Training and professional development of physics graduate teaching assistants (GTAs)

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Emory University
Physics Colloquium
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Georgia Tech College of Sciences
School of Physics

The need for GTA preparation

- Students in large-enrollment intro physics classes spend up to half of their in-class contact hours supervised by GTAs (labs, recitations, tutoring…)
- Potential to have large impact on student learning
- GTAs are novice teachers, sometimes have zero prior teaching experience
- **GTAs need preparation for teaching!**

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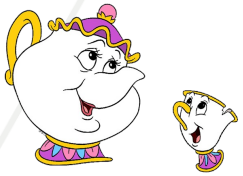
Tale as old as time…

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

GTA 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

- GTAs need to have the opportunity to **practice** and **receive feedback** on their performance, both before and during their teaching

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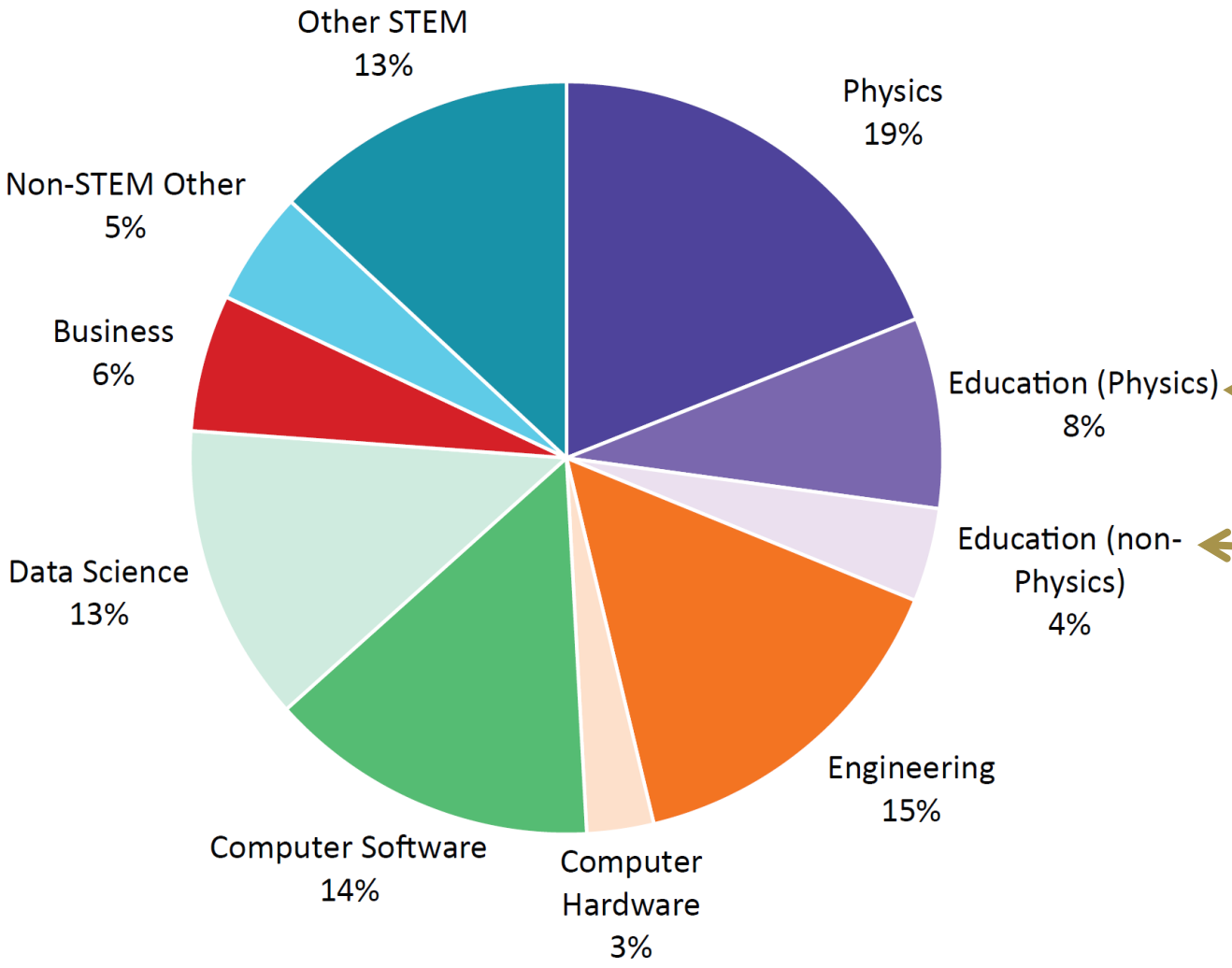
Otero & Alicea-Muñoz. "Research on the Development of Faculty, Graduate Teaching Assistants, and Undergraduate Learning Assistants". In *The International Handbook of Physics Education Research: Teaching Physics*. AIP Publishing (2023)

Most 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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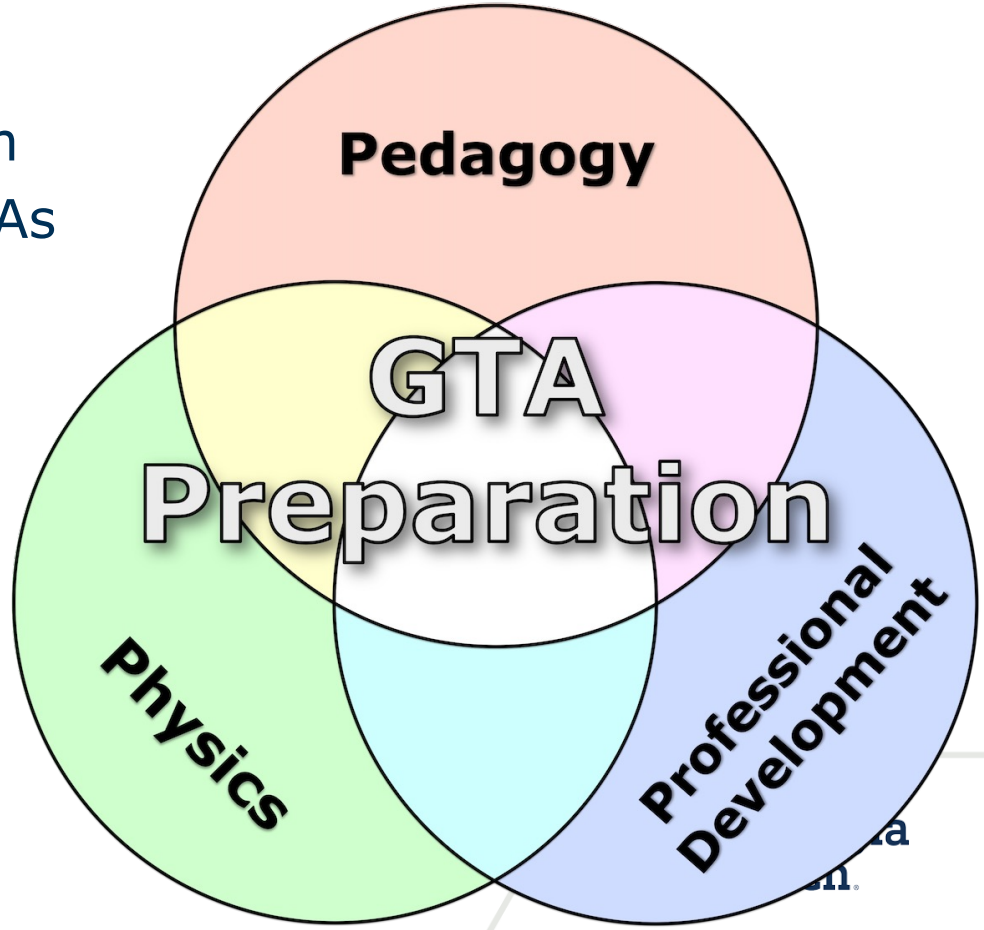
New Perspective on GTA Preparation

