

# Towards a more diverse and equitable physics graduate program

Danny Caballero (he/they)

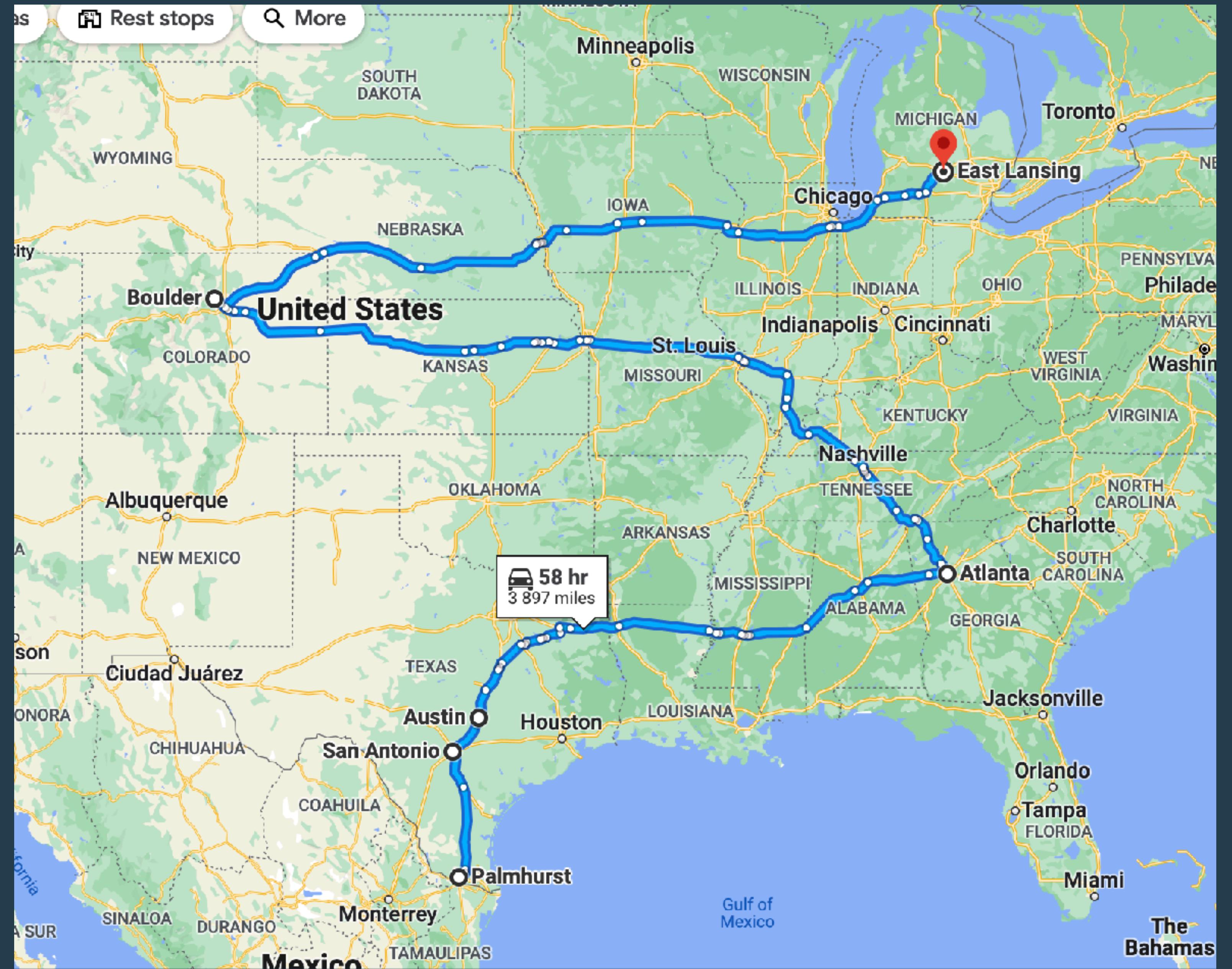
*Department of Physics and Astronomy*

*Department of Computational Mathematics, Science, and Engineering*

*CREATE For STEM Institute*



# In summary...



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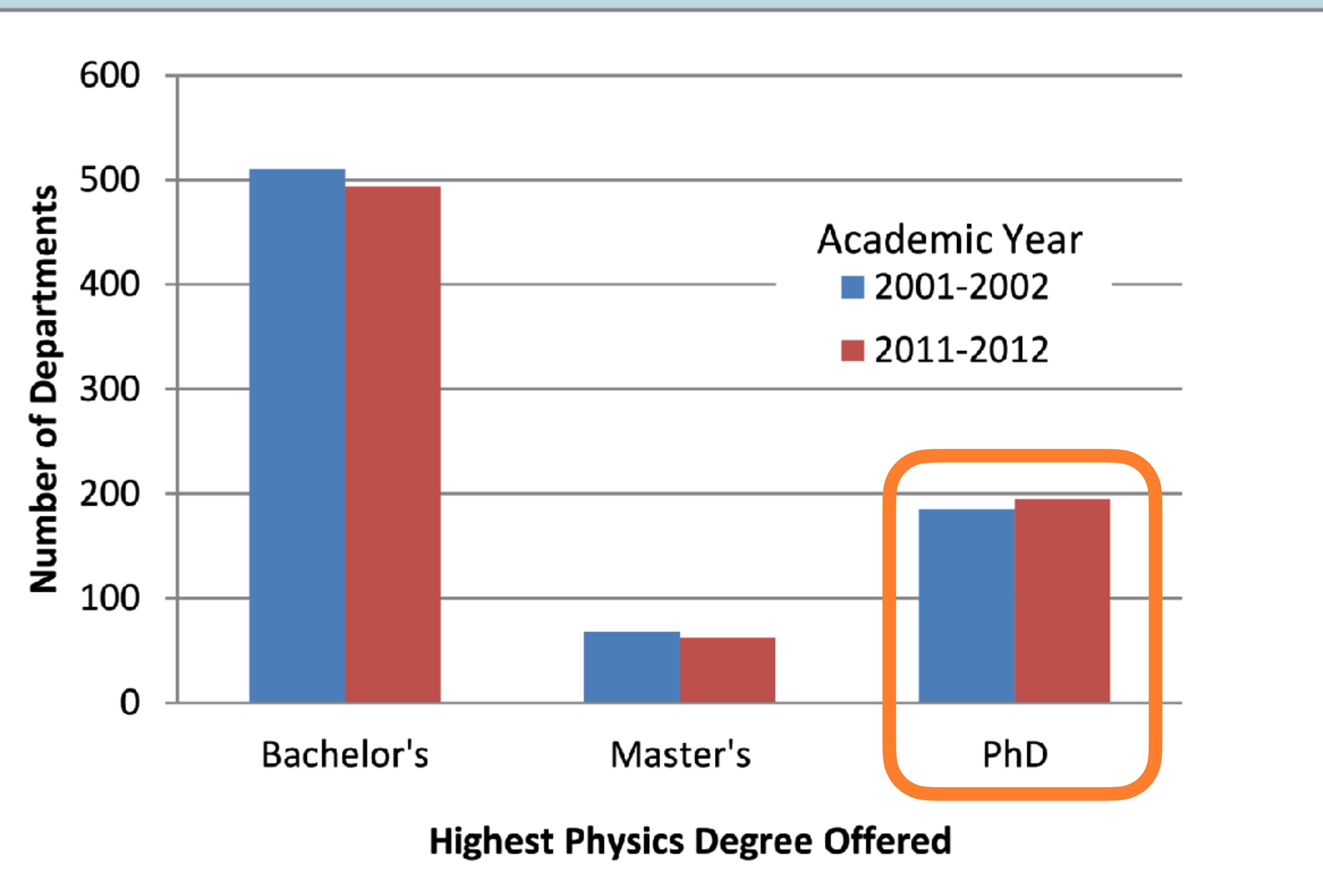
