Transforming the Preparation of Physics GTAs

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Georgia Tech College of Sciences
School of Physics

The need for TA preparation

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

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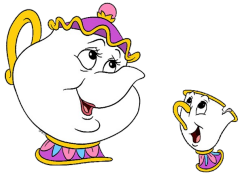
Tale as old as time…

"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

1980

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]

1990

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]

2000 and beyond

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]

[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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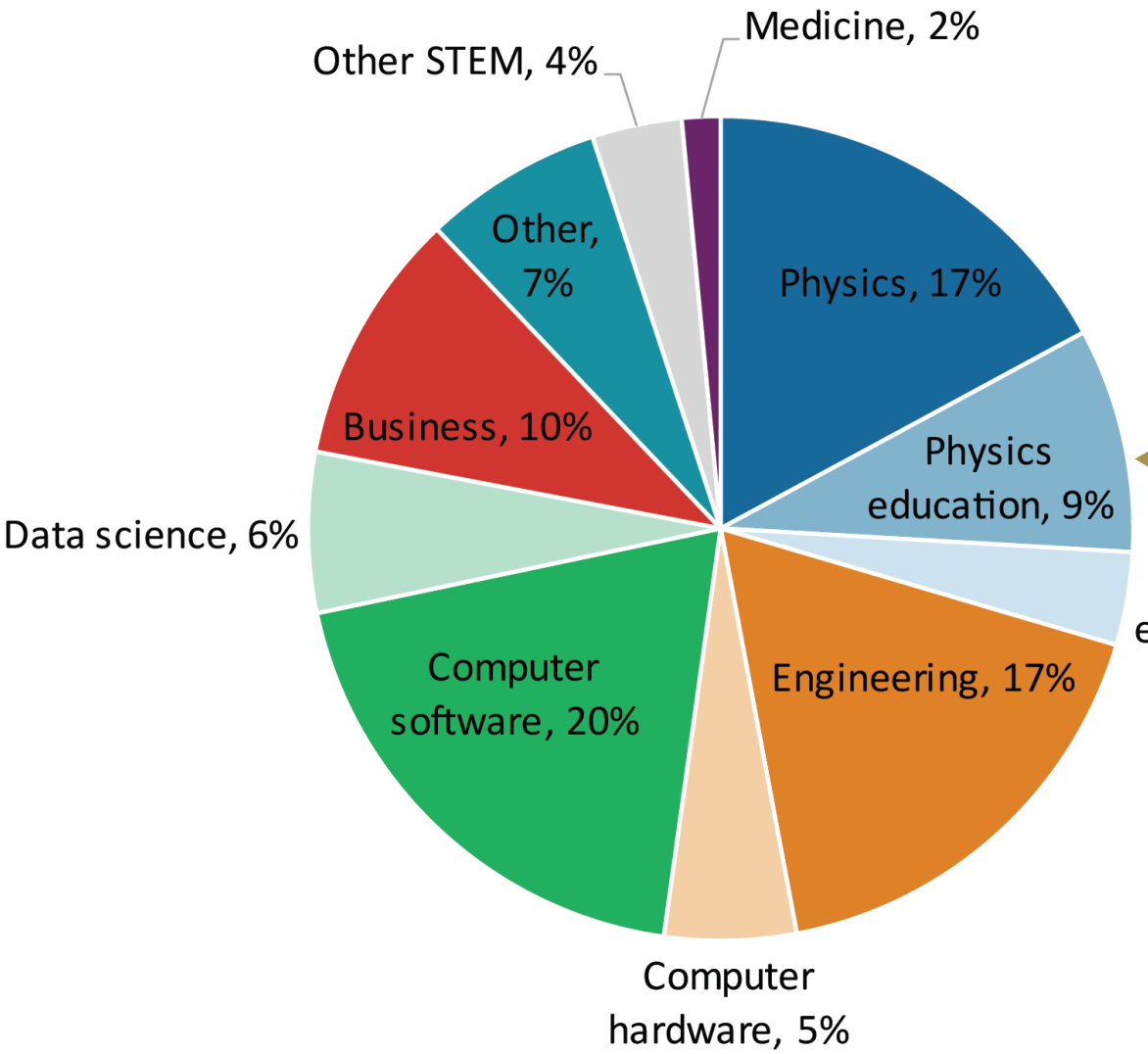
A majority of physics PhDs leave academia



Field of employment for new physics PhDs in potentially permanent positions, classes of 2014 through 2018

academic positions (13% of all 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 want to help GTAs develop **transferable professional skills** they can use outside the classroom
  - Especially important for grad students who don’t plan on staying in academia

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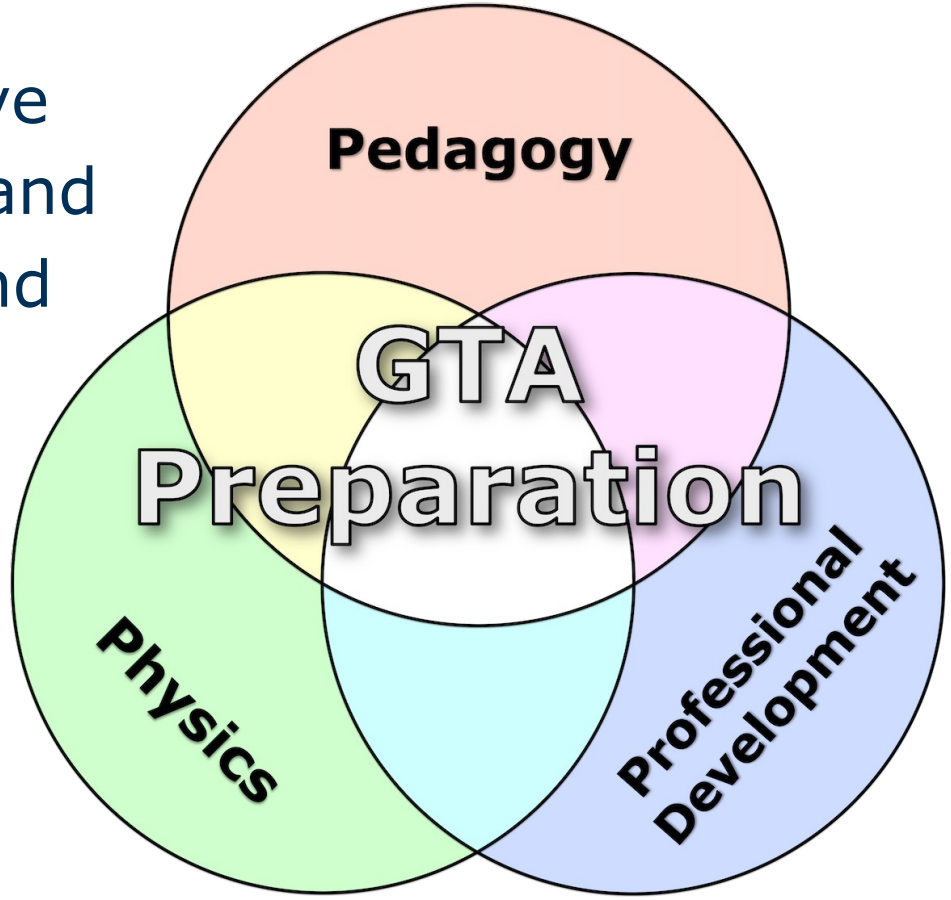
New Perspective on GTA Preparation