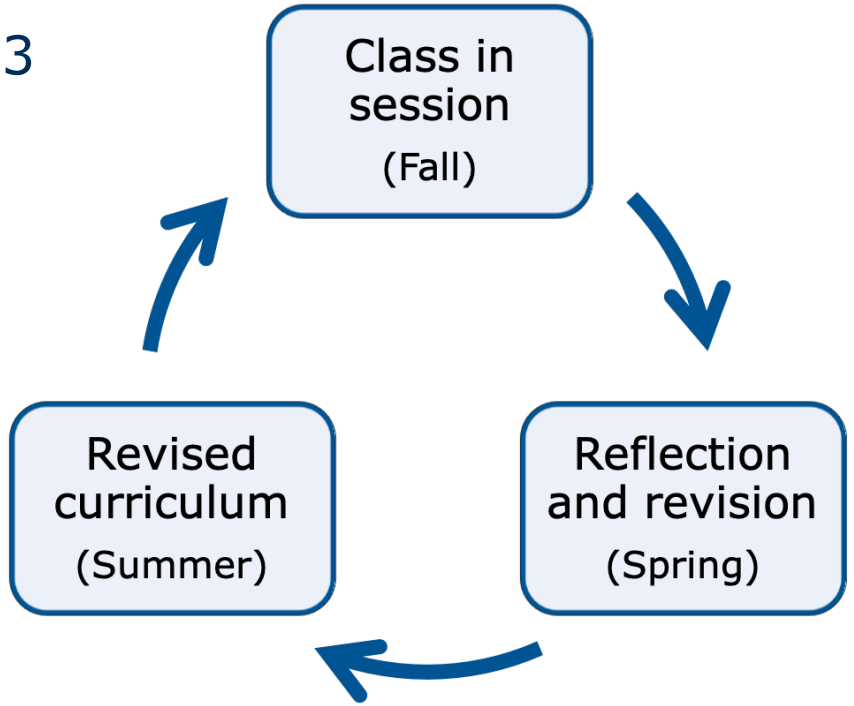
- We want to produce GTAs who are **motivated** and **effective** teachers
- We also want to help GTAs develop **transferable professional skills** they can use outside the classroom
- **3P Framework** – to have a comprehensive program for GTA preparation that is useful and valuable for TAs in the classroom 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, PhysRevPER 17, 020125 (2021)

Physics GTA Preparation Course

- One credit, pass/fail, required for first-time GTAs (mostly first-year PhD students), offered every Fall semester
  - Over 270 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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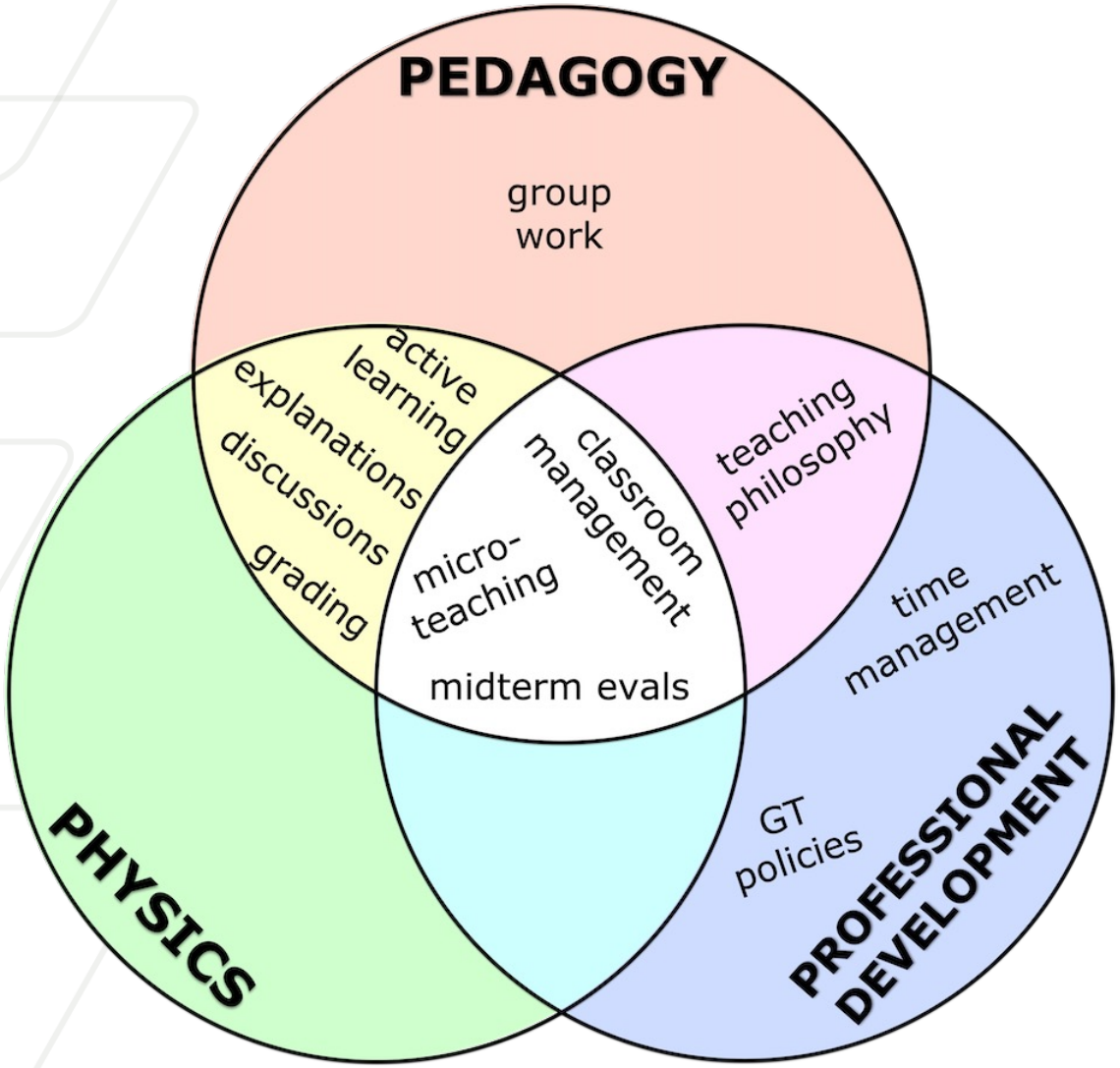
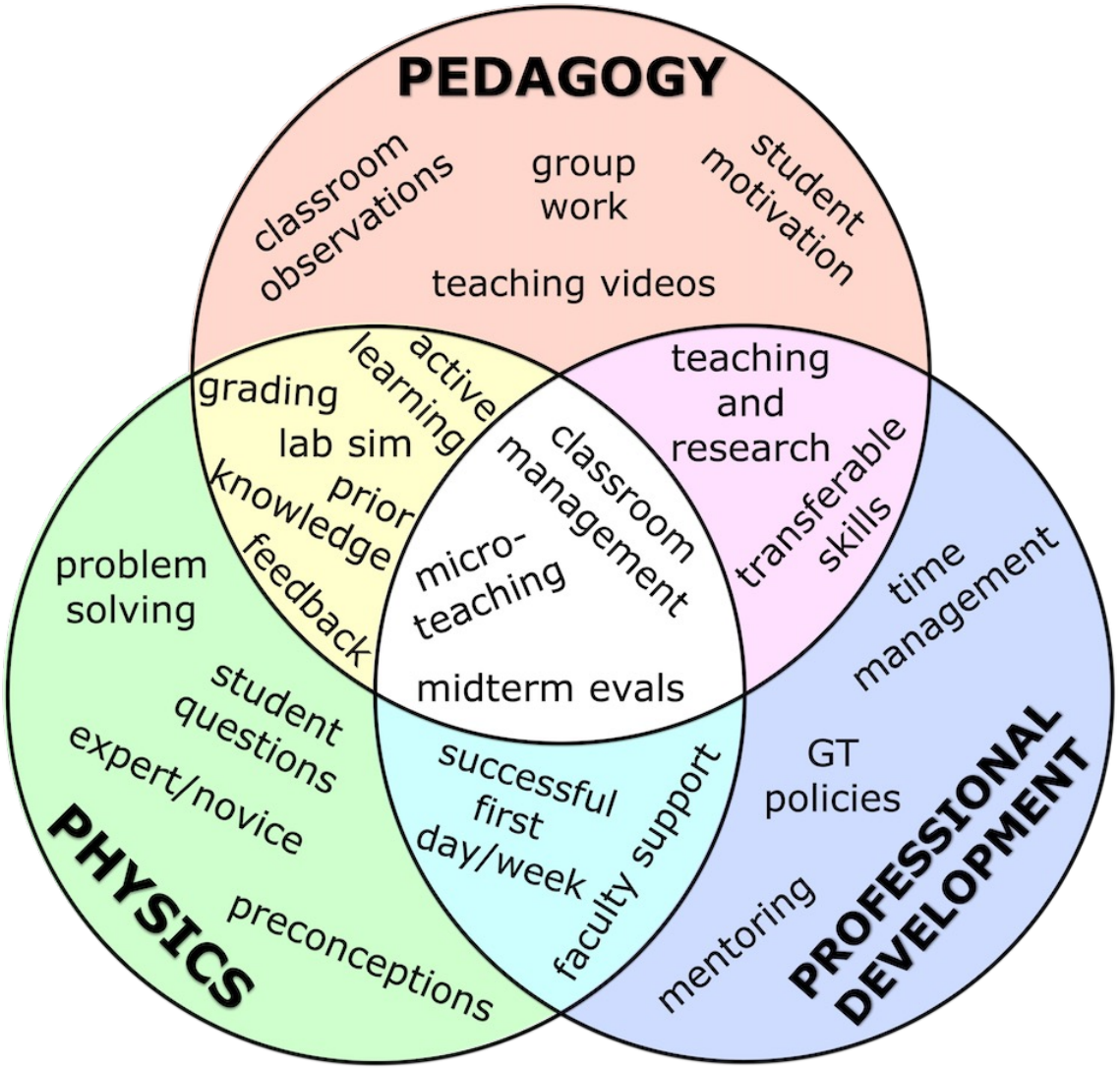