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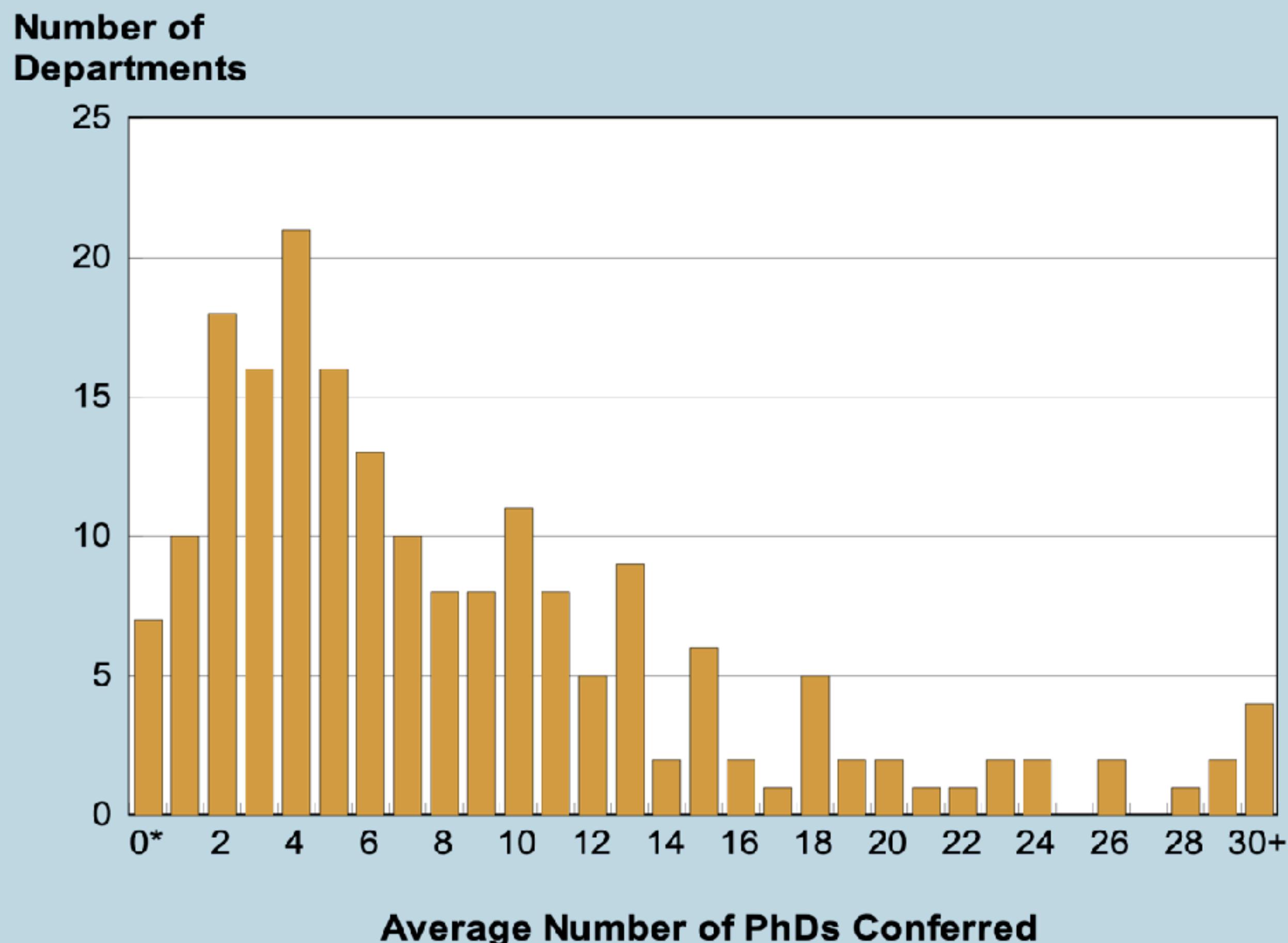
- Interested in understanding how the physical world works
- Developing the knowledge and skills to pursue scientific interests
- Joining a community interested in the enterprise of science
- Getting paid to do science
- Finding a career in science, science education, science policy, etc
- And many more (and some very personal) reasons...