- **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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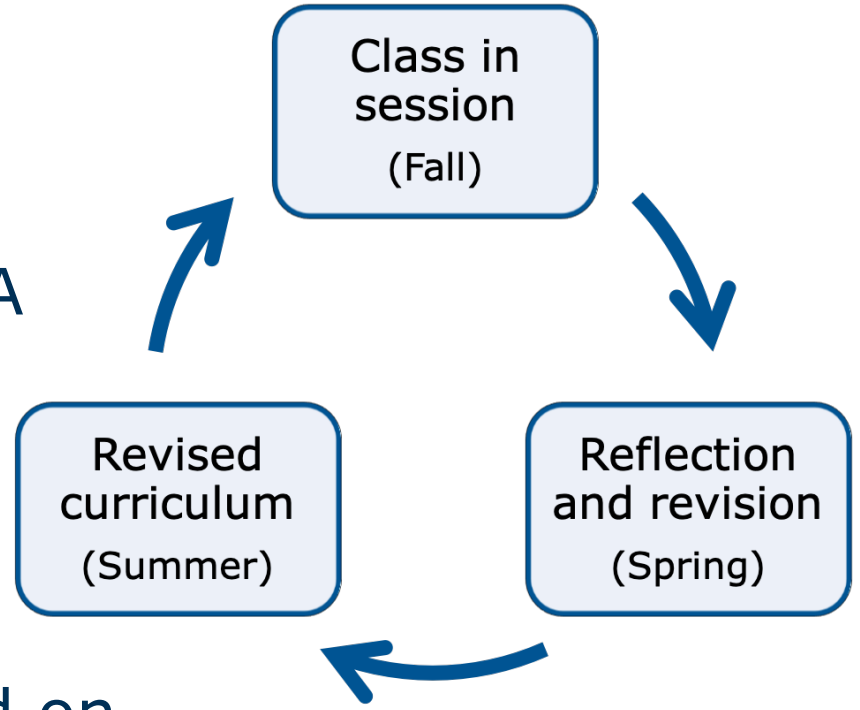
Physics GTA Preparation Course

- One credit, pass/fail, required for first-time GTAs, offered every Fall semester 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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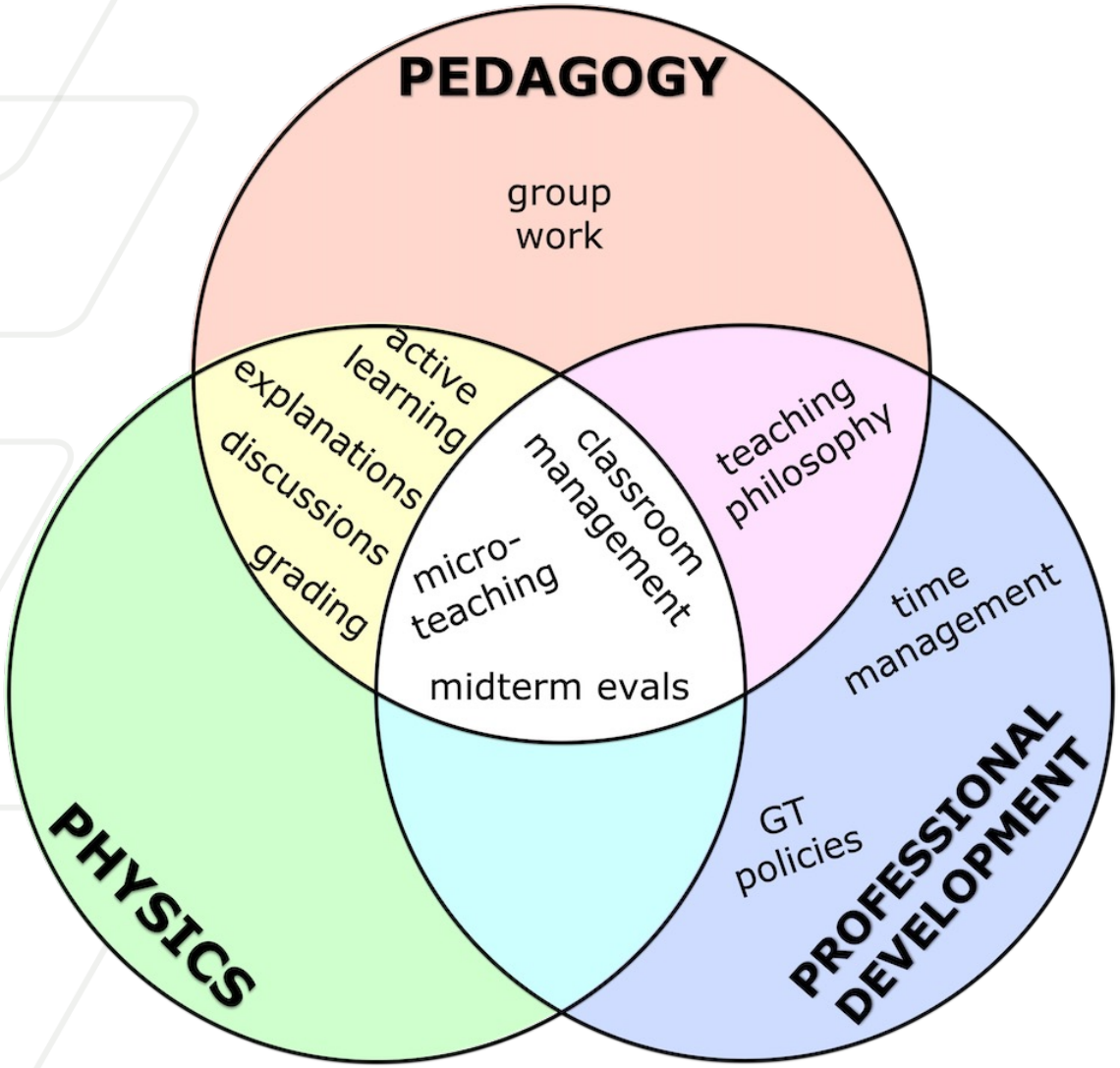
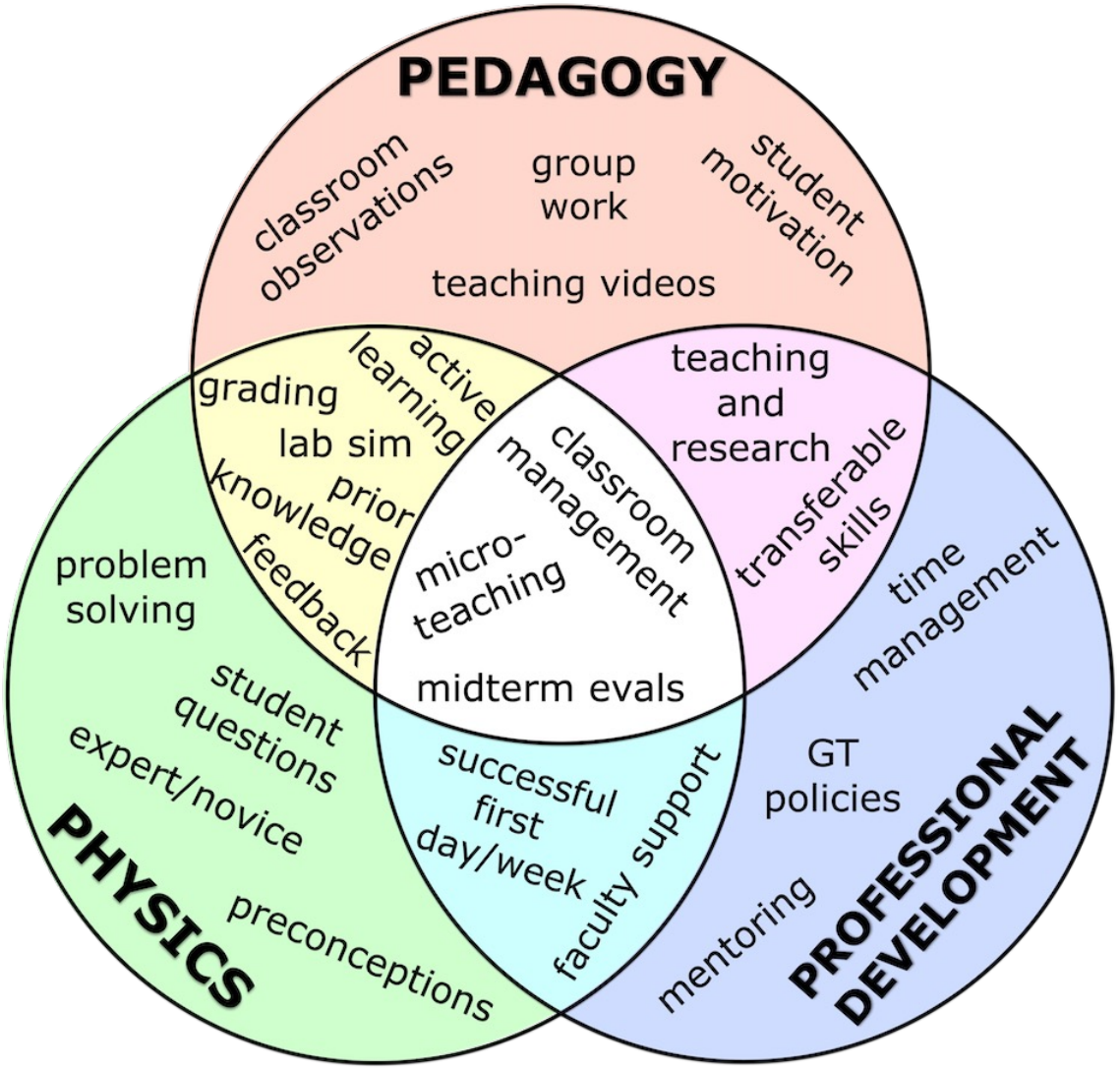