2013



2019

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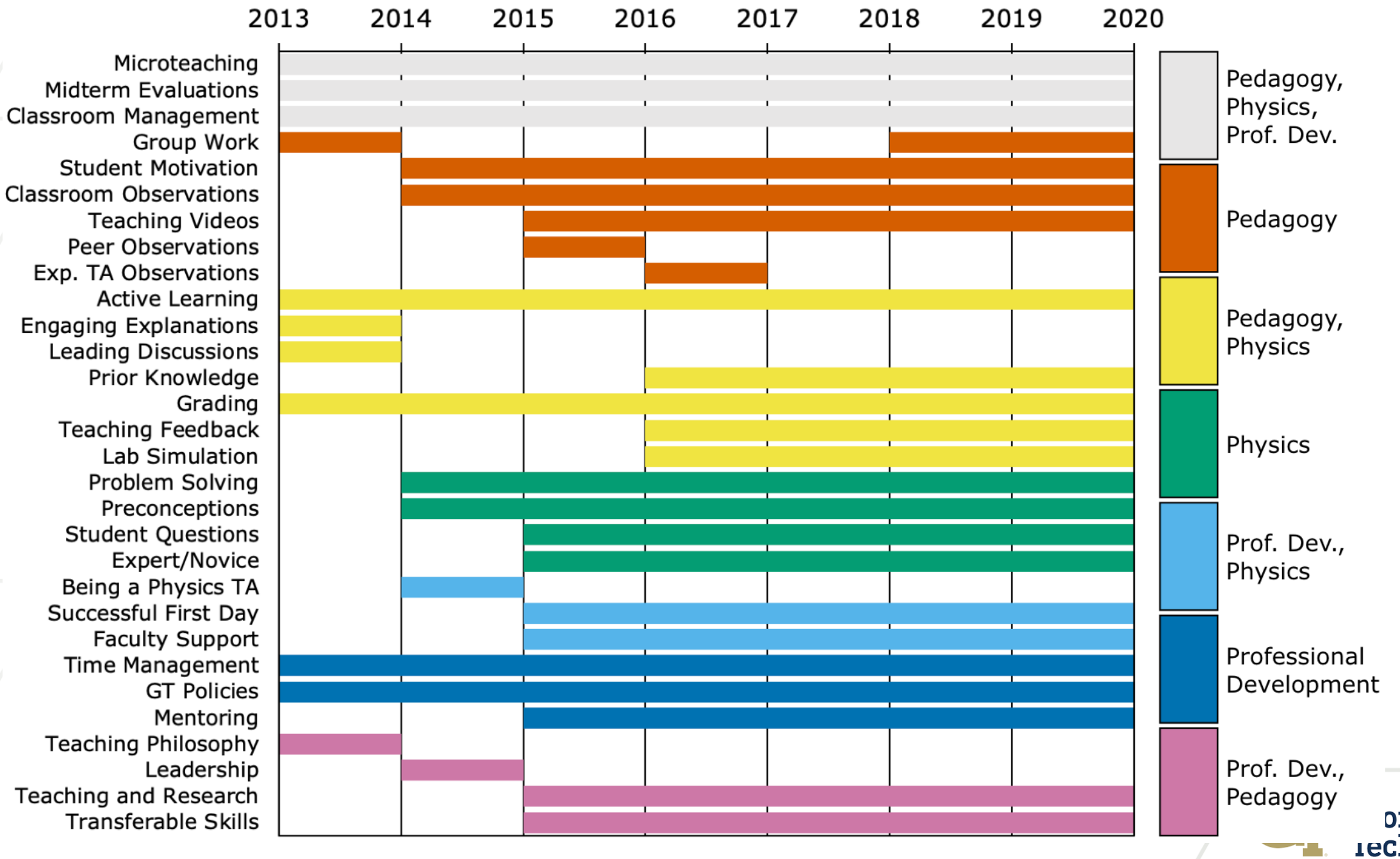

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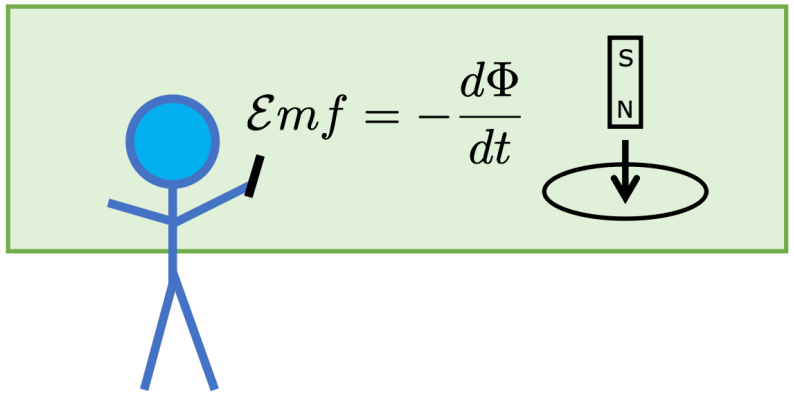
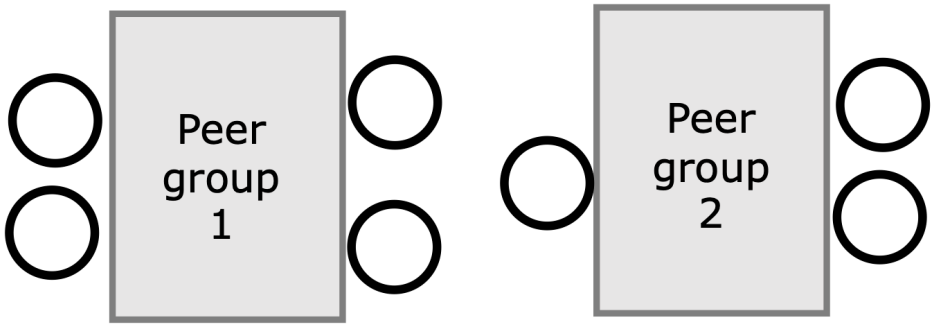
Things that work: Microteaching

- Short teaching practice in a safe environment, 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 GTA by instructor and the two peer groups





