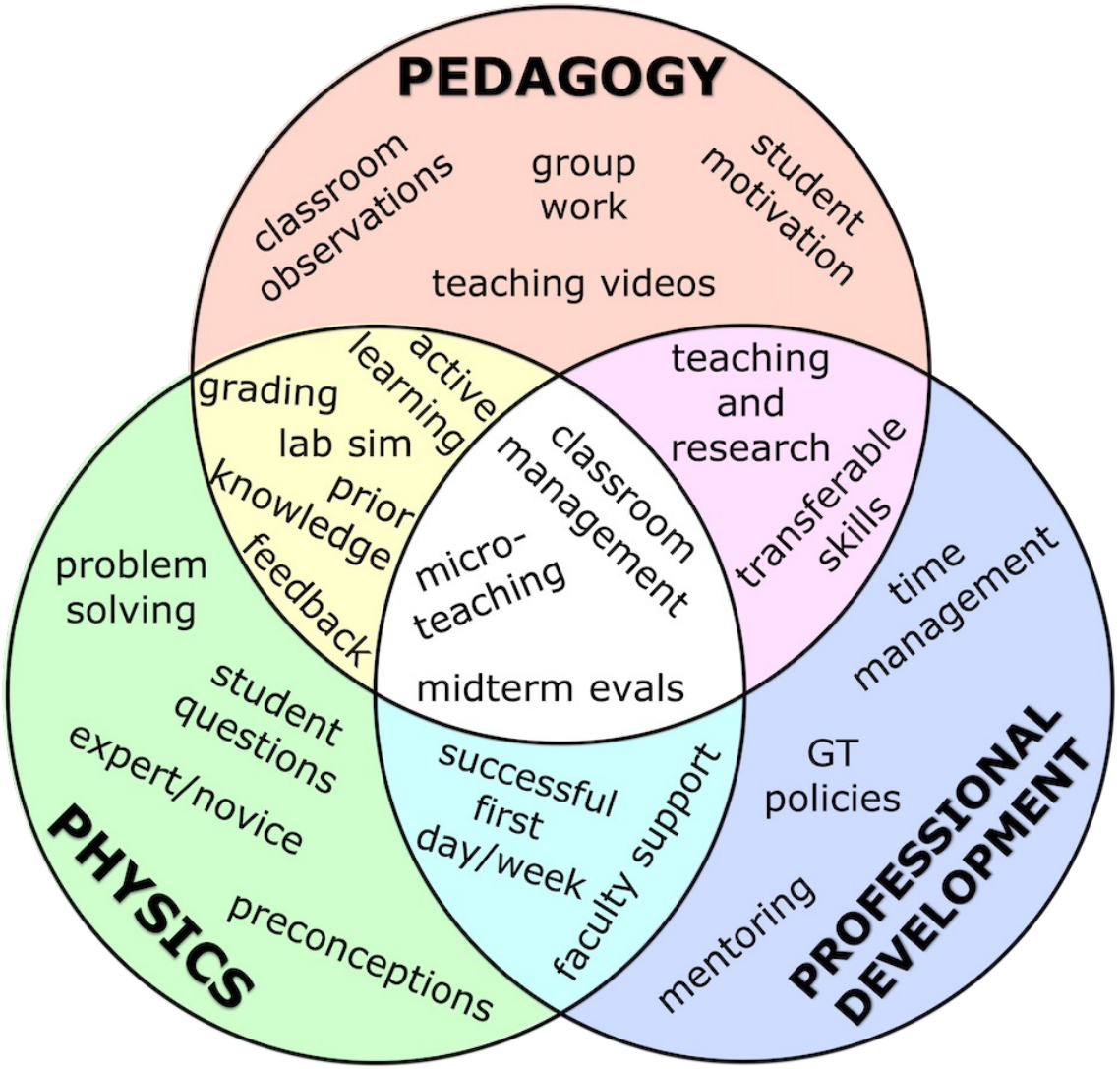


2013



2019

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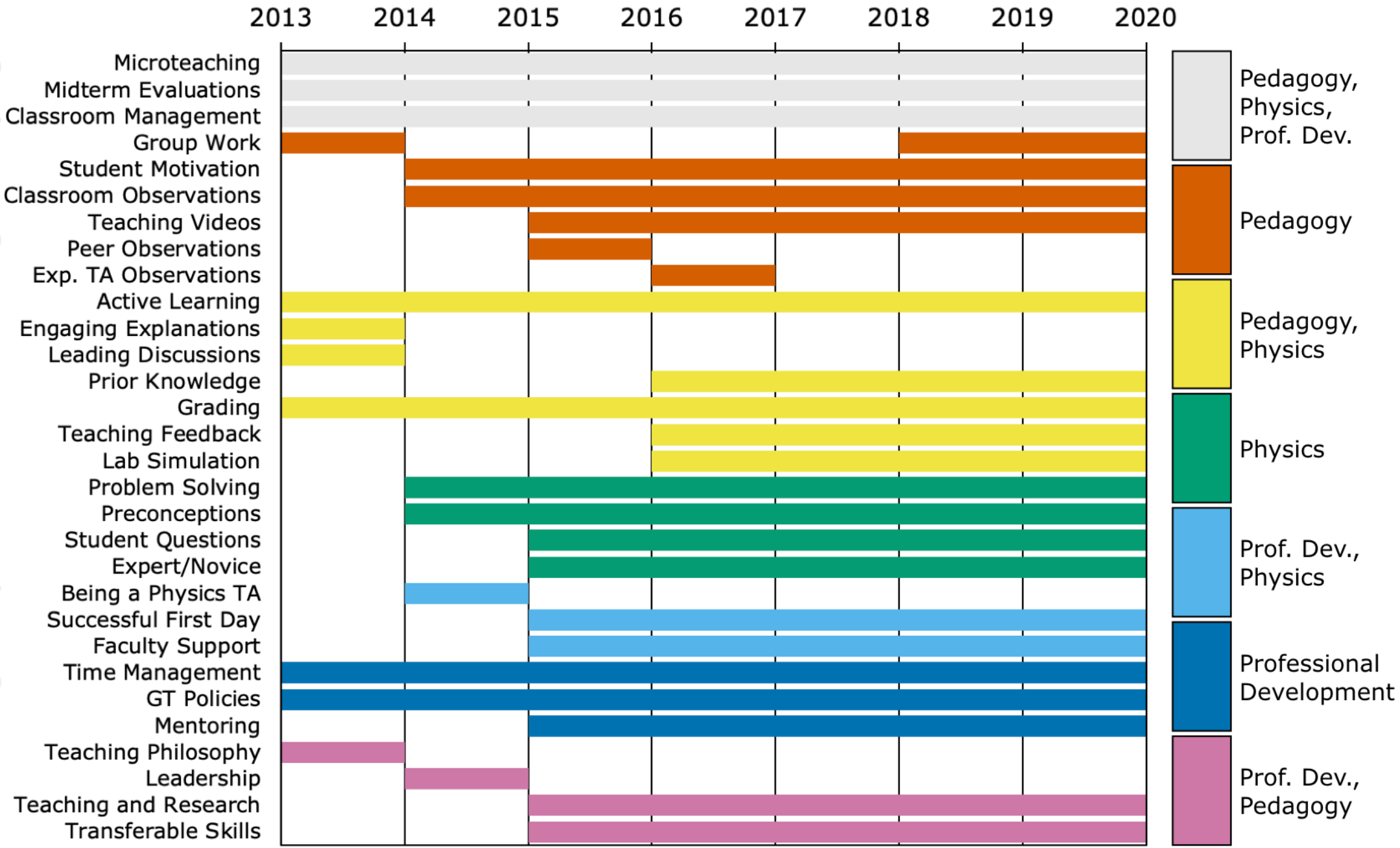
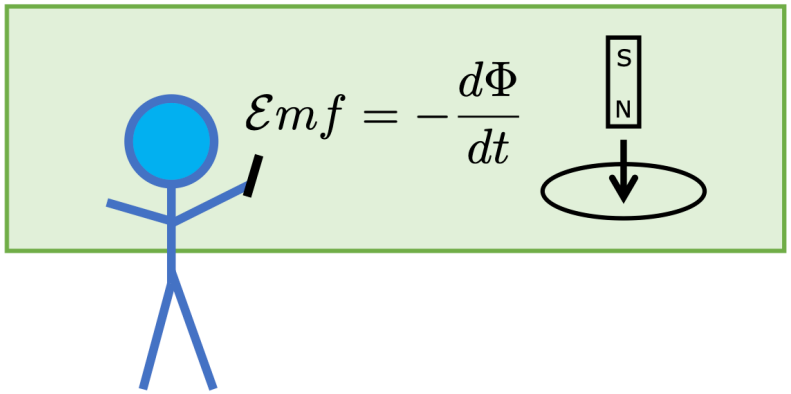