There are nearly 200 programs in the US granting PhDs in physics.

## Number of Degree-granting Physics Departments.



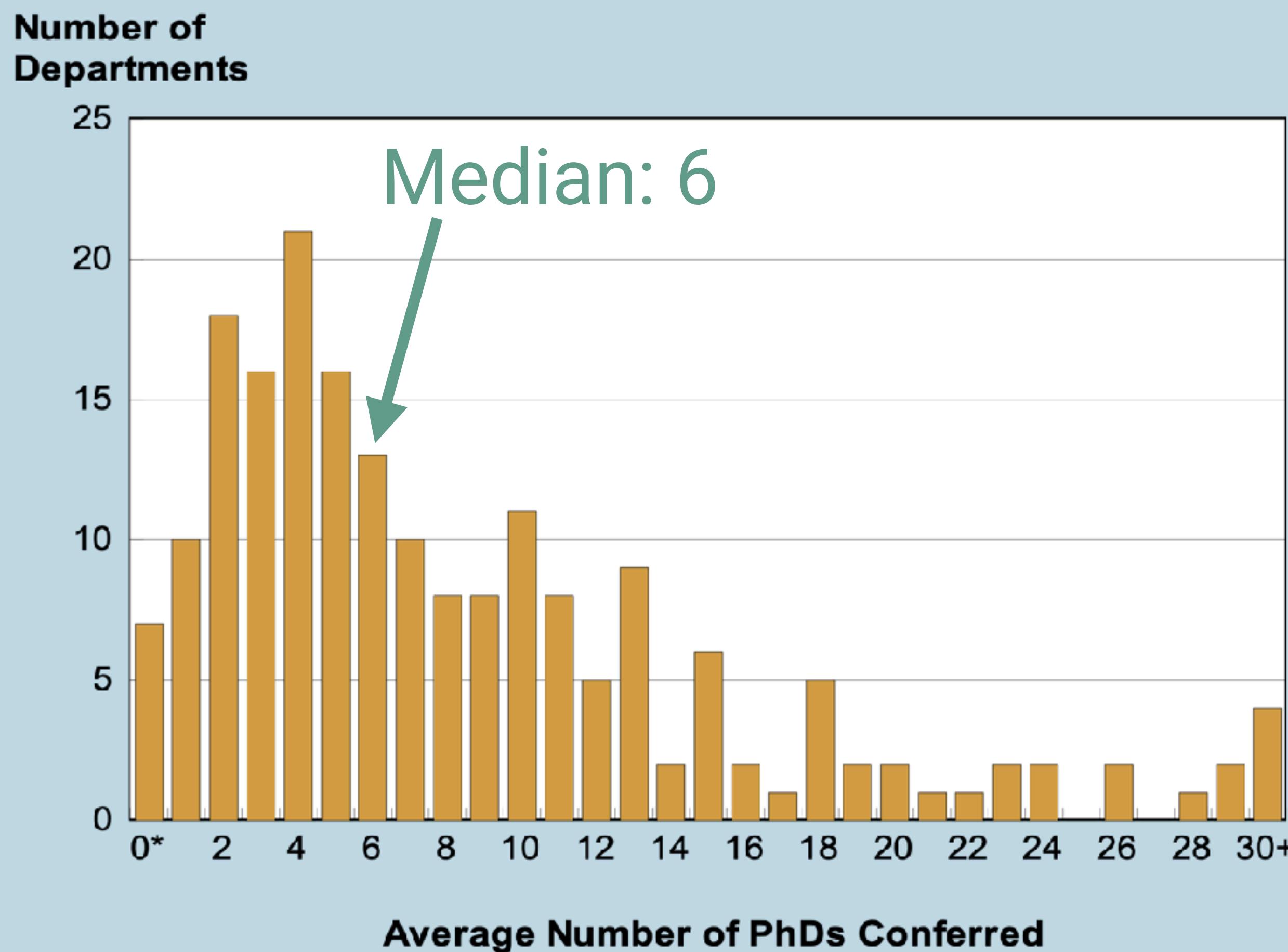
**Number of Doctoral-Granting Physics Departments in  
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\*Includes three departments that conferred one PhD during the 3-year period, classes of 2010, 2011 & 2012 combined.

CU Physics has one of the largest PhD programs in the country.