2013



2019

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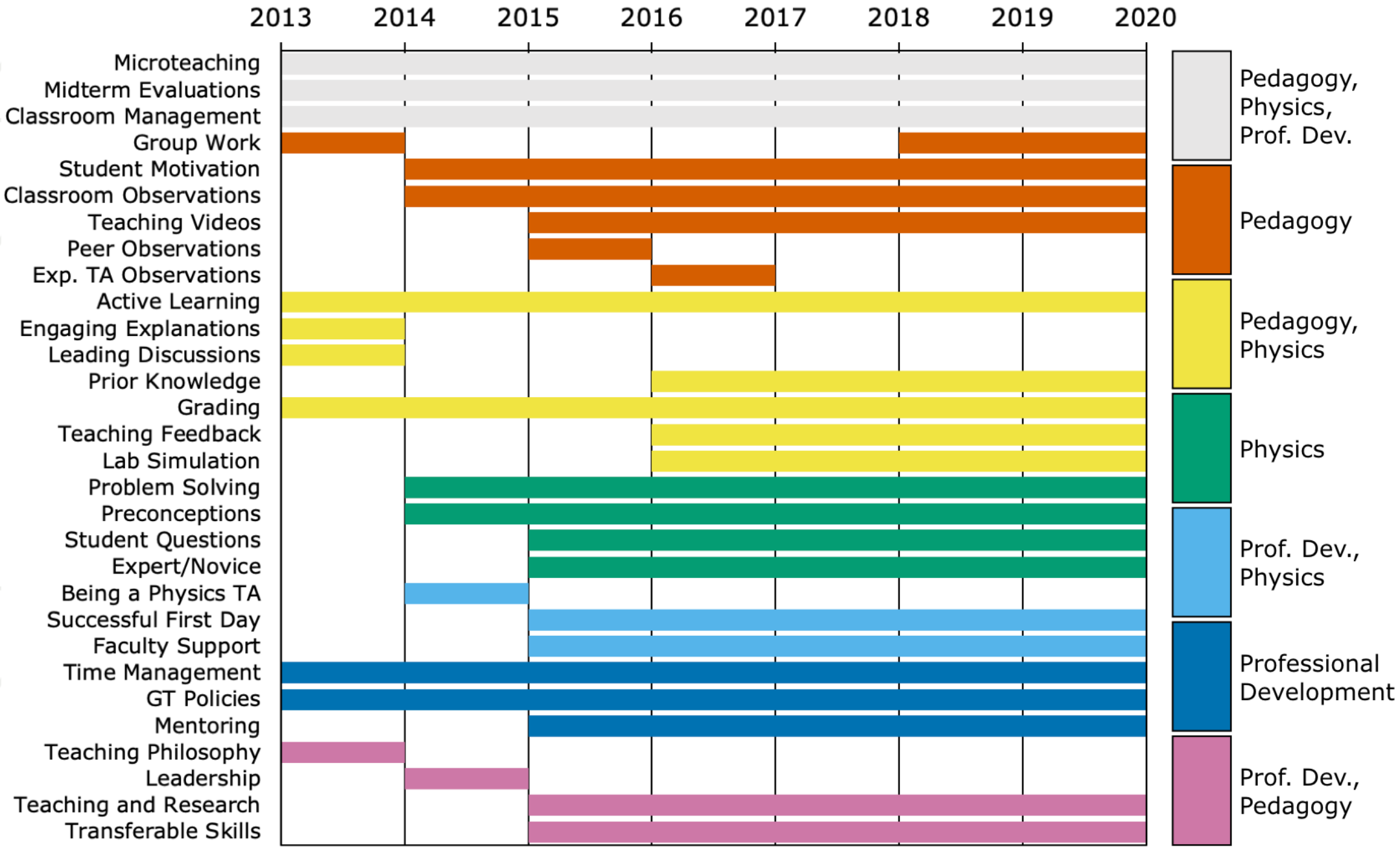
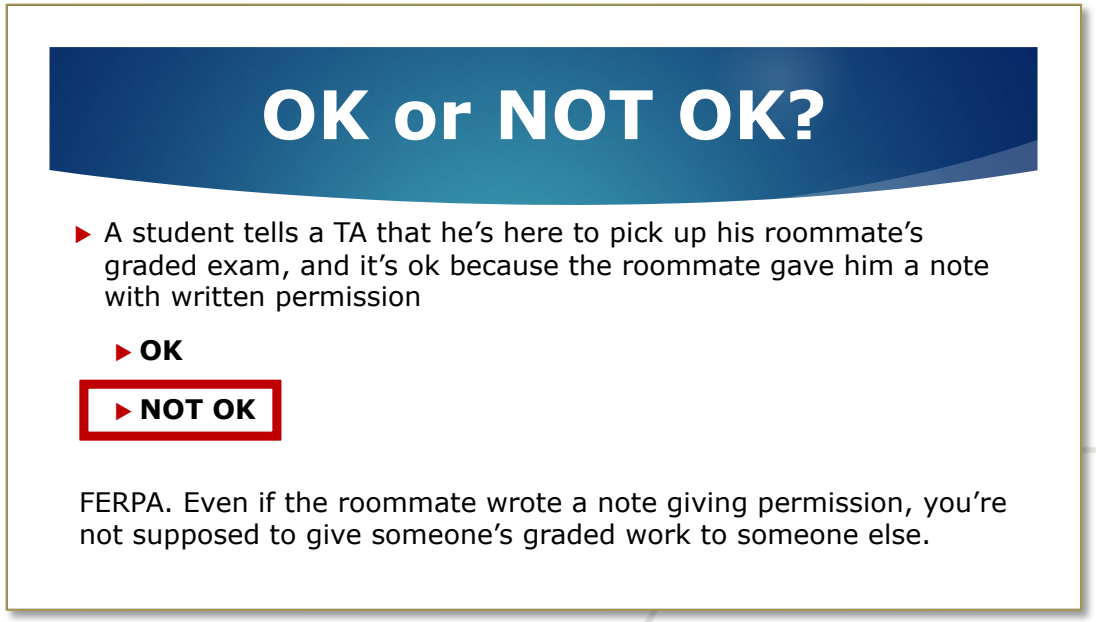