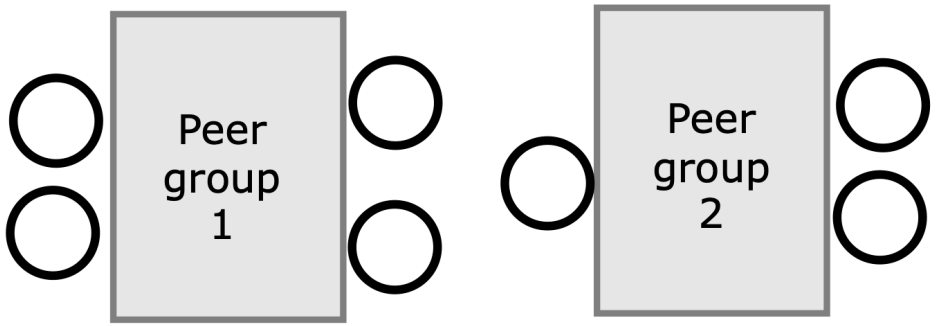
* Alicea-Muñoz et al, Phys. Rev. Phys. Educ. Res. 17, 020125 (2021)

GTA Prep Curriculum: Things that work

Microteaching

- Short teaching practice in a safe environment, with 8-10 grad students max per session
- Each person picks an intro physics problem beforehand
- Participants arranged into two peer groups
- One person at a time facilitates for 10min, everyone else are students
- No lecturing allowed! Interactive engagement!
- Feedback provided to each TA by instructor and the two peer groups
- Debrief reflection essay on activity and feedback received





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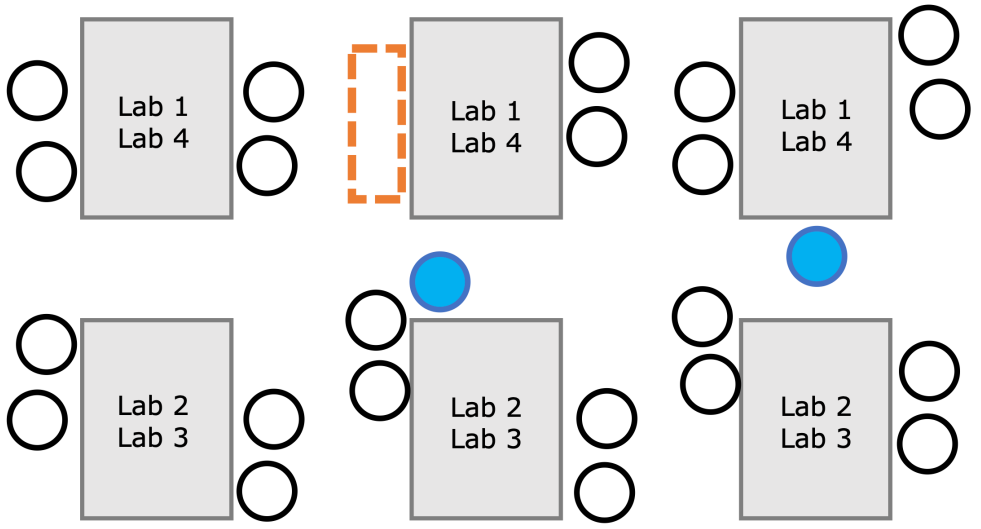
GTA Prep Curriculum: Things that work

Lab Simulation

- Like microteaching, but in a lab environment
- TAs individually assigned one lab to teach, and in pairs assigned labs in which to be students; all lab materials available for all in class website
- Teaching pairs facilitate lab for 10 minutes
- Two rounds: mechanics (labs 1 and 2), then electromagnetism (labs 3 and 4)
- An instructor follows each TA to observe and give feedback
- SABOTAGE! Secretly planted bad student behaviors – TAs get REALLY into it and have fun!



	Last Name	First Name	TA Role	Student Role
1	Bell	Jocelyn	Lab1	Round 1: Lab1 Round 2: Lab4
2	Curie	Marie	Lab2	
3	Eddington	Arthur	Lab1	Round 1: Lab2 Round 2: Lab3
4	Einstein	Albert	Lab2	
5	Feynman	Richard	Lab1	Round 1: Lab1 Round 2: Lab4
6	Hubble	Edwin	Lab2	
7	Meitner	Lise	Lab1	Round 1: Lab2 Round 2: Lab3
8	Rubin	Vera	Lab2	

GTA Prep Curriculum: Things that work

Teaching Physics

- Important to discuss the pedagogical content knowledge necessary for teaching physics
- Emphasize differences between experts and novices – point out grad students are both
- Introduction to active learning, share results from physics education research
- Group activities to address misconceptions and problem-solving

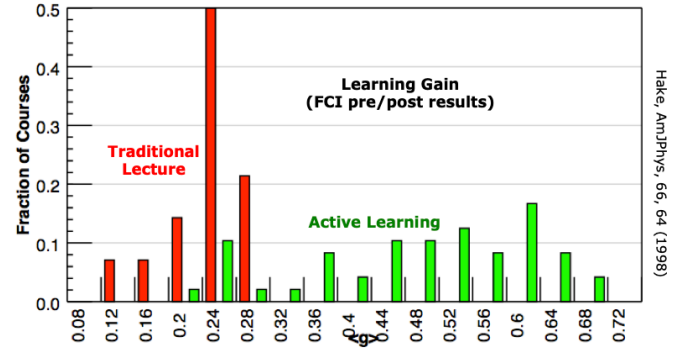
Novice vs Expert

Categorization and Representation of Physics Problems by Experts and Novices*

Michelene T. H. Chi
Paul J. Feltovich
Robert Glaser
University of Pittsburgh

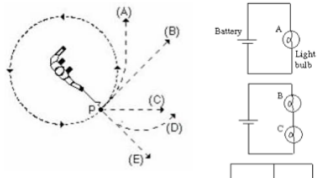
"Results from sorting tasks and protocols reveal that experts and novices begin their problem representations with specifiably different problem categories. [...] Experts initially abstract physics principles to approach and solve a problem representation, **whereas novices base their representation and approaches on the problem's literal features**."