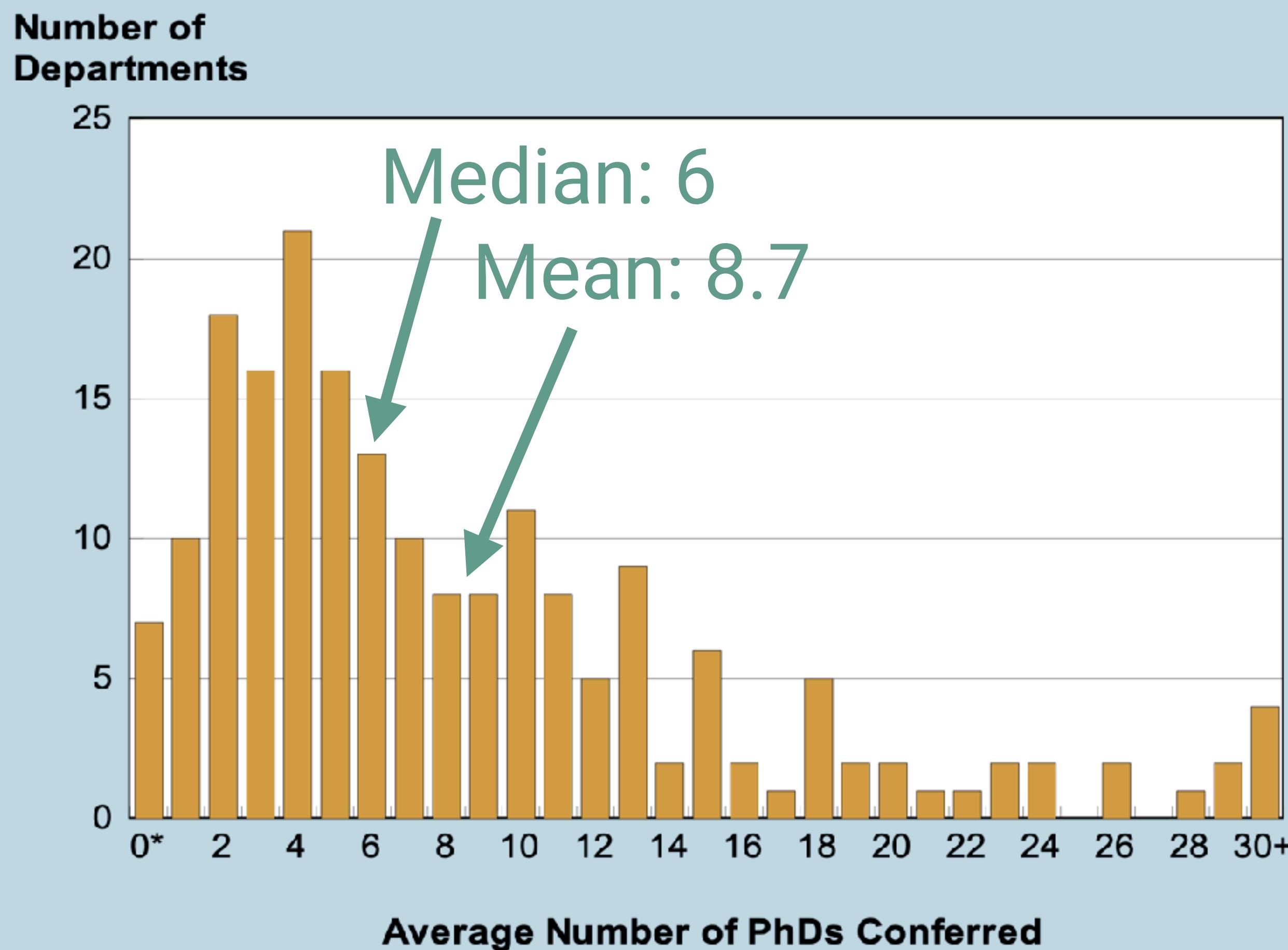
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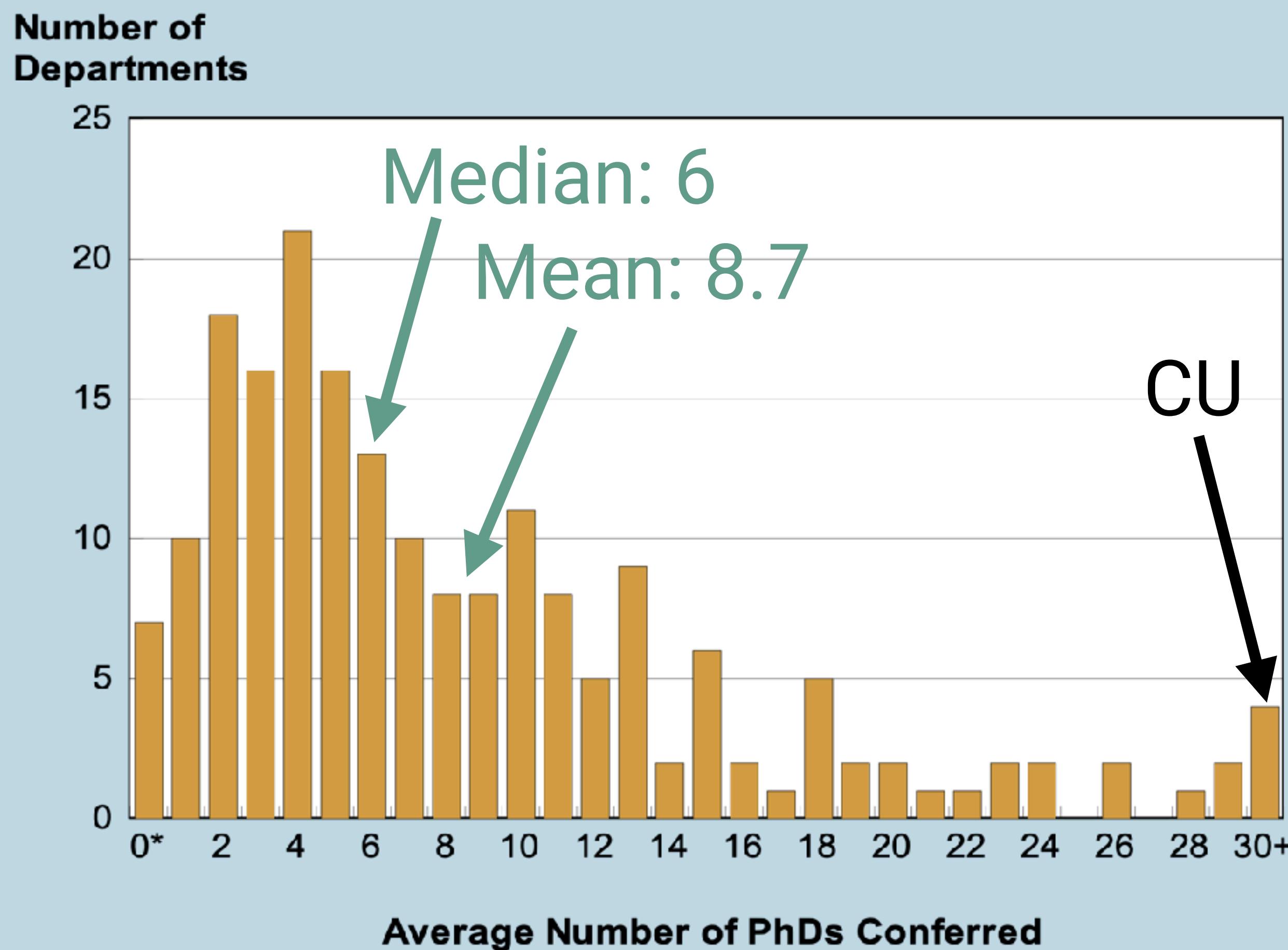
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