* Alicea-Muñoz et al, Phys. Rev. Phys. Educ. Res. 17, 020125 (2021)

Evolution of the Curriculum

- **Persistent over the years:** Microteaching*, Midterm Evaluations, Classroom Management, Active Learning, Grading, Time Management, Georgia Tech Policies
  - Microteaching worked well in Fall 2020, when everything was remote!
  - Grading has separate sessions for the different assignments; recent issues will result in changes for Fall 2023
  - GT Policies stopped being boring in 2017 with the introduction of the OK/NOT-OK game: sample slide →



* Alicea-Muñoz, AAPT SM20 Invited Talk

Evolution of the Curriculum

- **False starts:** Peer Observations, Experienced TA Observations, Leading Discussions, Being a Physics TA, Teaching Philosophy, Leadership
  - Most of these were complete disasters for various reasons…

Evolution of the Curriculum

- **Newer and successful:** Classroom Observations*, Teaching Videos, Lab Simulation**, Successful First Day/Week, Mentoring, Teaching and Research/Transferable Skills
  - Over 600 GB of classroom observation videos accumulated so far
  - TAs get *really* into the lab simulation roleplay; lab simulation didn't happen in Fall 2020 because everything was remote
  - Three mentoring meetings per semester with older graduate students, on topics about wellness, picking an advisor, and career guidance

* Alicea-Muñoz, AAPT SM22 Invited Talk
** Alicea-Muñoz, AAPT SM20 Invited Talk

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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 (expected publication in early 2023)

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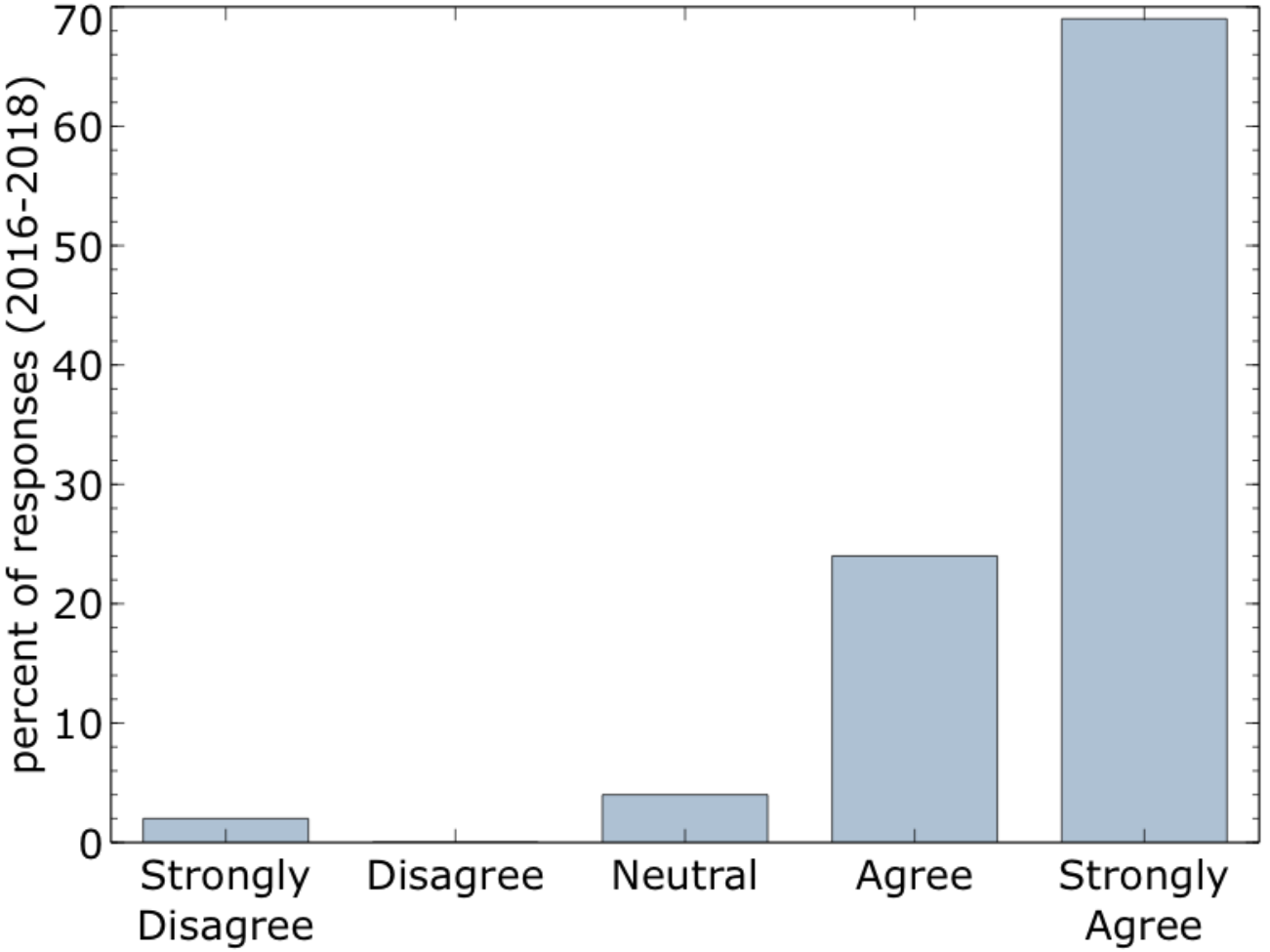
The initial conditions of first-time GTAs

- 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, PhD Dissertation, Georgia Tech (2020)