Physics Education Research shows...



Addressing Misconceptions

- Split up into three groups to work on these examples (for **10 minutes**):
  - Example 1 (FCI)
  - Example 2 (FMCE)
  - Example 3 (BEMA)
- Think of **reasons** why students would pick the incorrect answers (what misconception do they have?)
- Come up with ways to **address** the misconceptions



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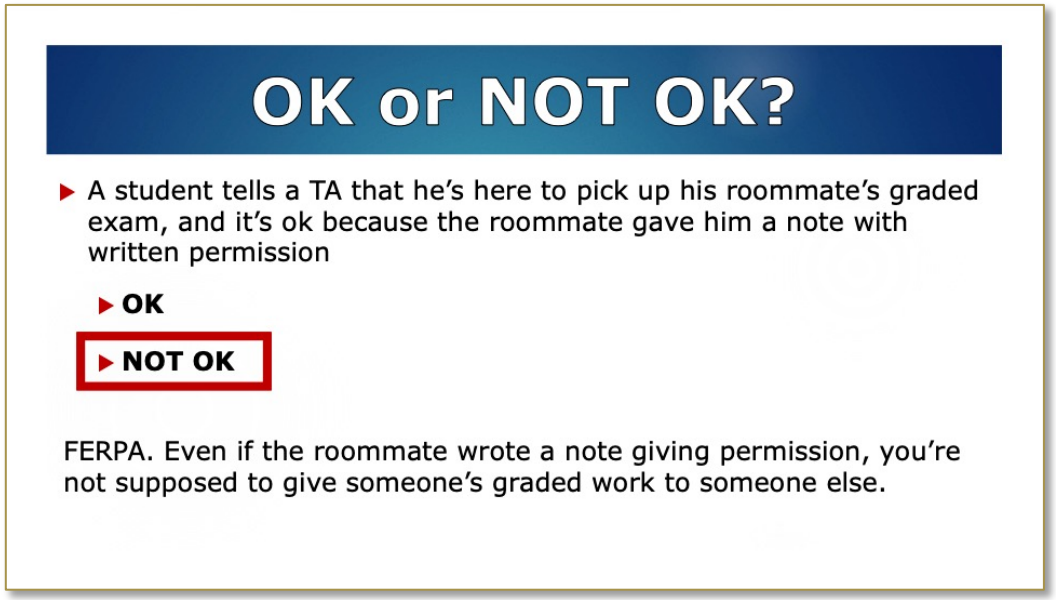
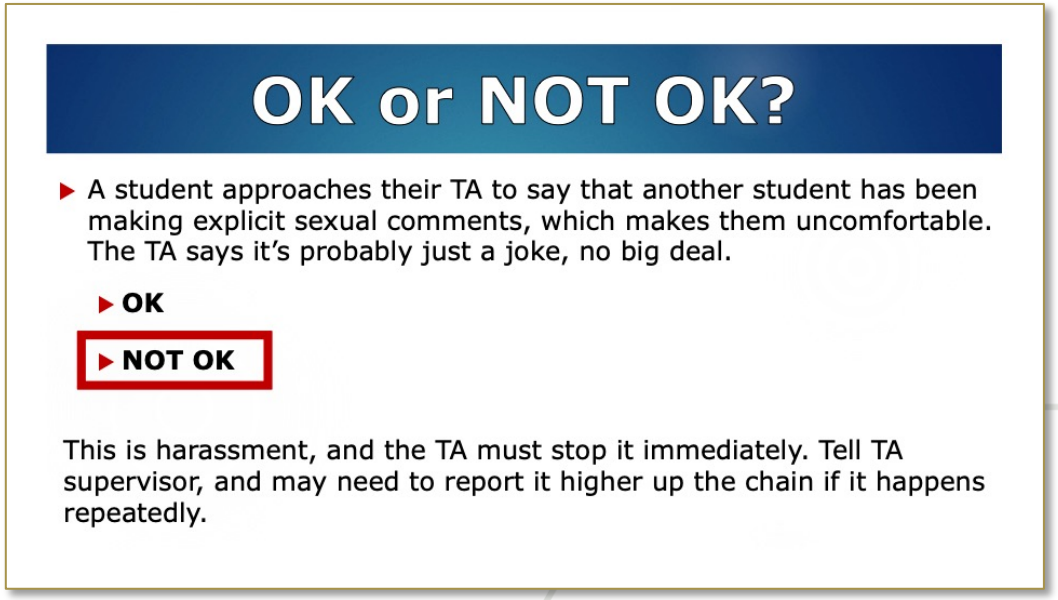
GTA Prep Curriculum: Things that work

OK / NOT-OK Game

- For discussion of academic policies (FERPA, sexual harassment, academic integrity, etc)
- Each TA given a card that says **OK** on one side and **NOT OK** on the other
- Scenario is read, each person votes (shows one side of the card), then correct answer is revealed
- Some scenarios are obvious and unanimous, while others are not and promote in-depth discussions
- TAs enjoy gamification of "boring" topics!





GTA Prep Curriculum: Things that work

Classroom Observations

- Useful tool to assess effectiveness of TA training by seeing first-hand what the TAs do in the classroom
- Can use research-validated evaluation criteria or write your own as needed
- TAs receive on-time feedback for reflection and improvement
- Video recorded observations can be used for future TA training sessions

N	GTA Evaluation Criteria
1	Uses the first 10 minutes of studio/lab effectively
2	Speaks with a clear, audible, and well-modulated voice
3	At the board, the GTA's handwriting is legible
4	Shows enthusiasm for physics and tries to motivate students
5	Checks for student understanding by asking probing questions (without sounding condescending)
6	Helps students develop the necessary problem-solving skills and coaches them without giving away the answers
7	When students are working in groups, the GTA makes sure that all group members are actively participating
8	Answers procedural questions quickly and efficiently
9	Spreads their time reasonably among the various groups of students in the lab/classroom
10	Comes to the lab/studio prepared and can think on their feet if there's a need for troubleshooting

Things that don’t work

Caveat: your mileage may vary! These were disasters for us, but they may work for you

- **Peer Observations** – TAs don’t feel knowledgeable enough to give their peers useful feedback … OR, TAs feel their peers are not knowledgeable enough to give them feedback

- **Experienced TA Observations** – Logistics! Do you have enough experienced TAs teaching the same classes as the first-time TAs?

- **Teaching Philosophy** – If the majority of your grad students plan on going to industry, they may feel this is useless

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Enrollment in GTA Preparation

Excluded from analysis →

Thesis analysis

Ongoing analysis (in prep.)