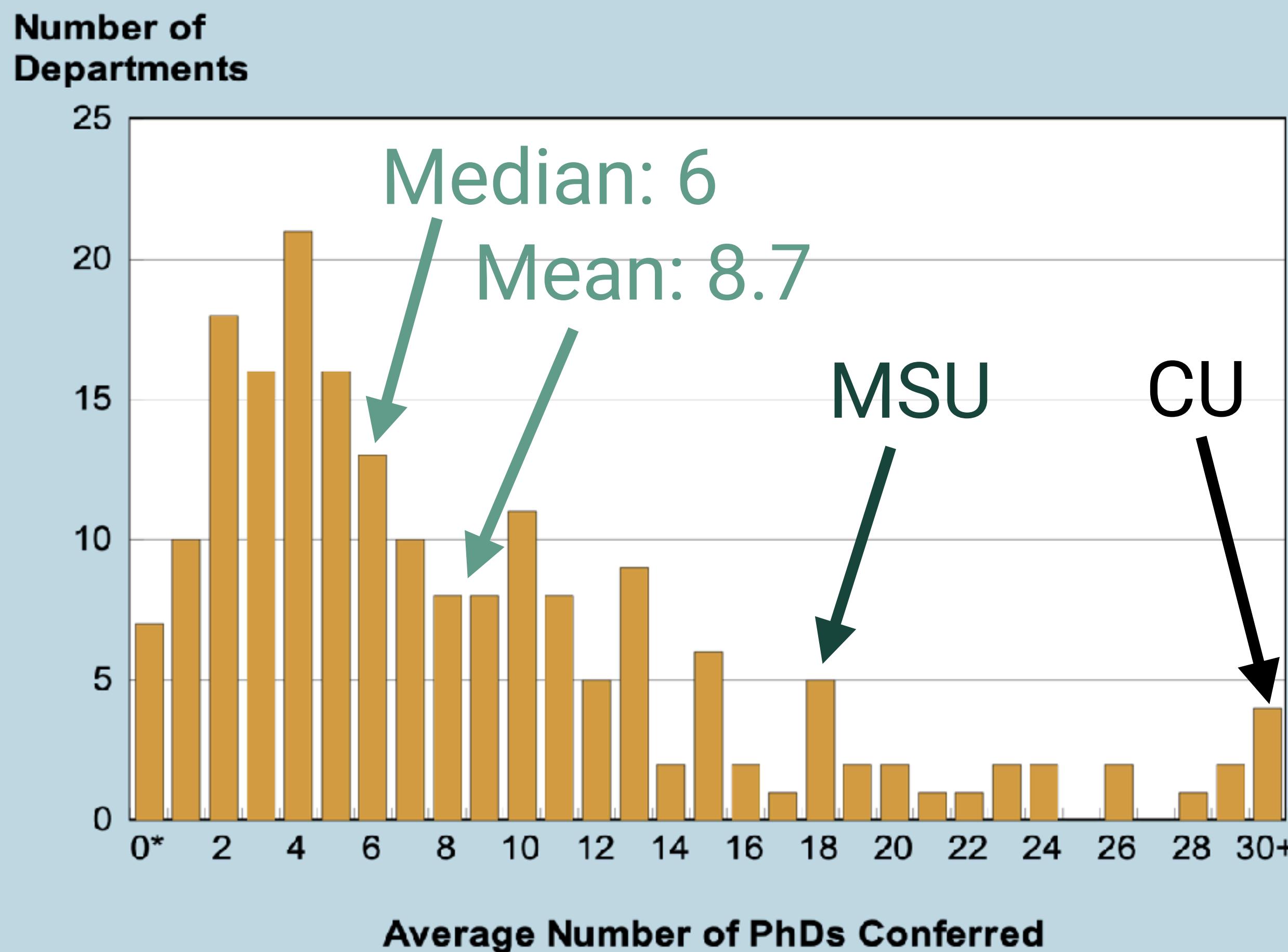
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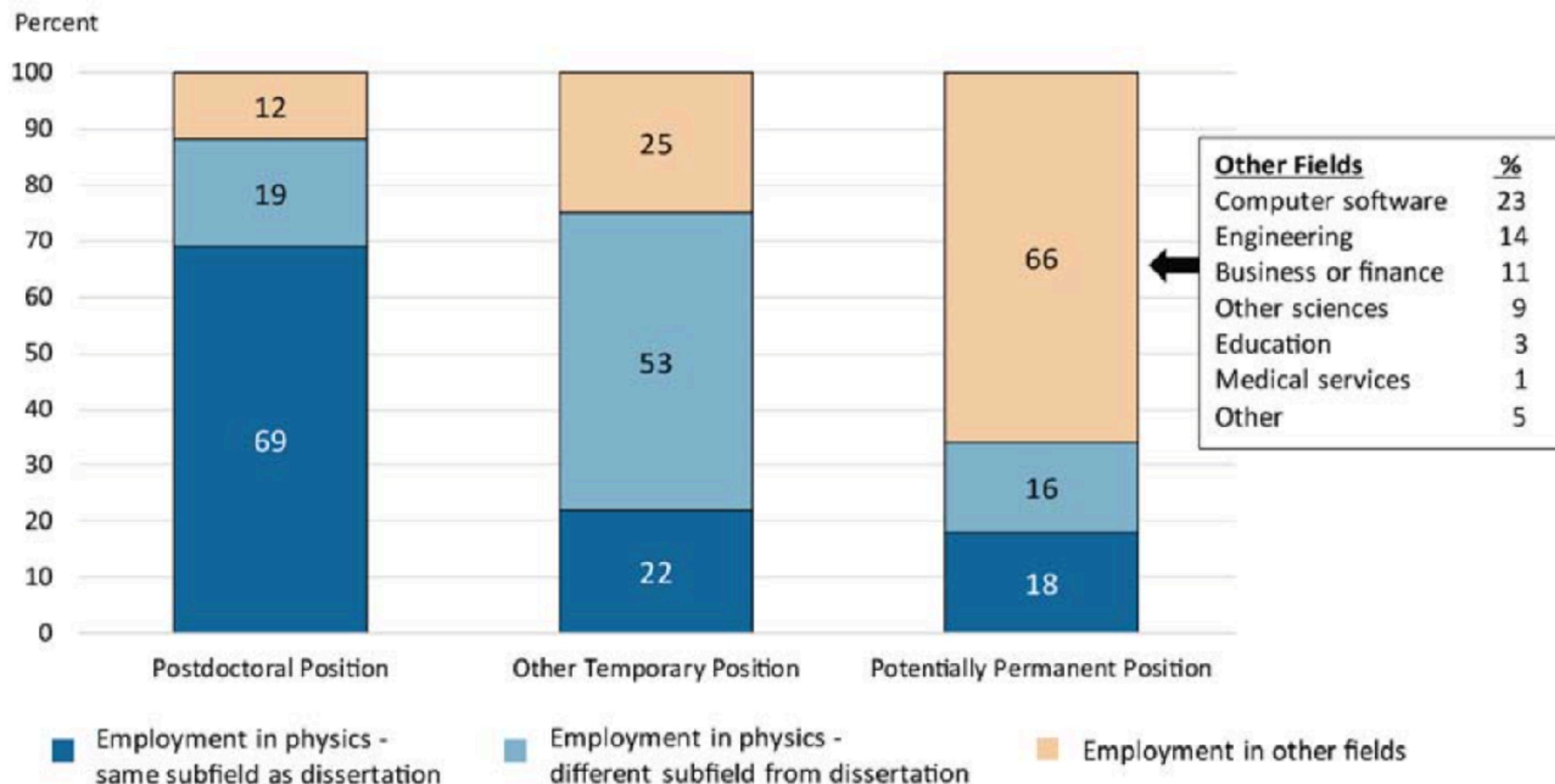
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