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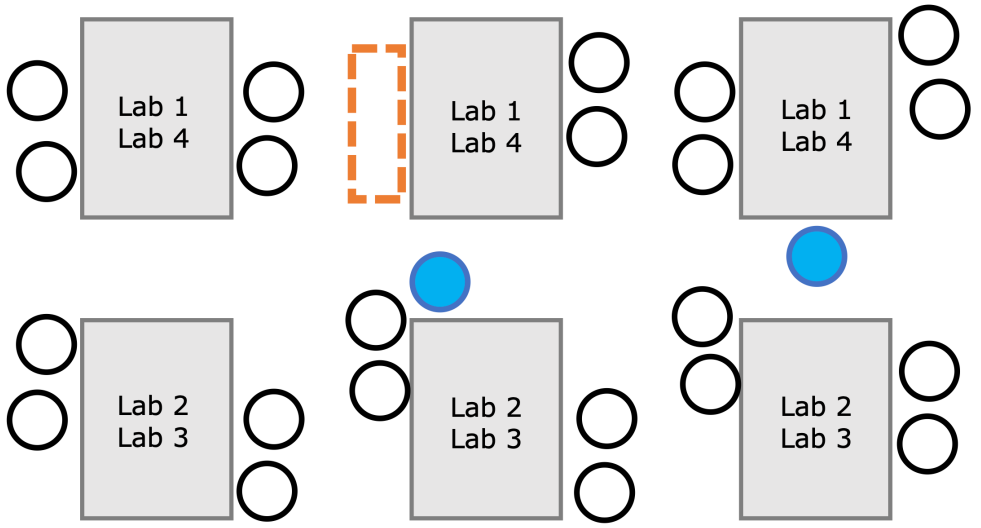
Things that work: Lab Simulation

- 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 GTA 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	

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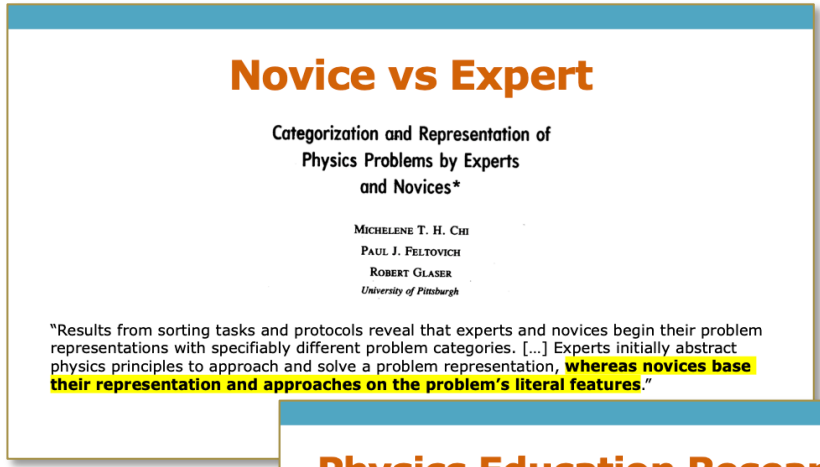
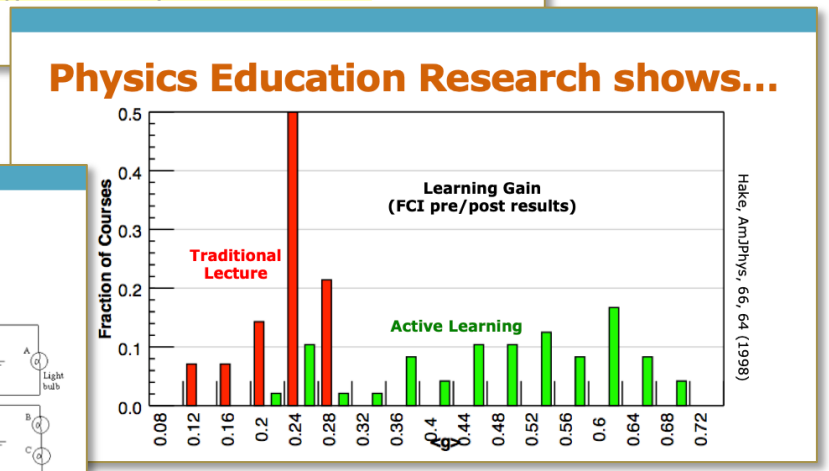
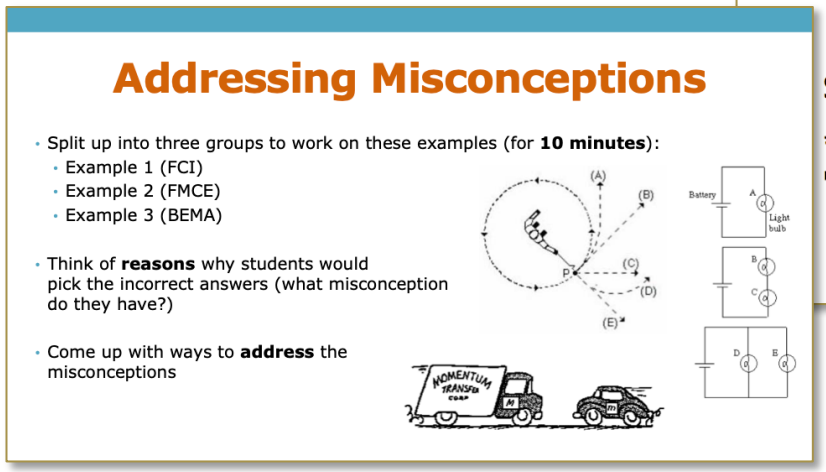
Things that work: Teaching Physics

- 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







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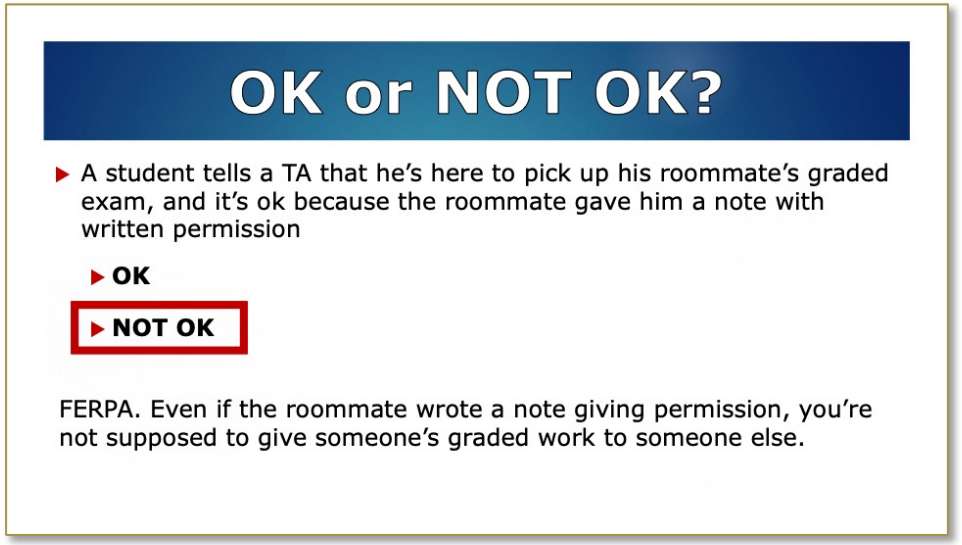
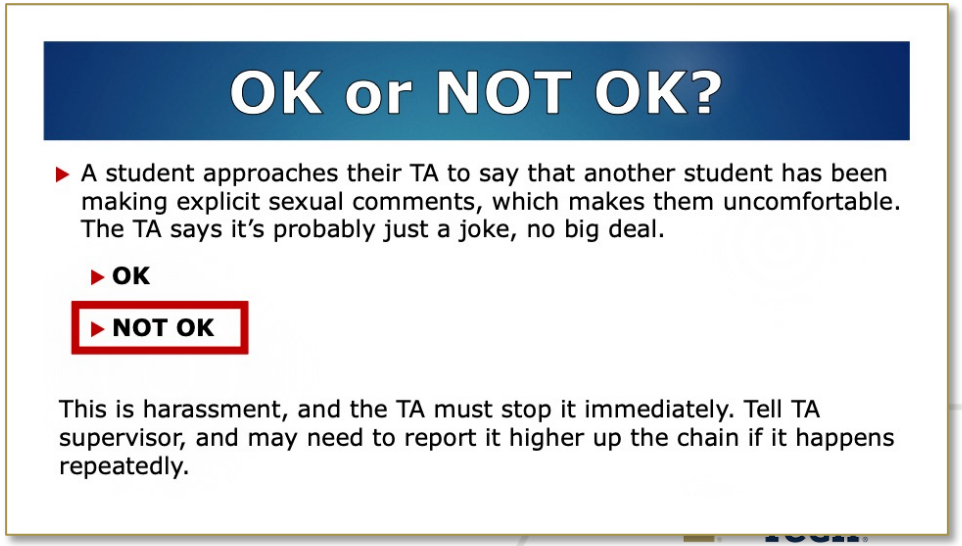
Things that work: OK/Not-OK Game

- 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
- GTAs enjoy gamification of "boring" topics!