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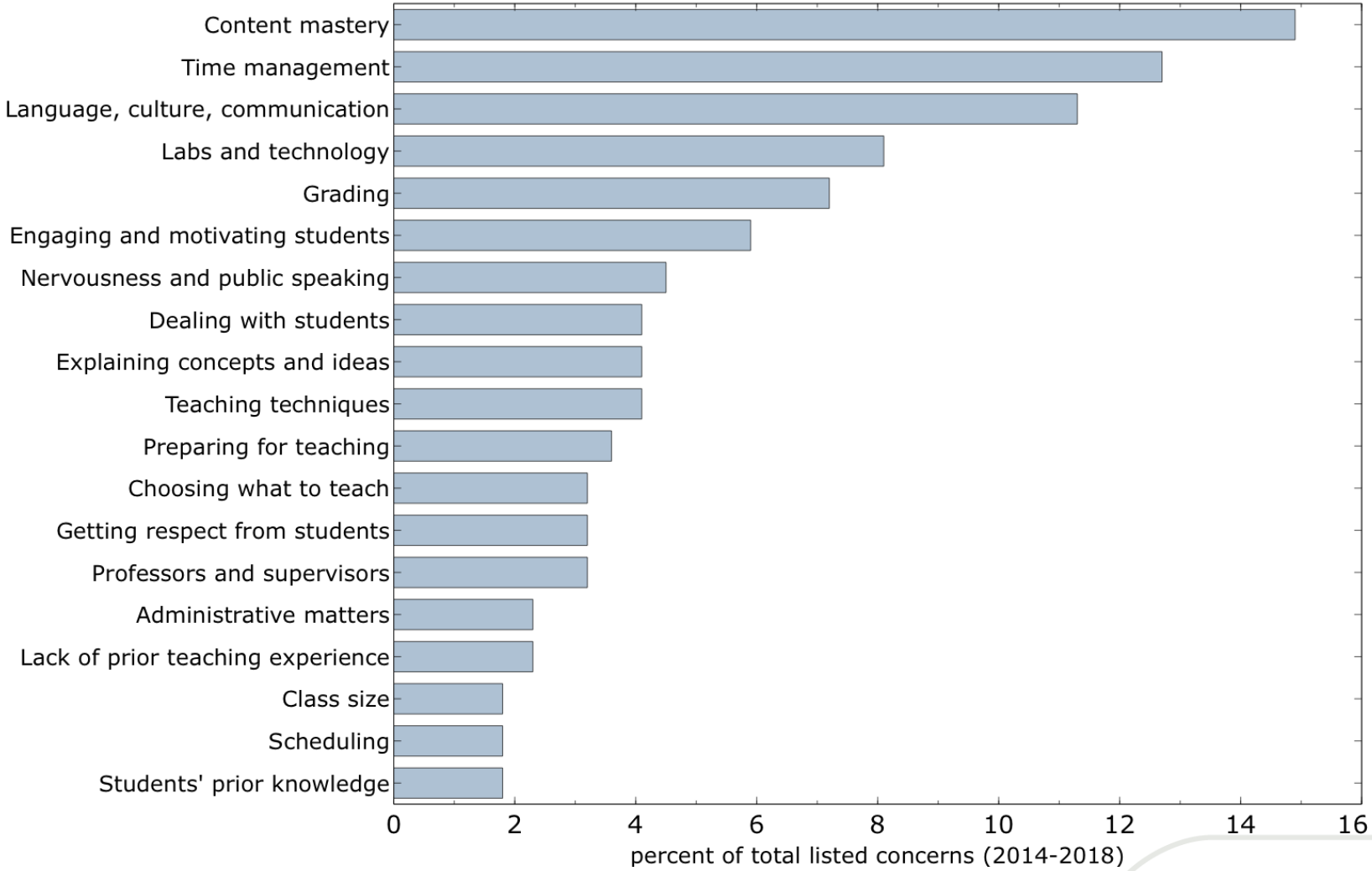
The initial conditions of first-time GTAs

- 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, PhD Dissertation, Georgia Tech (2020)

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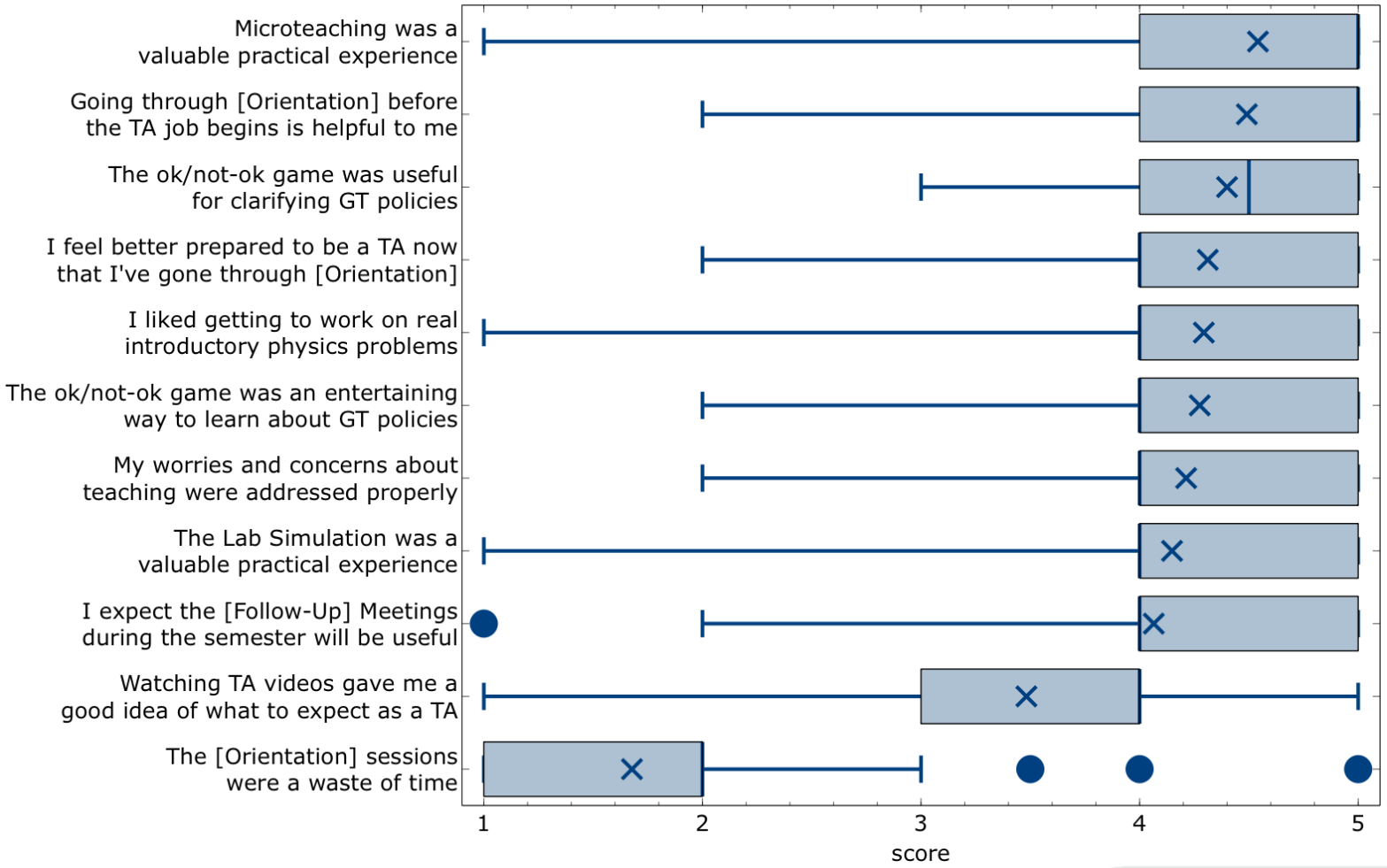
Orientation Survey