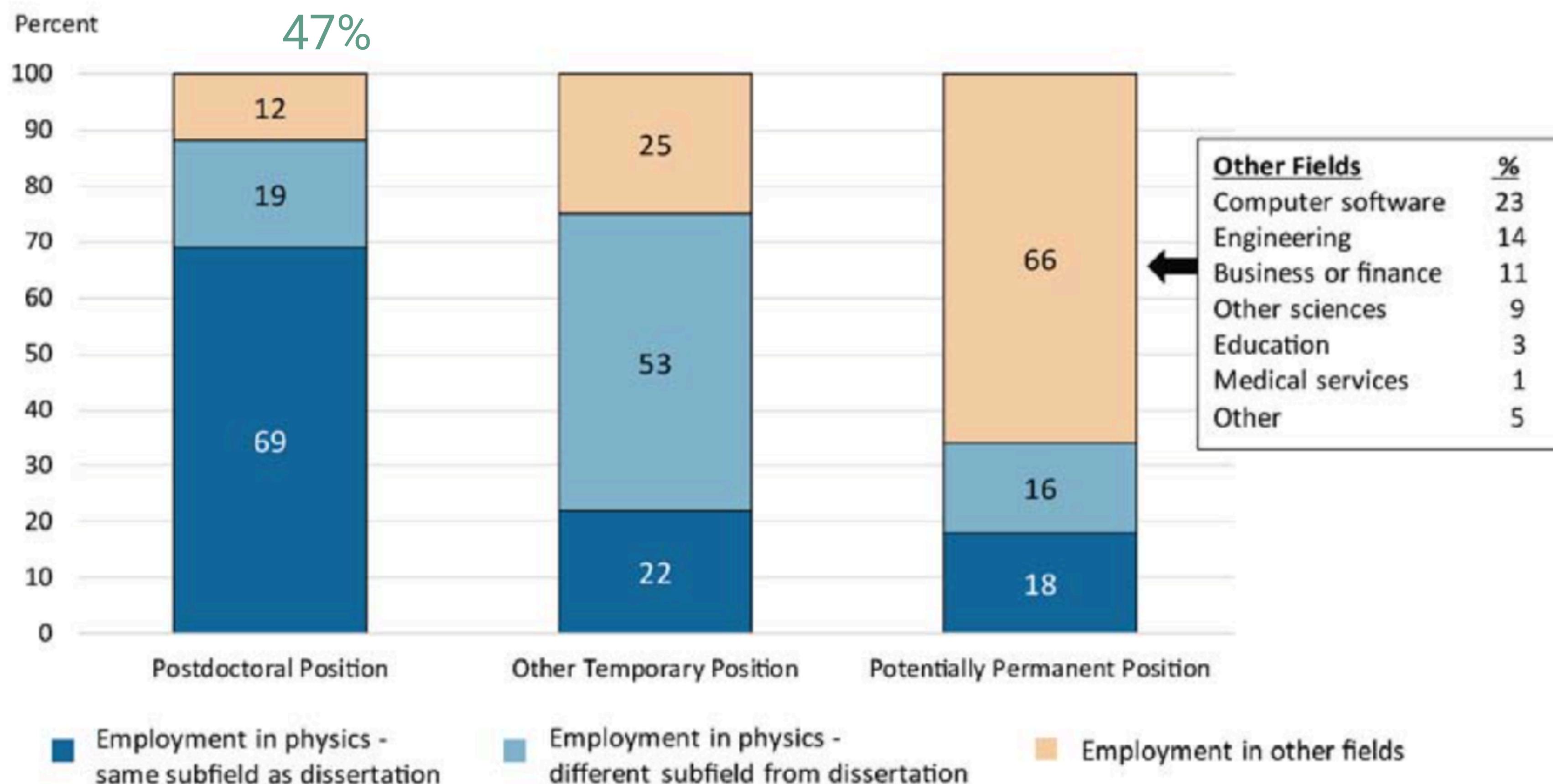
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## Employment Field of New Physics PhDs, Classes of 2015 & 2016 Combined