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Things that work: Classroom Observations

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

Alicea-Muñoz et al, PhysRevPER 17, 020125 (2021)

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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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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Enrollment in GTA Preparation

Excluded from analysis (pilot) →

Thesis analysis (2020)

In preparation (PhysRevPER, expected 2025)

Year	Enrolled	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	77 %	38 %	23 %
2023	25	100 %	20 %	68 %
2024	32	84%	16 %	47 %
Overall (sans 2013)	**255**	**80 %**	**26 %**	**41 %**

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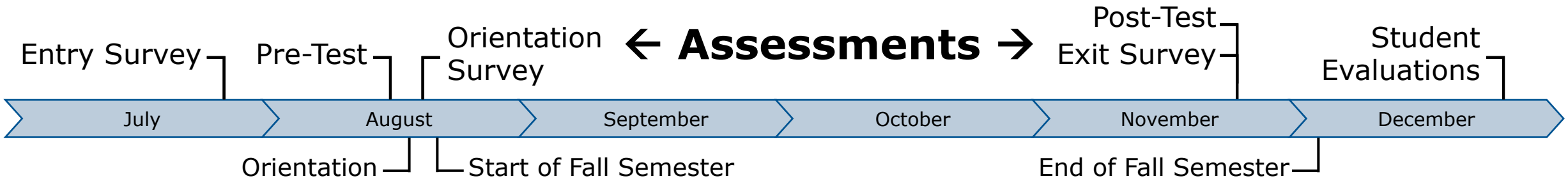
Program Assessment

- Assessment period spans 2014-2024
  - 204/255 graduate students signed informed consent (80%)
  - 26% women, 41% international, ~60% with no prior teaching experience
- Mixed-methods assessments spread throughout Fall semester



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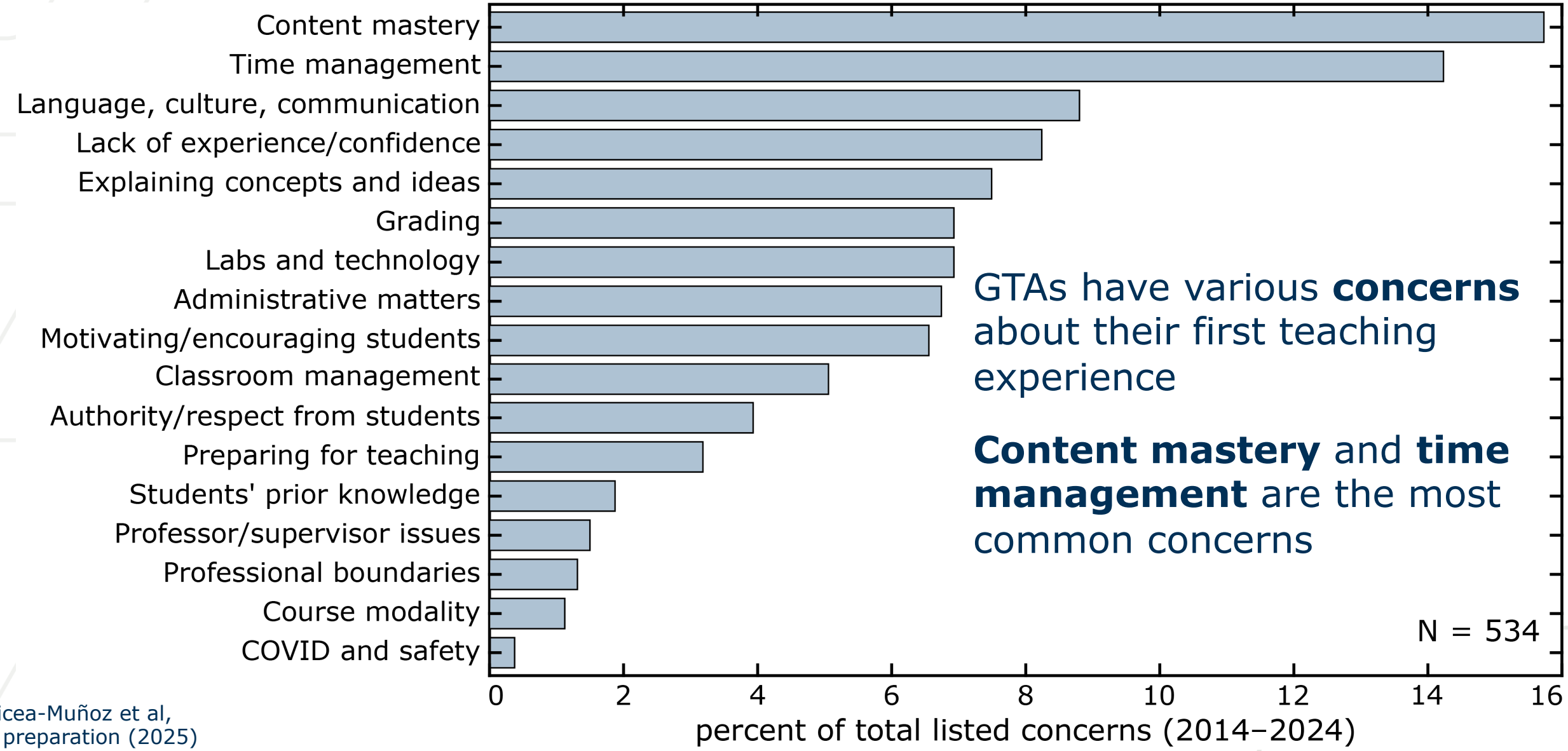
Initial conditions of first-time GTAs



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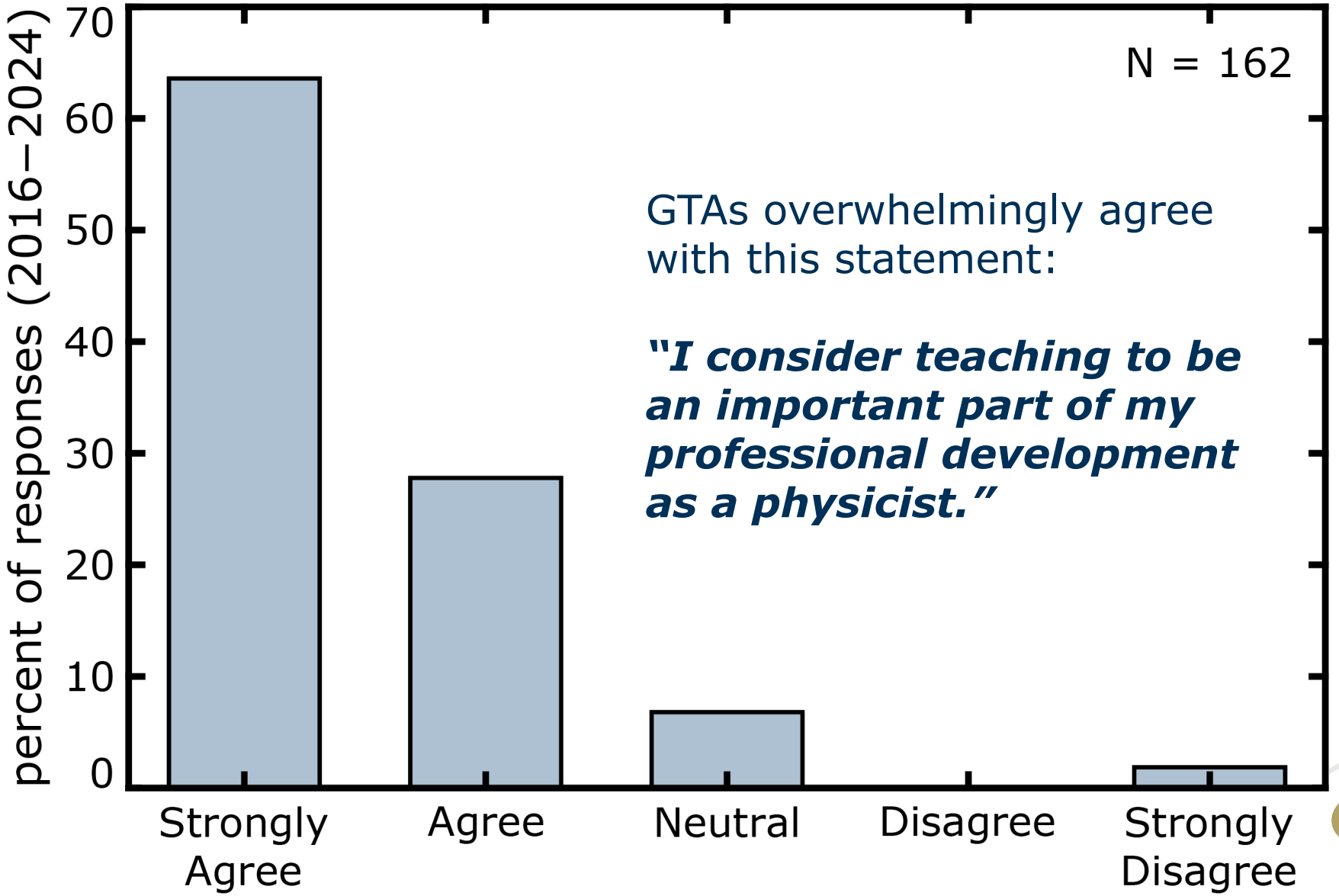
Initial conditions of first-time GTAs