Future work →

Year	Enrollment	IRB Consent	Women	International
2013	22	N/A	5 %	18 %
2014	13	62 %	23 %	54 %
2015	34	85 %	29 %	35 %
2016	23	83 %	26 %	48 %
2017	26	77 %	15 %	54 %
2018	16	81 %	50 %	13 %
2019	18	78 %	33 %	17 %
2020	22	55 %	32 %	32 %
2021	20	85 %	25 %	50 %
2022	26	pending	38 %	23 %
Overall	**220**	**pending**	**27 %**	**35 %**

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Program Assessment

- Mixed-methods approach, with assessments selected to give a broad idea of how effective the class has been, following a modified Kirkpatrick* model (reaction, learning, behavior, results)
- Assessment timeline:**

* Kirkpatrick, *Evaluating Training Programs: The Four Levels*, 1994 and Wyse et al, CBE-Life Sciences Education, 13, 2014

** Alicea-Muñoz et al, In Preparation (will be submitted soon to Phys Rev PER)

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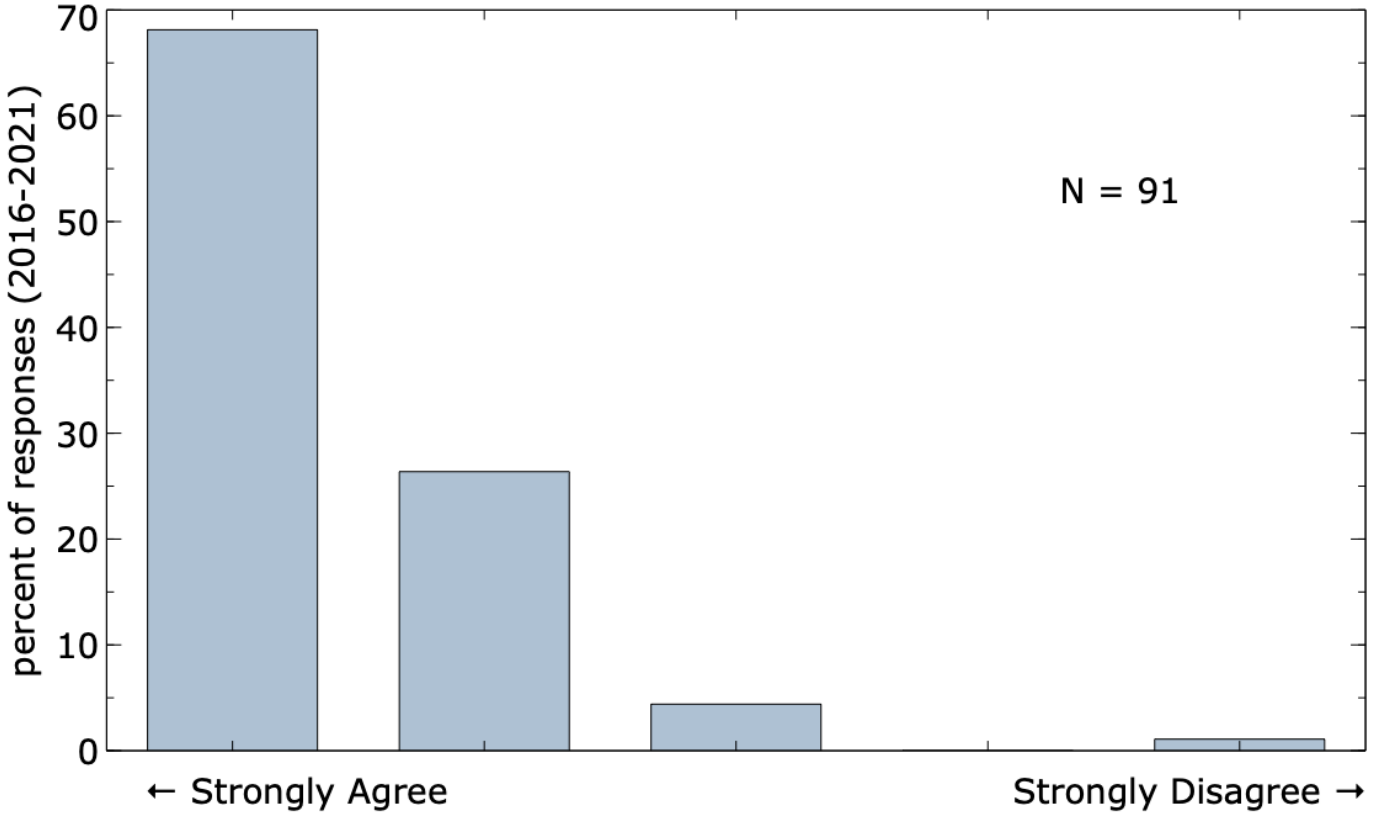
The initial conditions of first-time GTAs

- Roughly 60% of first-time GTAs have no prior teaching experience

- **An overwhelming majority of first-time GTAs consider teaching important for their professional development**
  - "I consider teaching to be an important part of my professional development as a physicist."



* Alicea-Muñoz et al, In Preparation (expected 2023)

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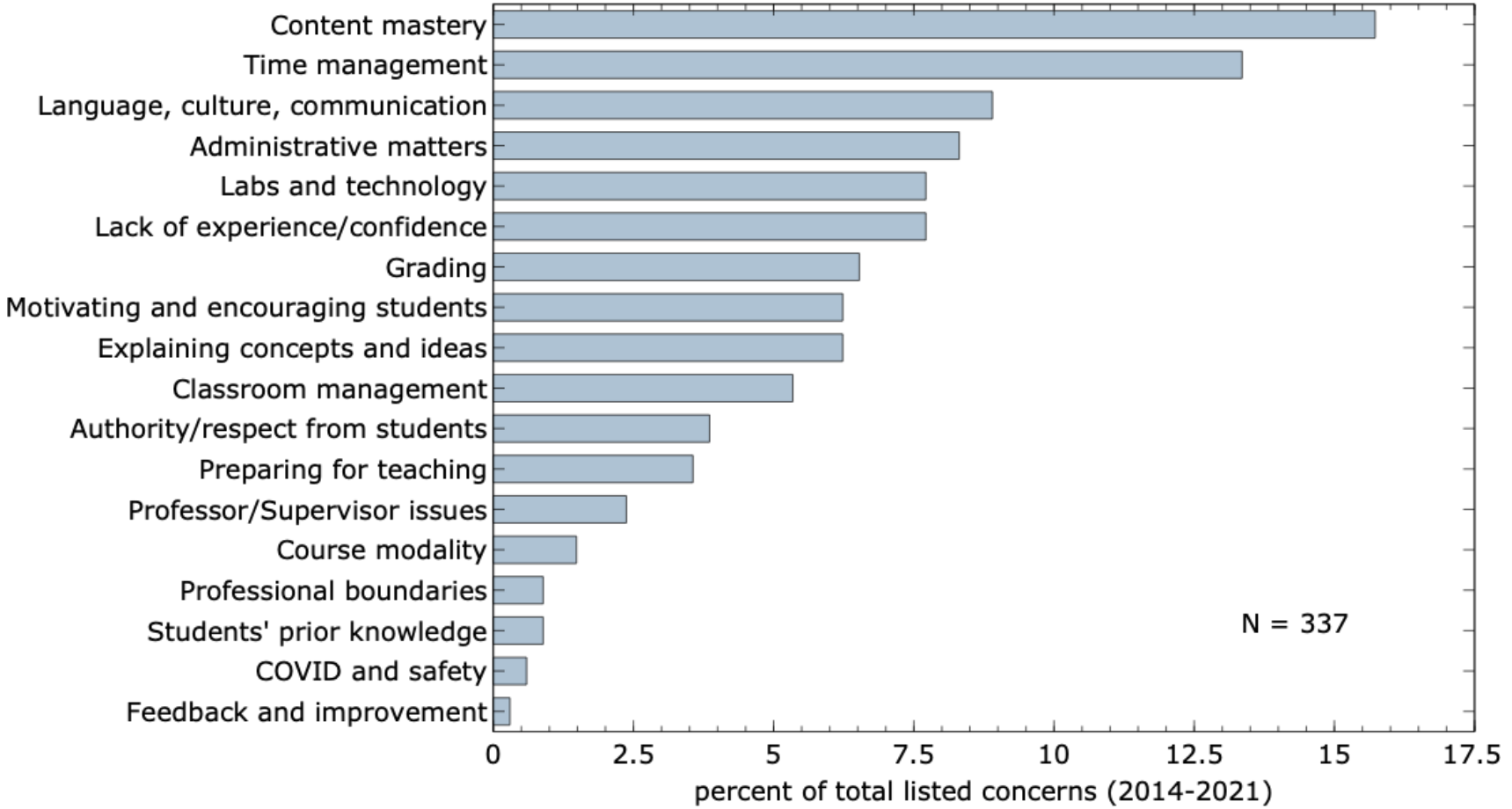
The initial conditions of first-time GTAs