- 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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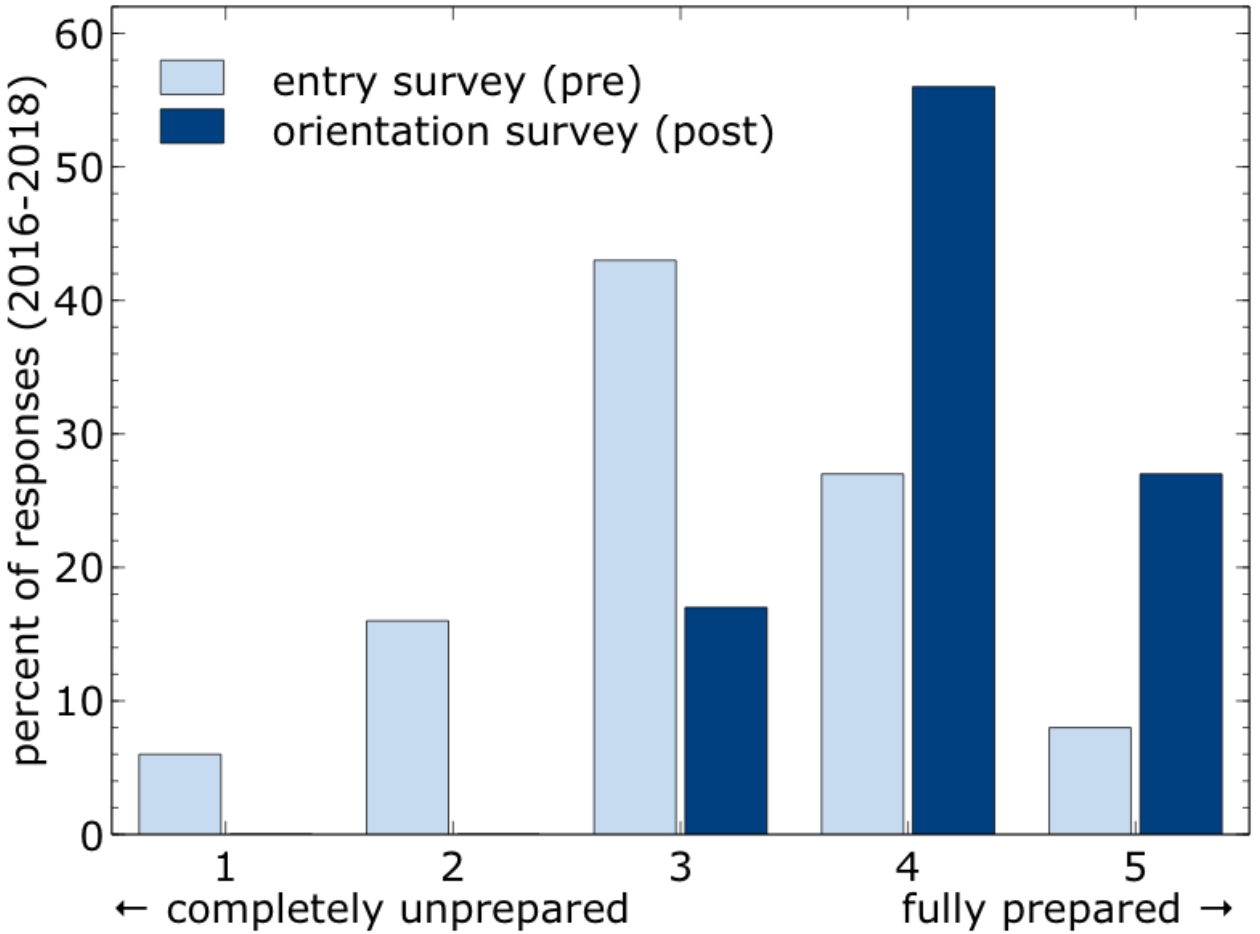
Orientation Survey: Preparedness

- "How prepared do you feel for your first GTA assignment at Georgia Tech?"
- **Pre:** Entry Survey ($N = 49$, not anon)
- **Post:** Orientation Survey ($N = 64$, anon)
- Statistically significant pre/post difference (KS test, $p < 0.001$), and very large effect size (Cohen's $d = 1.333$)
- **GTAs feel better prepared for teaching after the Orientation**



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

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Final Survey

- At end of semester, asked GTAs to rate usefulness of lessons

- **Overall top 3** most useful:
  1. Microteaching (4.40 ± 0.95)
  2. Lab Simulation (4.30 ± 1.09)
  3. Teaching Physics (4.10 ± 1.05)

- **Yearly top 3** most useful are more nuanced →

Rank	Item	Score ($M \pm SD$)
	2015	
1	Microteaching	4.38 ± 1.07
2	Individual Classroom Observations	3.79 ± 1.29
3	Teaching Physics	3.76 ± 1.06
	2016	
1	Microteaching	4.32 ± 0.72
2	Teaching Physics	4.23 ± 0.69
3	Individual Classroom Observations	4.09 ± 1.11
	2017	
1	Intro & Georgia Tech Policies	4.38 ± 0.82
2	Microteaching	4.35 ± 1.07
3	Teaching Physics	4.29 ± 1.20
	2018	
1	Lab Simulation	4.80 ± 0.41
2	Microteaching	4.67 ± 0.82
3	Teaching Physics	4.33 ± 1.11

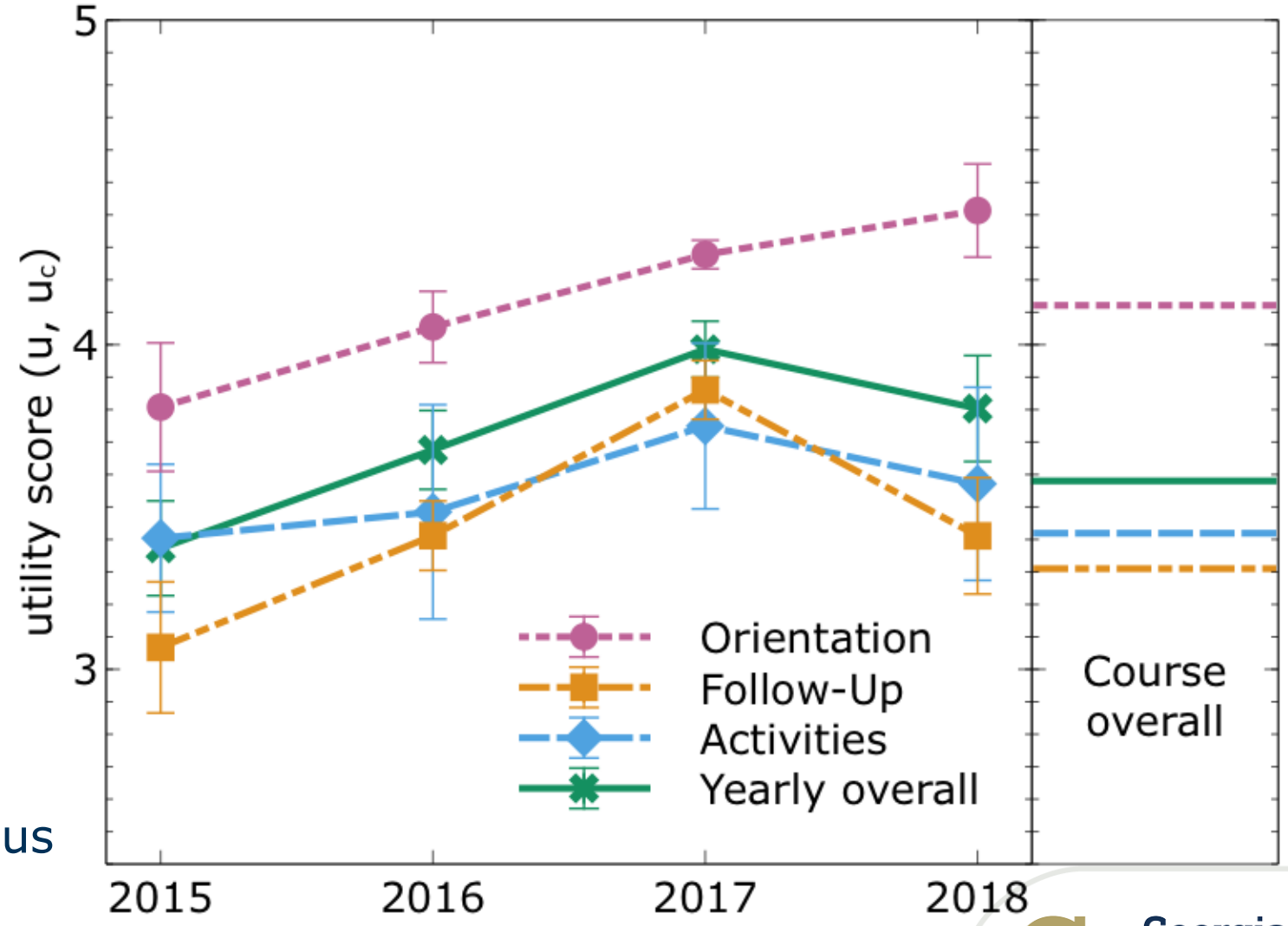
* Alicea-Muñoz, PhD Dissertation, Georgia Tech (2020)