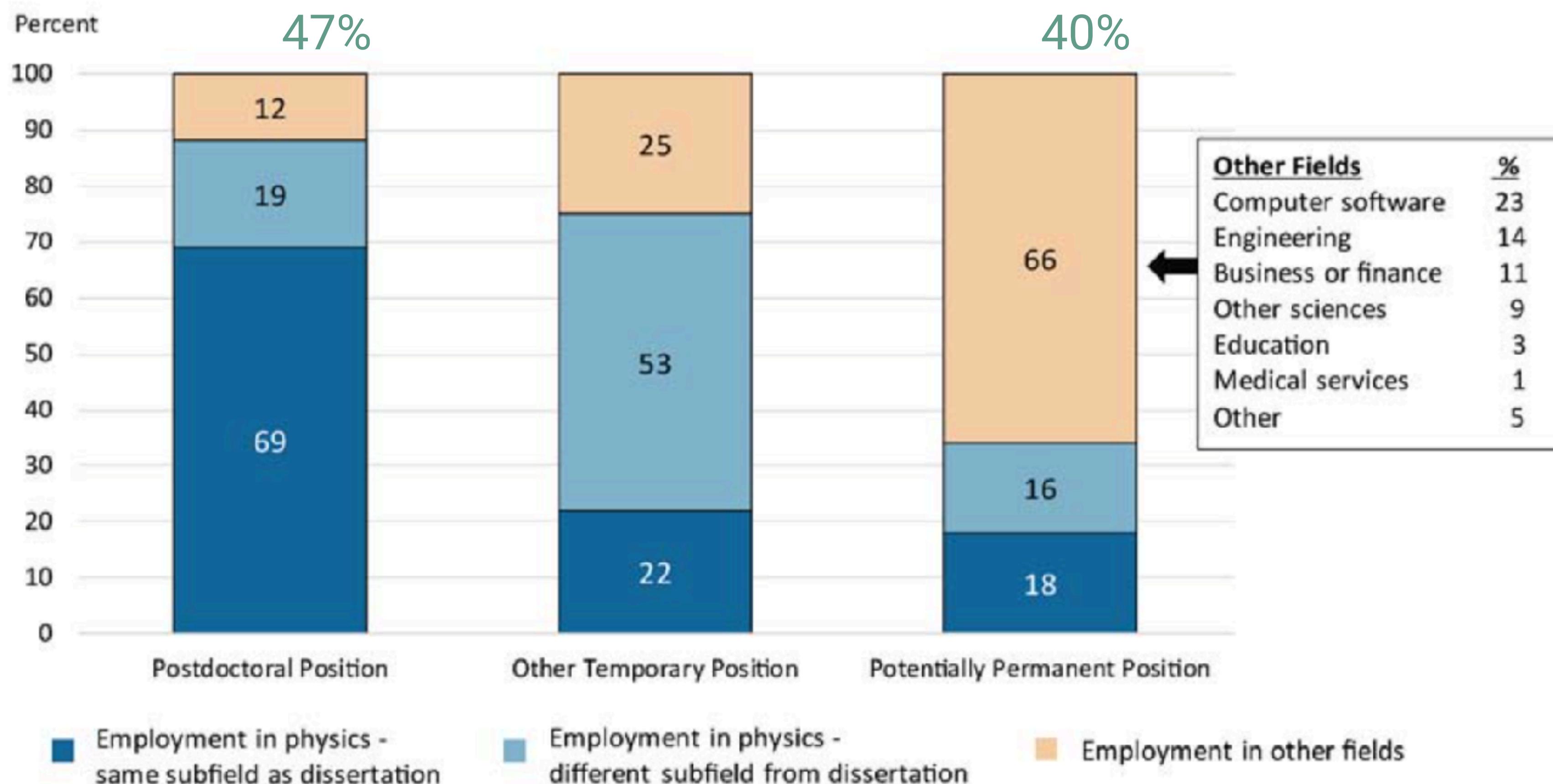
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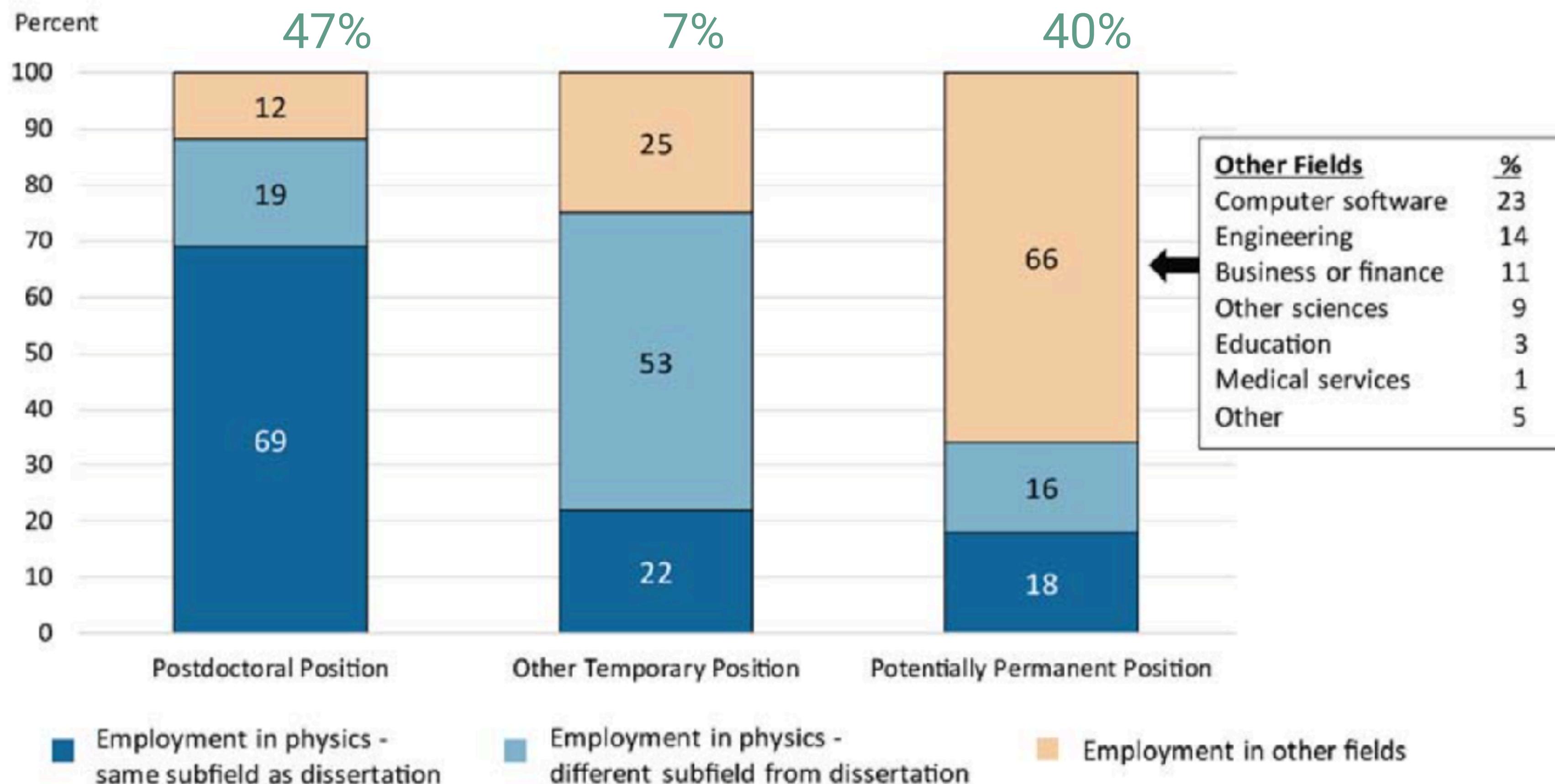
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