- Top 3 concerns about teaching
- **First-time GTAs are worried about their physics knowledge and how to manage their time**
- Non-native English speakers also worry about language and culture issues



* Alicea-Muñoz et al, In Preparation (expected 2023)

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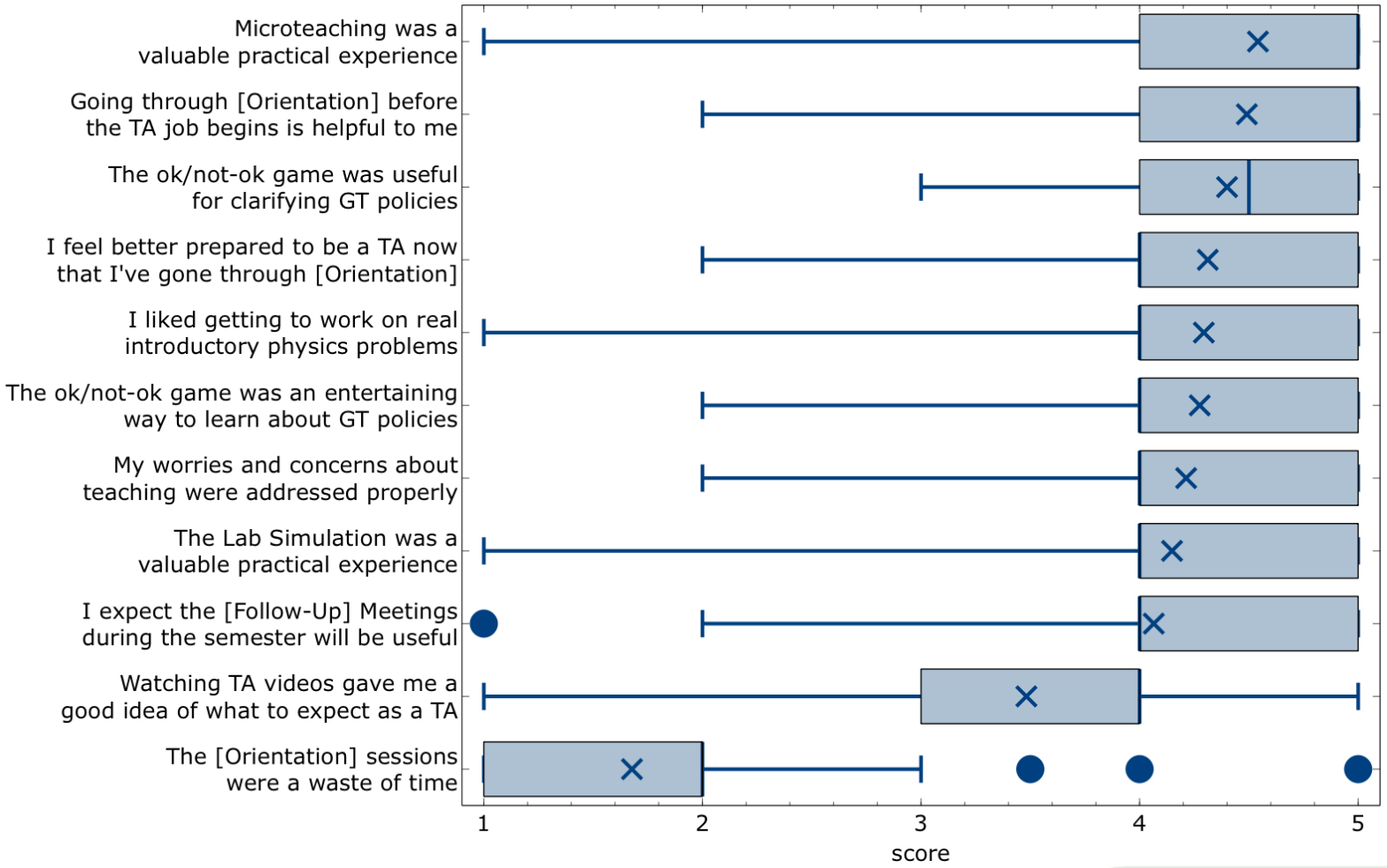
Orientation Survey

- Anonymous, Likert-type statements to assess five categories: Class Activities, Guests, Materials, Timing, Usefulness
- Open-ended comments indicated GTAs felt better prepared for teaching
- **GTAs enjoy the interactive nature of the class and consider the Orientation to be useful**



* Alicea-Muñoz, PhD Dissertation, Georgia Tech (2020)