Final Survey: Utility Scores

- Utility scores:

$$u = \frac{1}{N} \sum_i M_i$$

- Course overall: 3.58 ± 0.12 (mean ± standard error)
- **Most useful: Orientation** (every year its perceived usefulness increased)
- Analysis of more recent data (2019-2021) in progress; curious to see how 2020 comes out



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

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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."
- Complete case analysis: matched pre/post pairs with responses to every item
- For each student: teacher-centered mean, learner-centered mean (in pre-test and again in post-test)

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

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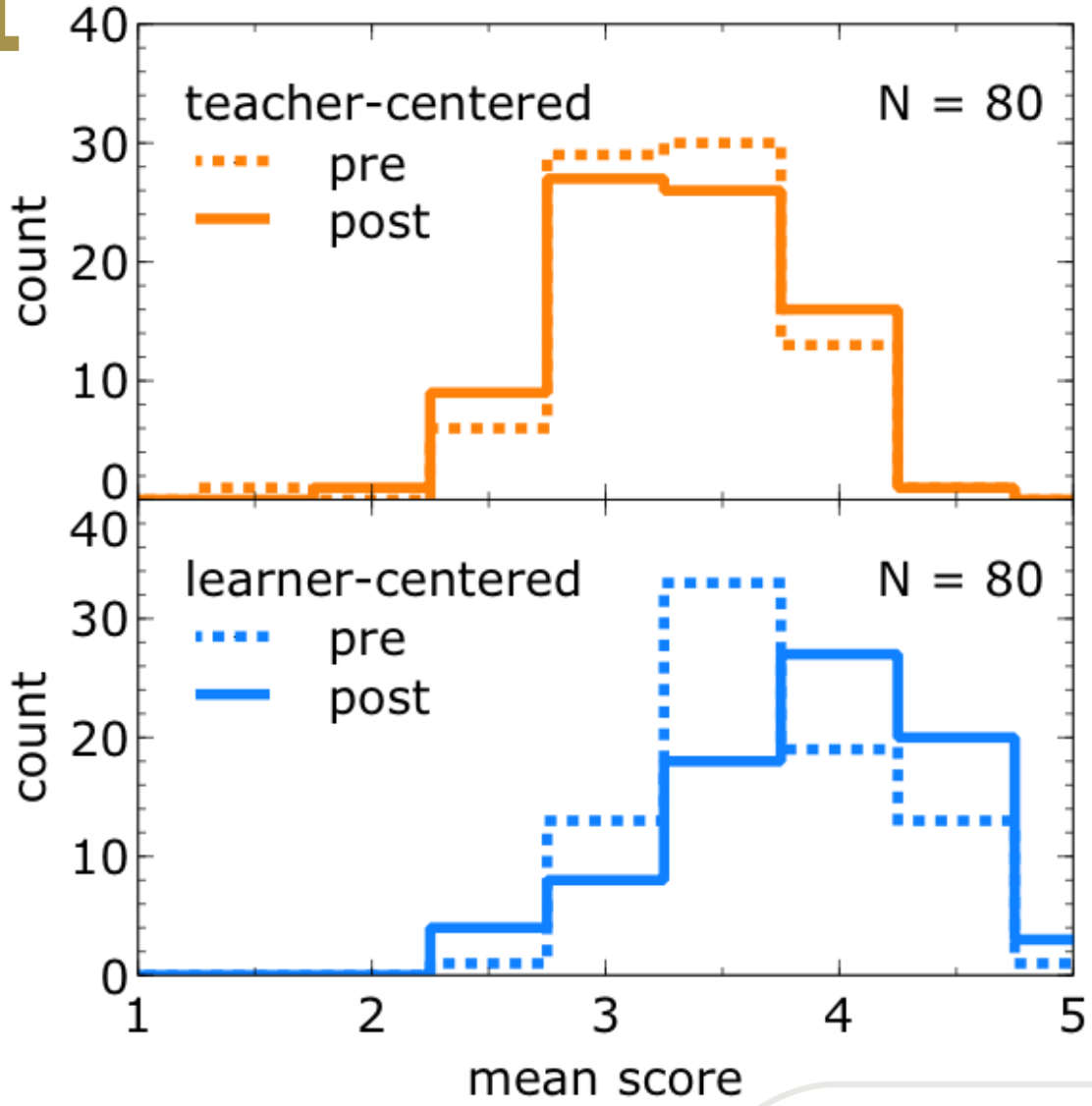
Pre/Post Tests: ATI

- No statistical difference in pre/post teacher-centered distributions (KS test, $p = 0.304$)
- Statistical difference in pre/post learner-centered distributions (KS test, $p = 0.046$) and means (t-test, $p = 0.037$); small effect size ($d = 0.254$)

- **GTAs adopt more learner-centered approaches to teaching after one semester of GTA preparation**