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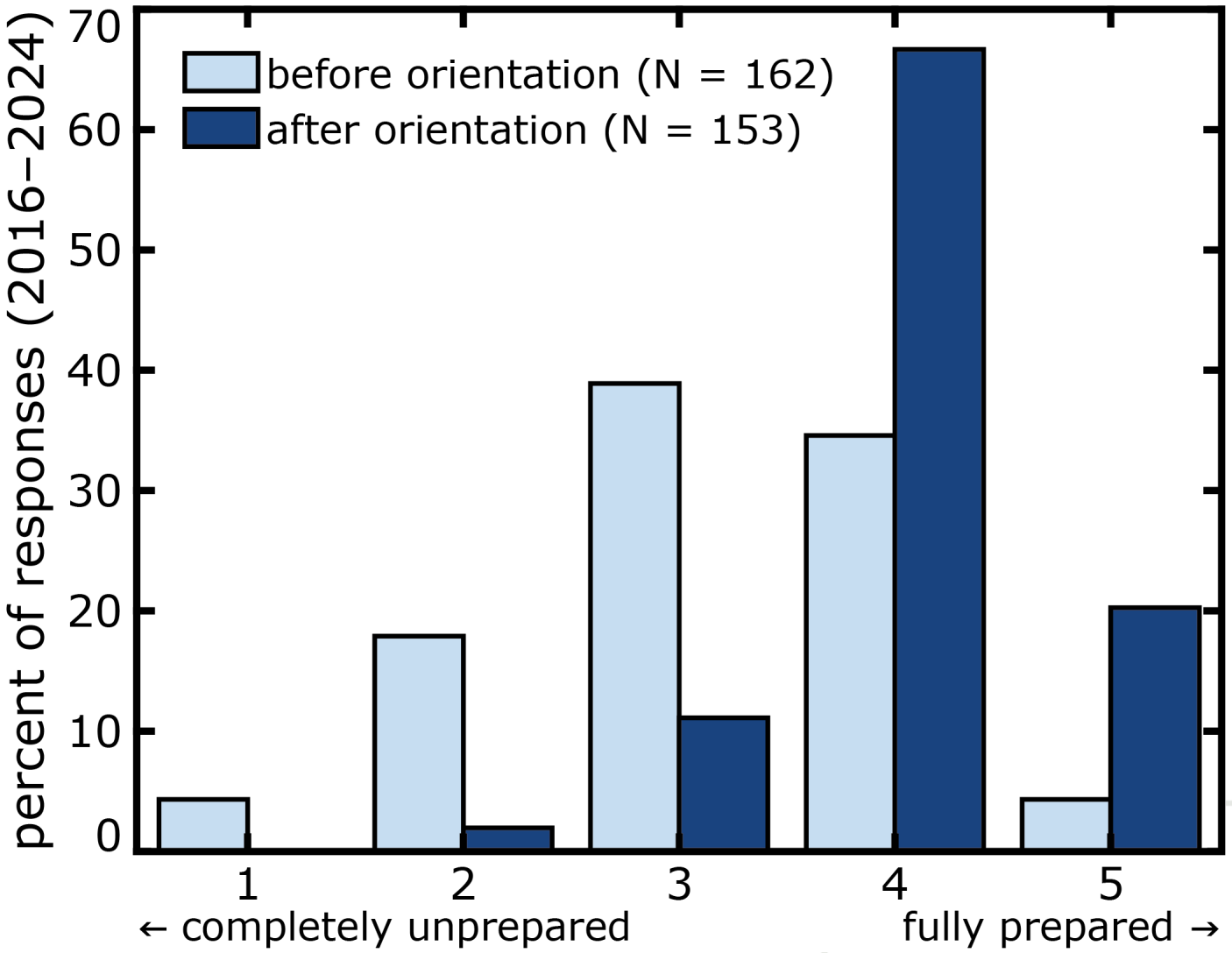
GTAs feel better prepared for teaching after going through the Orientation

- Same question asked before and after Orientation:

  "How prepared do you feel for your first GTA assignment at Georgia Tech?"

- Very large effect size (Cohen's d = 1.119)



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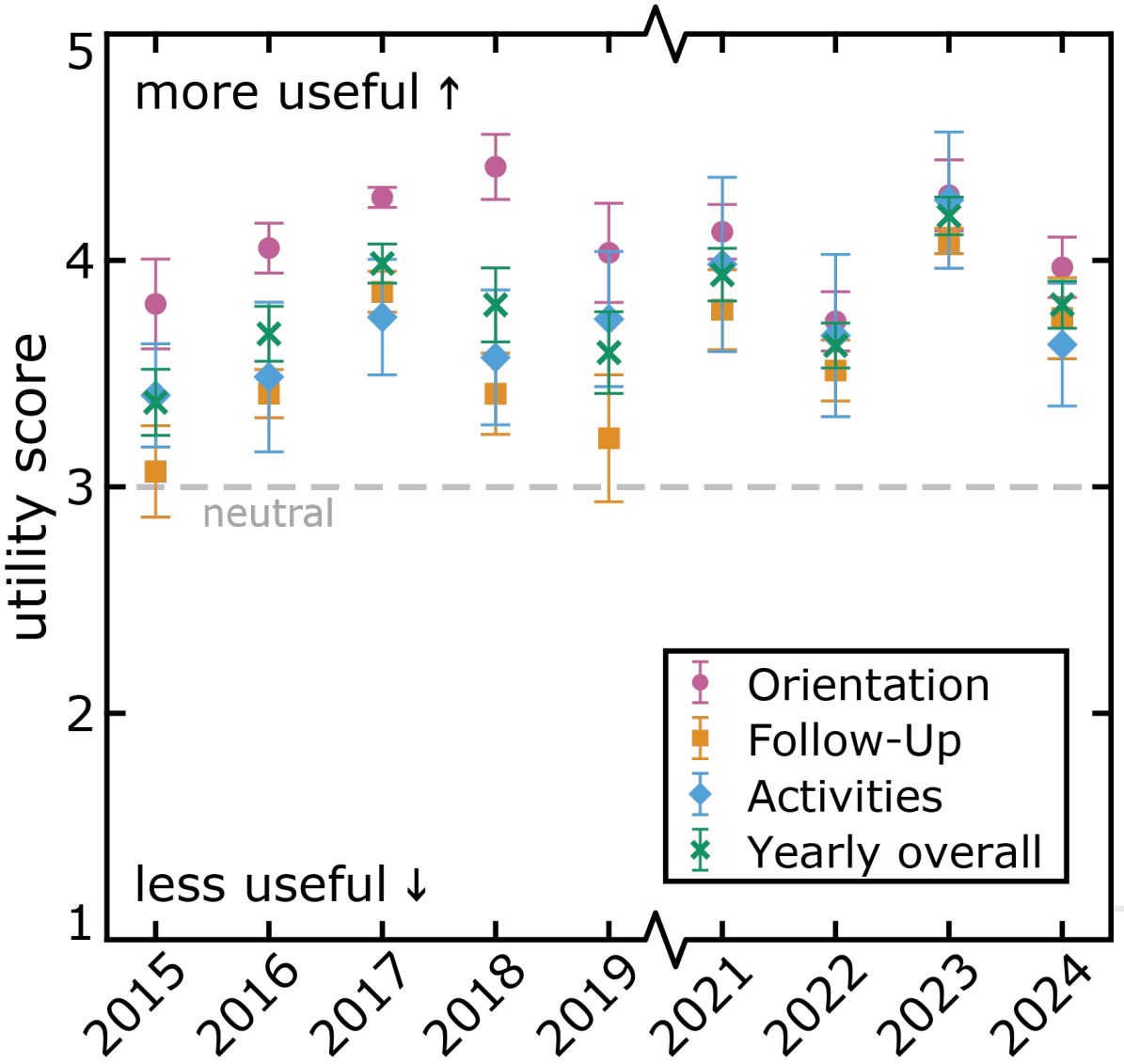
At the end of the semester, GTAs indicate the class in general was useful