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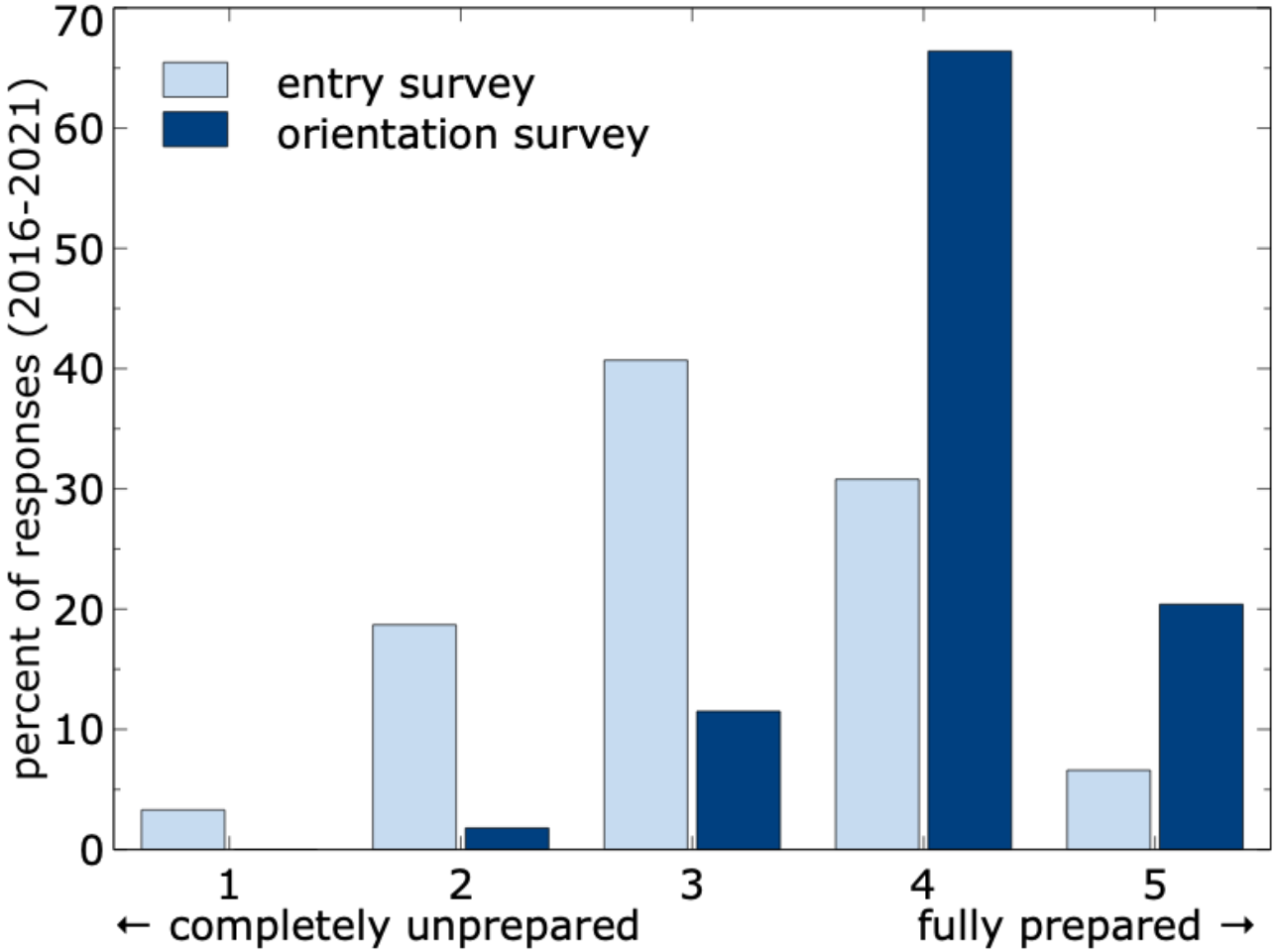
Orientation Survey: Preparedness

- "How prepared do you feel for your first GTA assignment at Georgia Tech?"
- **Pre:** Entry Survey ($N = 91$, not anon)
- **Post:** Orientation Survey ($N = 113$, anon)
- Statistically significant pre/post difference (KS test, $D = 0.494$, $p < 0.001$), and very large effect size (Cohen's $d = 1.08$)
- **GTAs feel better prepared for teaching after the Orientation**



* Alicea-Muñoz et al, In Preparation (expected 2023)

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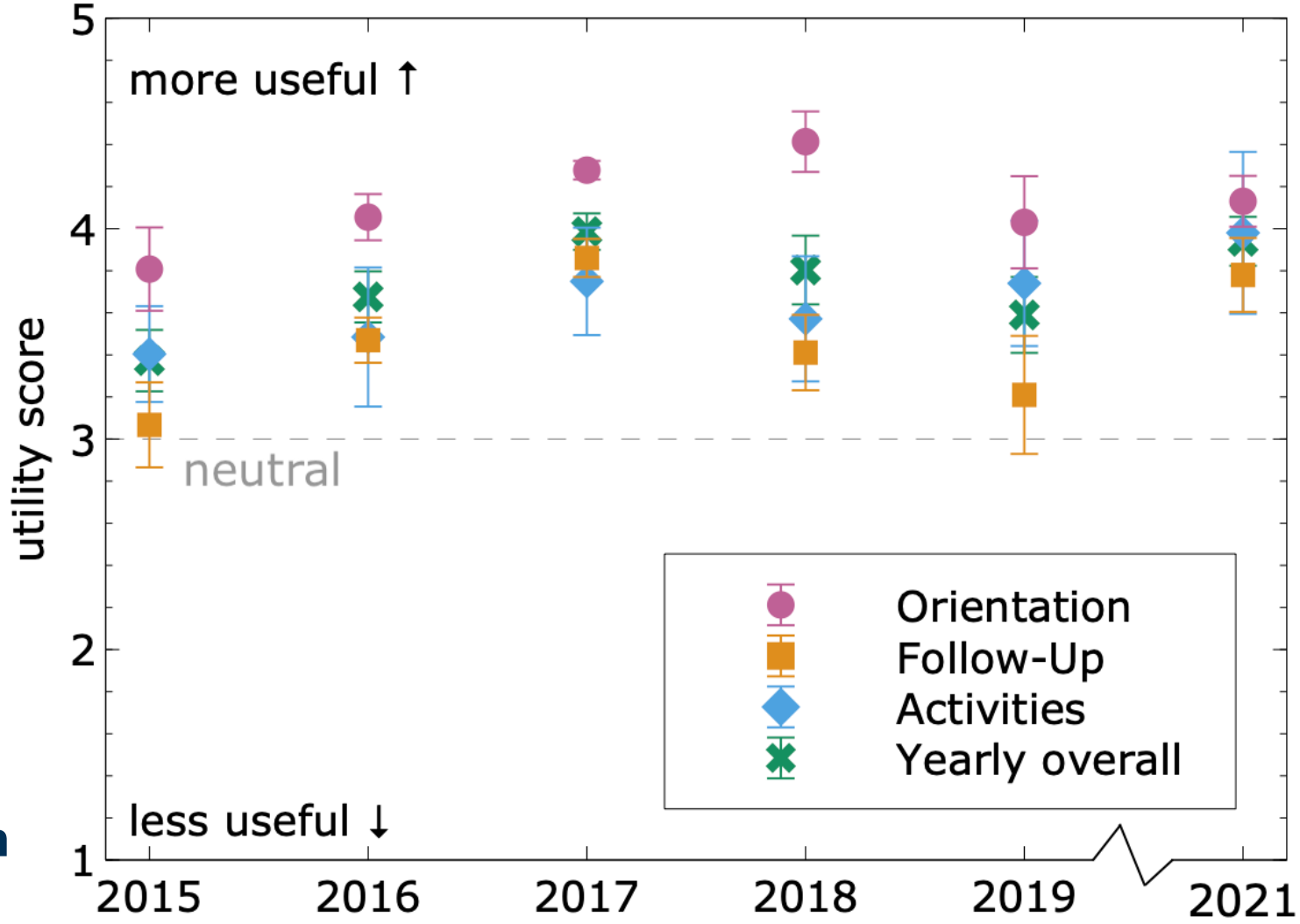
Exit Survey: Utility Scores