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

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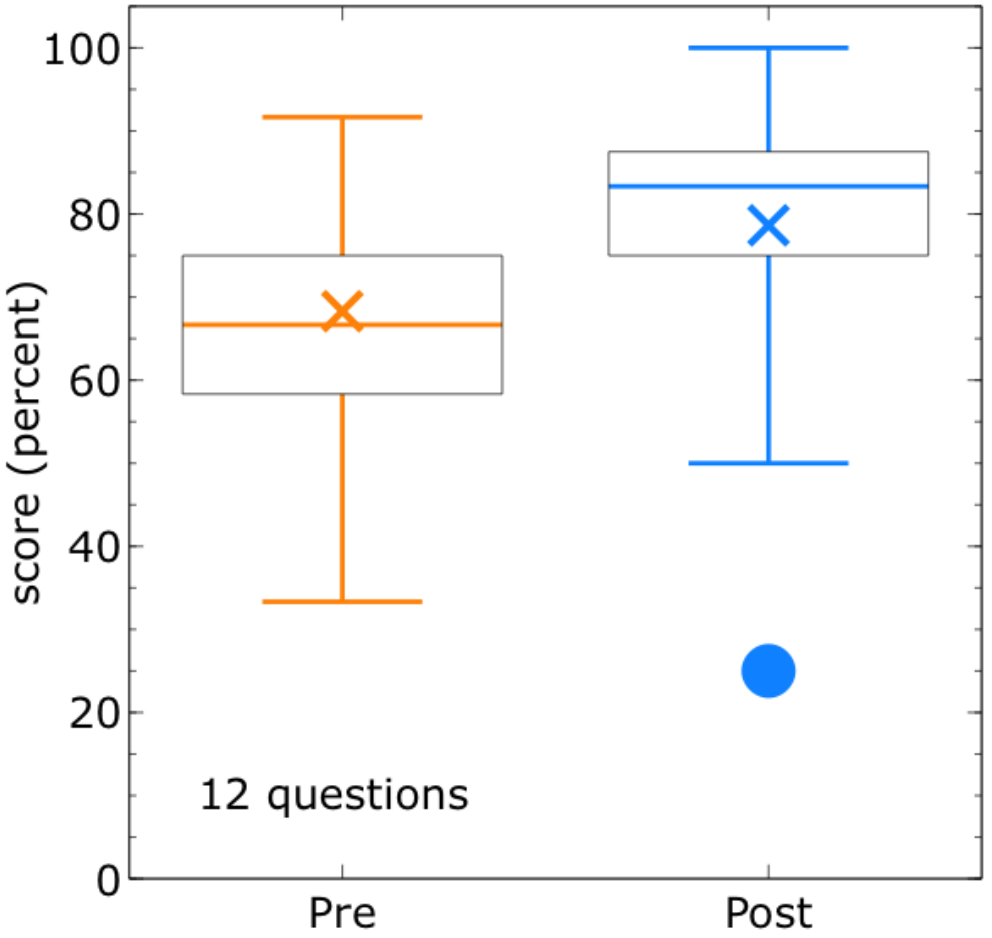
Pre/Post Tests: Knowledge Quiz

- Multiple choice test measuring five categories
- Matched pre/post pairs; each question is either correct or incorrect; a student's score is percentage of correct responses
- Analysis focused on 12 questions that repeated every year with exact same wording; post-tests always scored higher than pre-tests (all had statistically significant t-tests)
- **GTAs' pedagogical knowledge increases after one semester of GTA preparation**



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

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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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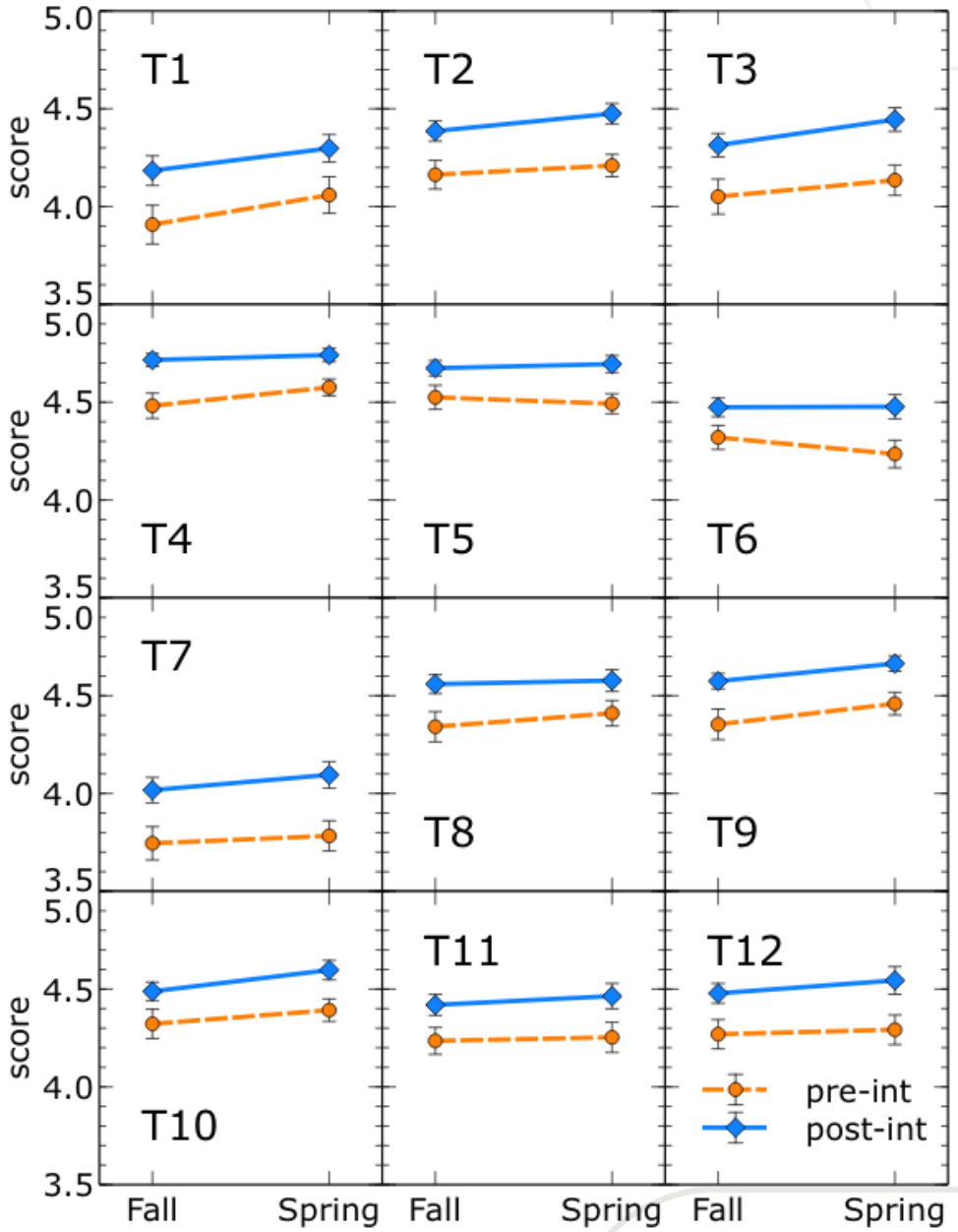
End-of-Semester Student Evaluations

- 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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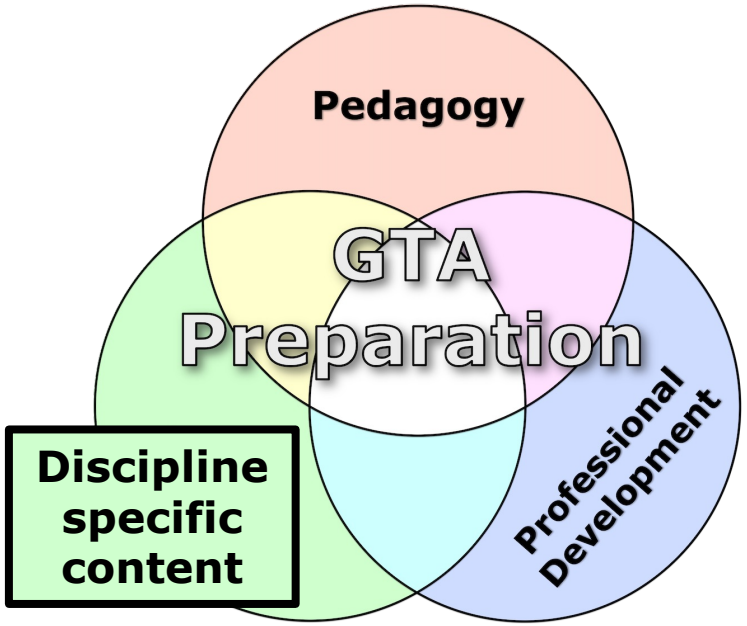
Broader significance of our work

- 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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