- 5-point Likert items, one for each session in Orientation, Follow-Ups, and Activities
- **Utility score:** mean of means, in each category and yearly
- Course overall:
  3.65 ± 0.11 (M±SE)
- **Orientation** always considered most useful part of the course



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Approaches to Teaching Inventory

- ATI: research-validated instrument* to determine how teacher-centered or learner-centered is an instructor's approach to teaching
- 16 Likert items creating two 8-item Likert scales, one for teacher-centered and one for learner-centered
- GTAs fill out ATI before the Orientation (pre-test) and again on the last day of classes (post-test)
- Our results are mixed but trending more towards learner-centered

* Trigwell & Prosser, Educational Psychology Review, 16 (2004)
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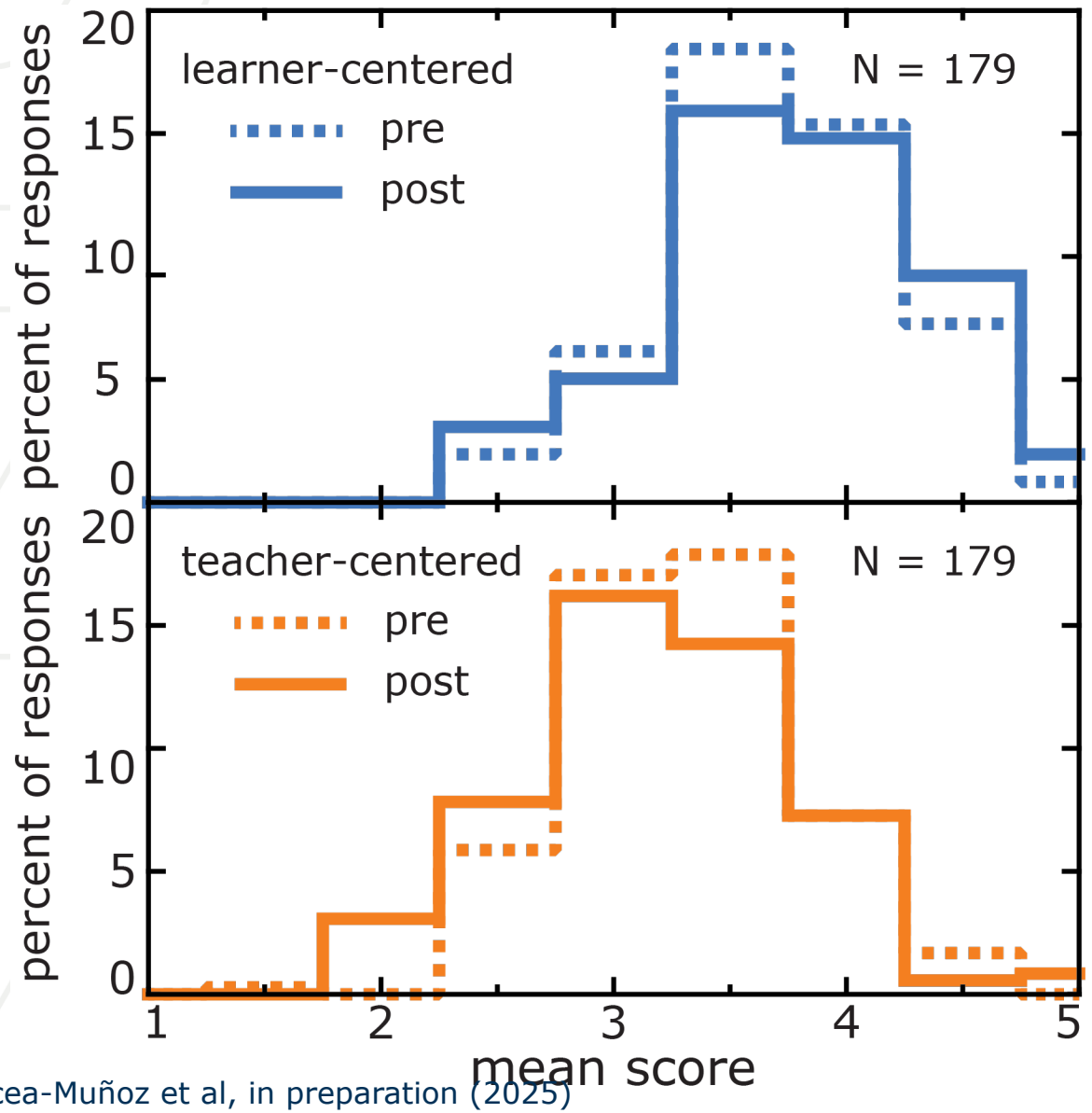
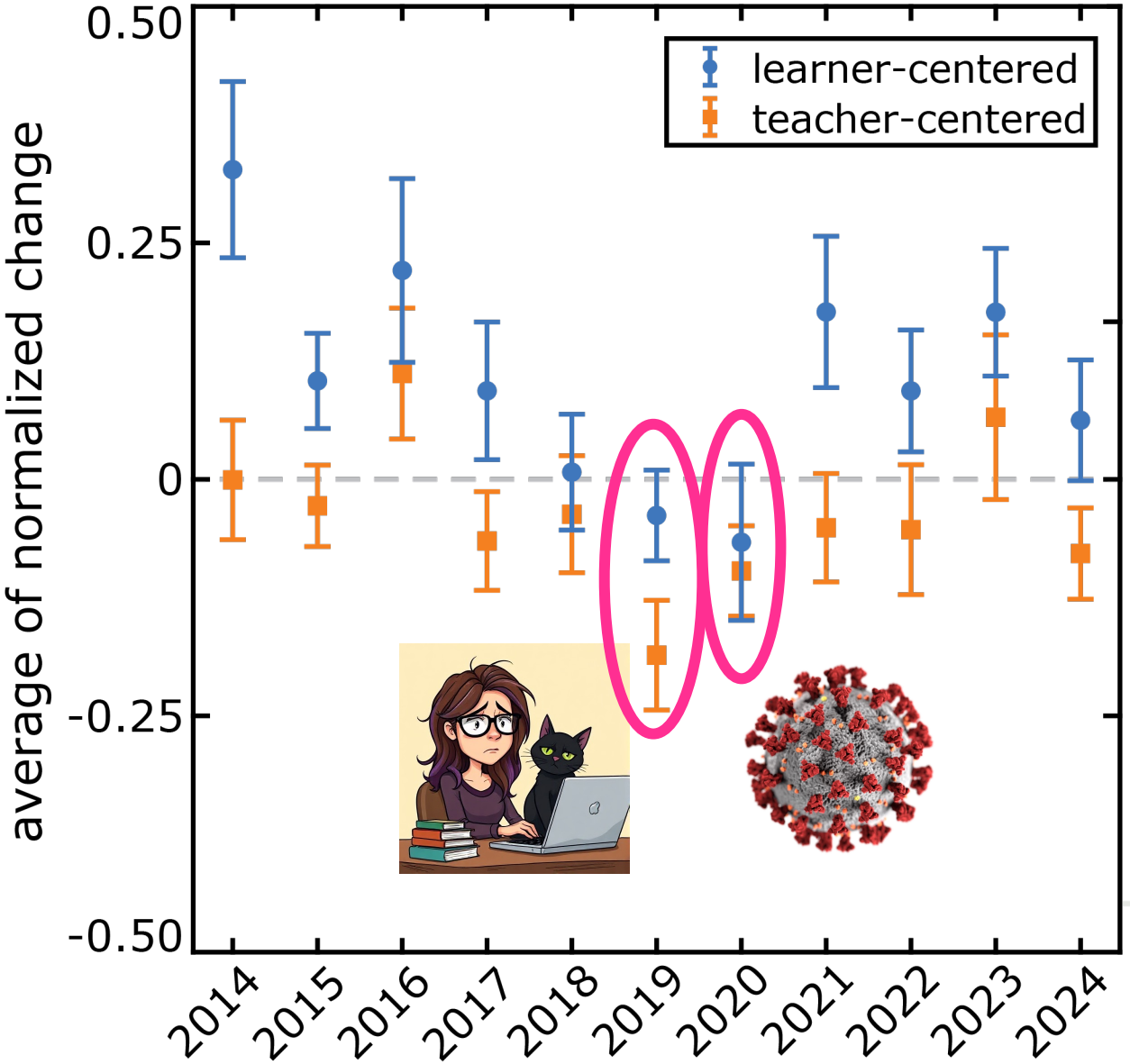
Approaches to Teaching Inventory