- At the end of the semester GTAs rate usefulness of lessons
- From full data (sans 2020), the most useful elements are:
  - Microteaching
  - Lab Simulation
  - Teaching Physics
- Utility score: calculate mean of each item, then average those by category
- **GTAs perceive the Orientation to be the most useful period of the course**



* Alicea-Muñoz et al, In Preparation (expected 2023)

Pre/Post Tests: ATI

- Approaches to Teaching Inventory*
- 16 Likert-type items in 2 scales to measure:
  - Information Transmission (teacher-centered approaches)
    - e.g., "I feel it is important to present a lot of facts to students so that they know what they have to learn for this subject."
  - Conceptual Change (learner-centered approaches)
    - e.g., "I encourage students to restructure their existing knowledge in terms of the new way of thinking about the subject that they will develop."

* Trigwell & Prosser, Educational Psychology Review, 16, 2004

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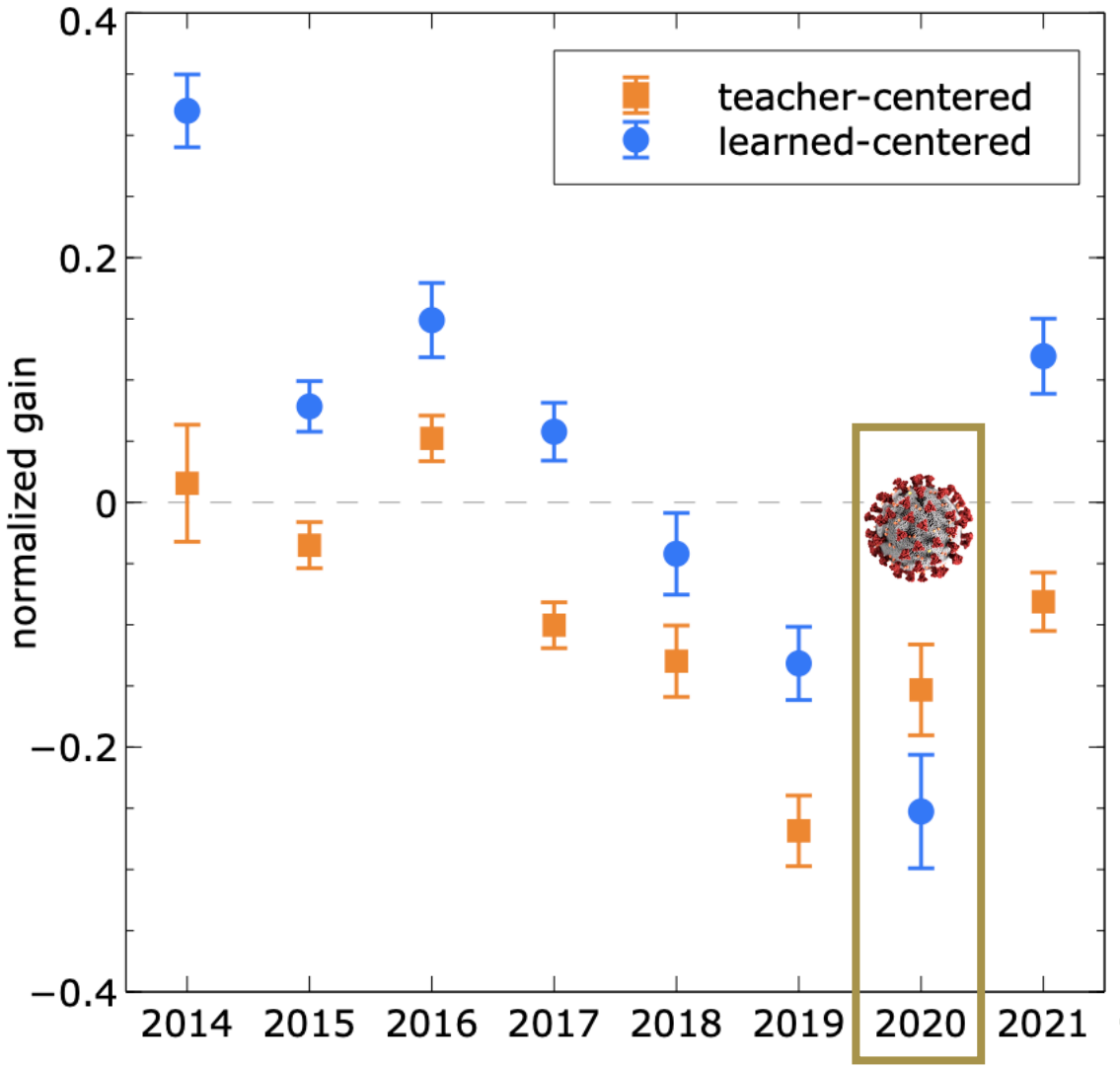
Pre/Post Tests: ATI

- Complete case analysis: matched pre/post pairs with responses to every item
- For each GTA: teacher-centered mean, learner-centered mean (pre, then post)
- For each year, calculate normalized gain for teacher-centered and learner-centered
- **Except for 2020, every year had higher normalized gains in learner-centered than teacher-centered**
- **Most years have negative gains in teacher-centered – moving away from "sage on the stage"**



* Alicea-Muñoz et al, In Preparation (expected 2023)

End-of-Semester Student Evaluations

- **Caveat!!!** Student evaluations alone CANNOT measure teaching effectiveness
- **Pre-intervention:** GTAs with first teaching experience in 2011-2012
- **Post-intervention:** GTAs with first teaching experience in 2013-2015 (first three years of GTA prep course)
- Analysis of student evaluation scores for only **first Fall** and **first Spring** semester of teaching (when each grad student was a first-time GTA)

Item Code	Description
T1	Oral communication skills
T2	Written communication skills
T3	Explained concepts clearly
T4	Familiarity with course concepts
T5	Respect for students
T6	Attitude about their teaching role
T7	Stimulated interest in subject
T8	Approachability
T9	Level of preparedness
T10	Classroom management
T11	Actively engaged students
T12	Overall effectiveness

* Alicea-Muñoz, PhD Dissertation, Georgia Tech (2020)

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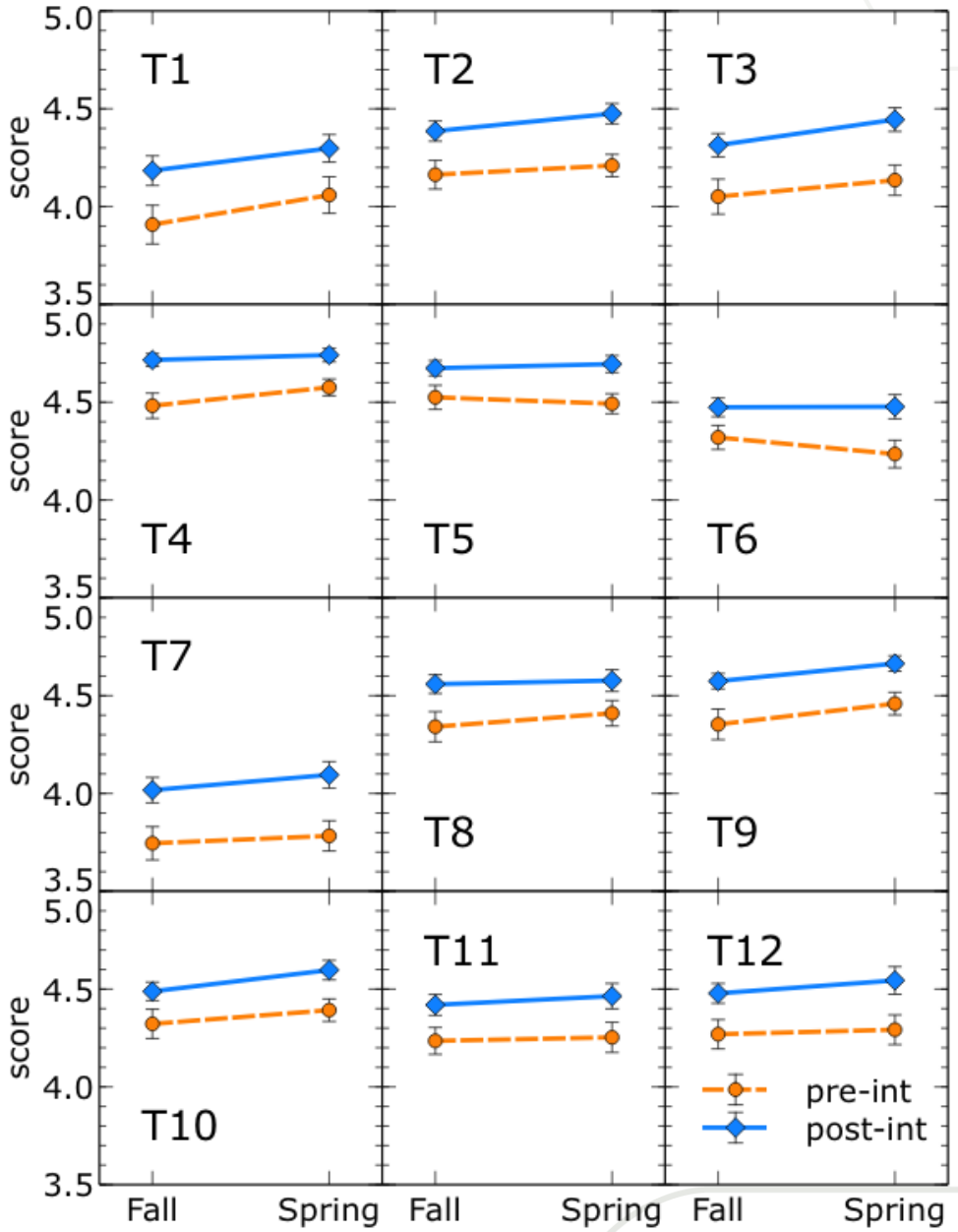
End-of-Semester Student Evaluations

- Post-intervention group was **always rated higher** than pre-intervention group (most differences are statistically significant)
- **Highest rated:** familiarity with concepts, respect for students, approachability, level of preparedness
- **Lowest rated:** stimulated interest in subject
- For most items, rating in first Spring is higher than rating in first Fall

- **Participating in GTA prep leads to higher student evaluations**



* Alicea-Muñoz, PhD Dissertation, Georgia Tech (2020)

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Answering the Research Questions

1. What elements of a formal GTA preparation program do GTAs perceive as the **most useful** or beneficial for their professional development?
    - *Microteaching, Lab Simulation, Teaching Physics*
    - *GTAs appreciate hands-on activities in which they get to practice teaching and receive feedback on their performance*
    - *GTAs are interested in developing the pedagogical content knowledge necessary for teaching physics*

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Answering the Research Questions

2. What effect does a formal GTA preparation program have on graduate students' **teaching self-efficacy** and **attitudes** about teaching?
    - *GTAs report feeling better prepared for teaching after participating in the Orientation*
    - *GTAs adopt more learner-centered approaches to teaching after participating in the GTA prep course*

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Answering the Research Questions

3. Does a formal GTA preparation program have an effect on graduate students' **teaching effectiveness**?
    - *GTAs who participate in the GTA prep course are rated consistently higher in end-of-semester student evaluations than GTAs who predated the course; this COULD be an indication of better teaching effectiveness*

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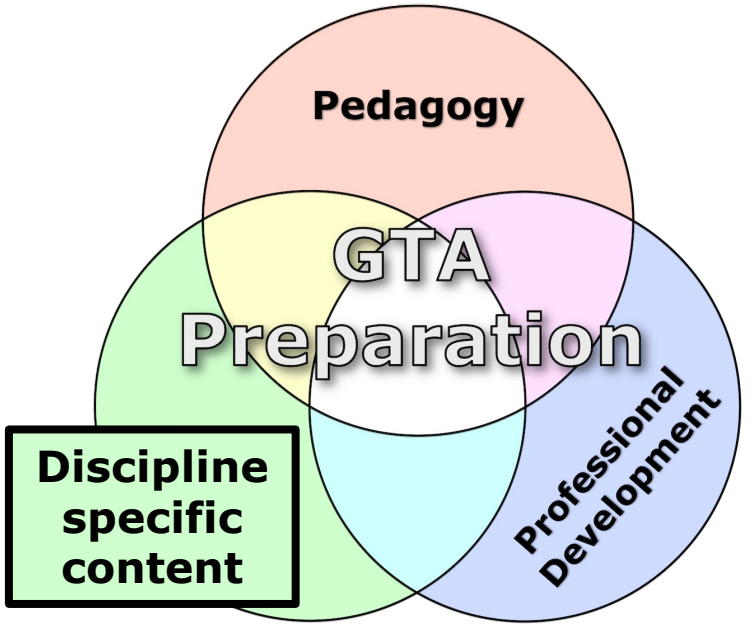
Broader significance of our work

- There is no “one-size-fits-all” approach to GTA preparation
- Lots of work has been done, but most of it focuses on GTAs as future faculty – we shouldn’t ignore the ones who leave academia!
- The 3P Framework can provide universal guidance that ensures broader professional development as an integral part of GTA preparation
- Generalized to other fields: 3P → PDP (pedagogy, discipline-specific content, professional development)



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Summary

- Our Physics GTA Preparation course successfully **integrates** pedagogy, physics, and professional development
- The course satisfies the principles for **best practices** in GTA preparation, and is effective at preparing GTAs for their teaching roles
- Our method of curriculum development, the 3P Framework, can provide **universal guidance** for GTA preparation that is useful for graduate students no matter what their career goals are
- **Current project:** I want to know more about the GTA preparation strategies used in other institutions. Would you like to participate in my **National Survey of Physics GTA Preparation**? Scan this → to get included in the contact list!

Scan this other one → for all my GTA prep research and materials

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