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End-of-Semester Student Evaluations

- **Caveat!!!** Student evaluations alone CANNOT measure teaching effectiveness
- **No GTA prep:** GTAs with first teaching experience in 2011-2012
- **With GTA prep:** GTAs with first teaching experience in 2013-2021
- 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

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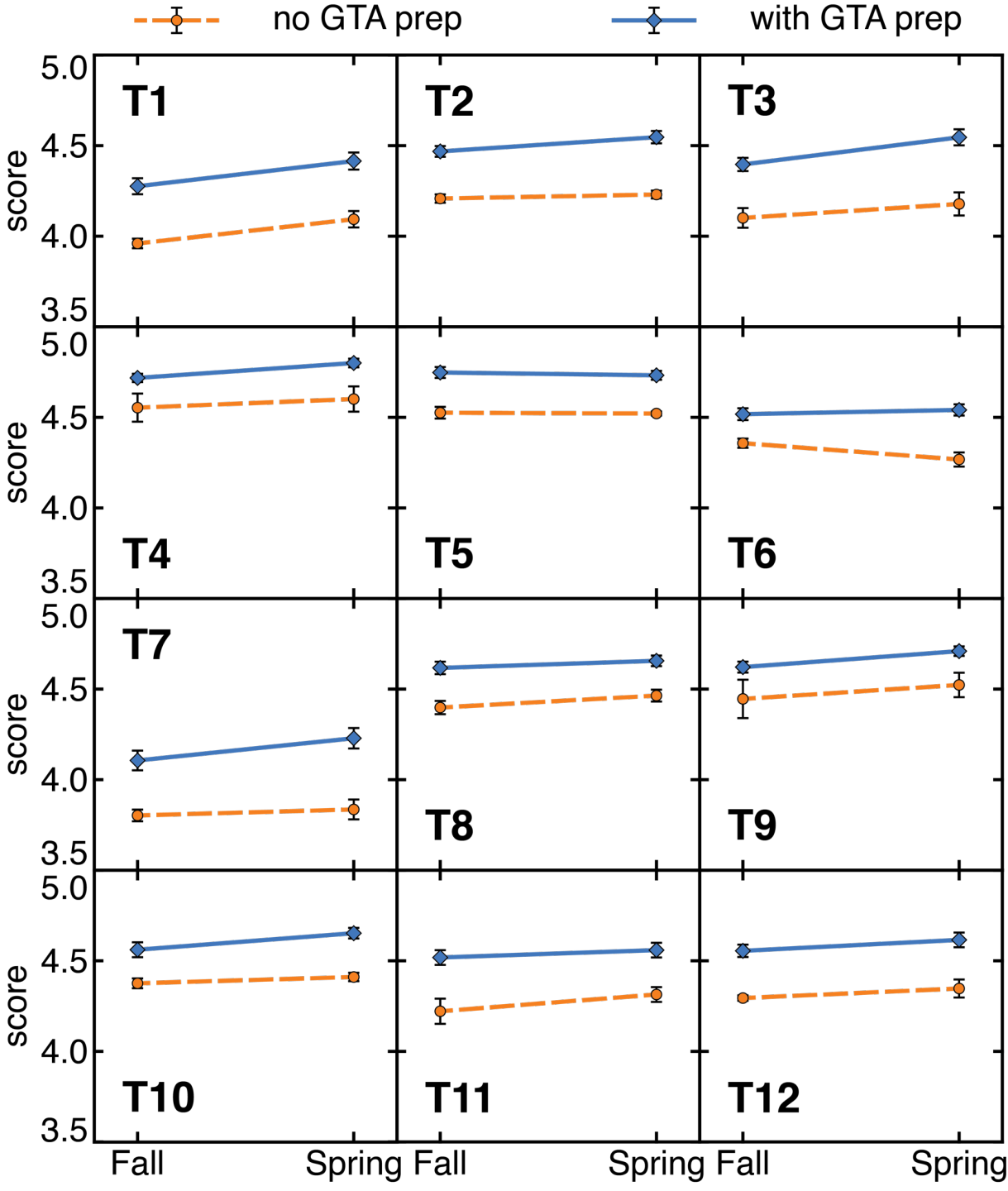
End-of-Semester Student Evaluations

- GTAs who participated in prep course **always rated higher**
- **Highest rated:** respect for students, familiarity with concepts, 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**



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Answering the Research Questions

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, Classroom Observations
- 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

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

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, though not a guarantee, of better teaching effectiveness

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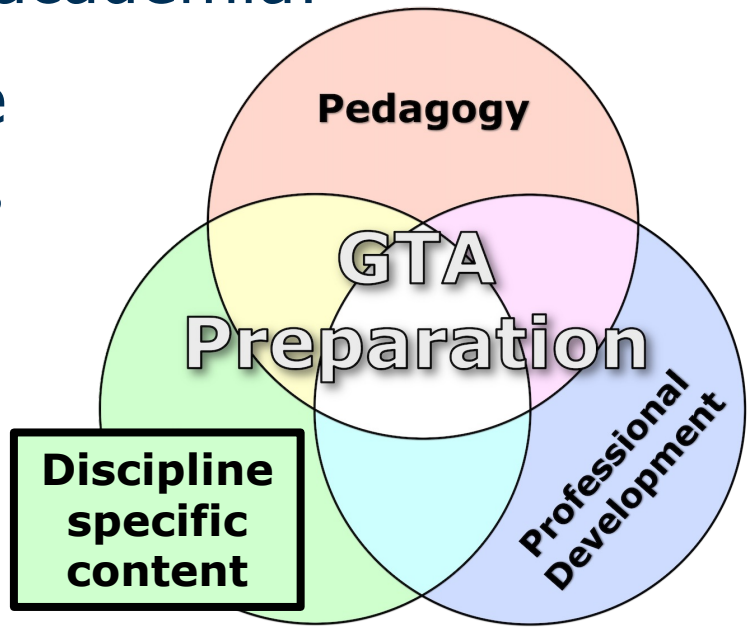
Broader significance of our work

- 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**, and is **effective** at preparing GTAs for their first teaching roles
- First-time GTAs consider teaching to be an **important** part of their professional development, and are **concerned** about **content mastery** and **time management**, among other things
- GTAs **feel better prepared** for teaching after participating in GTA preparation, adopt more **learner-centered** teaching approaches, and their students consider them **effective teachers**

Scan here →
for all my GTA prep
research and materials