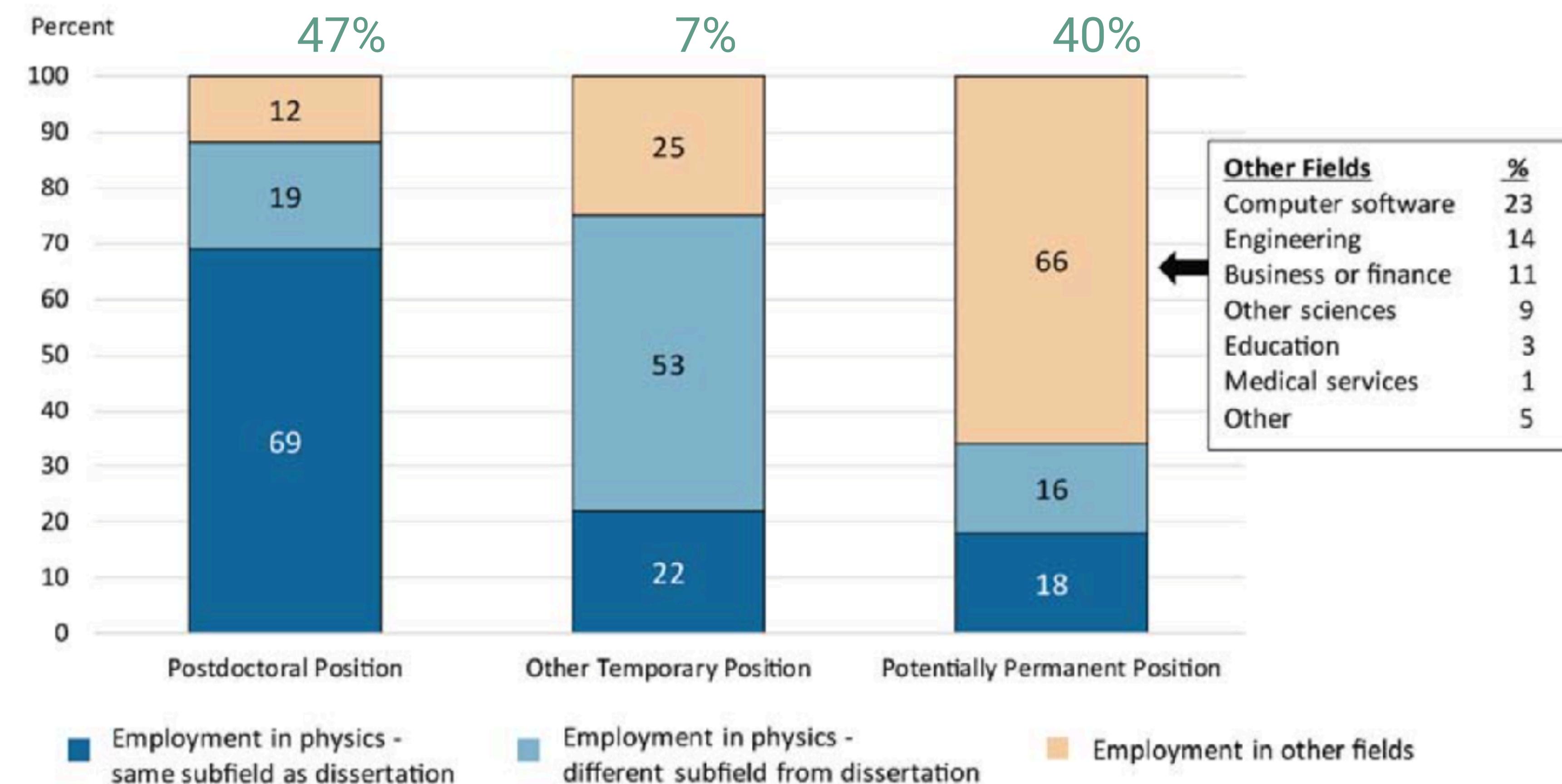


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~33% of PhD  
graduates are not  
working in physics

~40% are working  
in the same  
subfield of physics

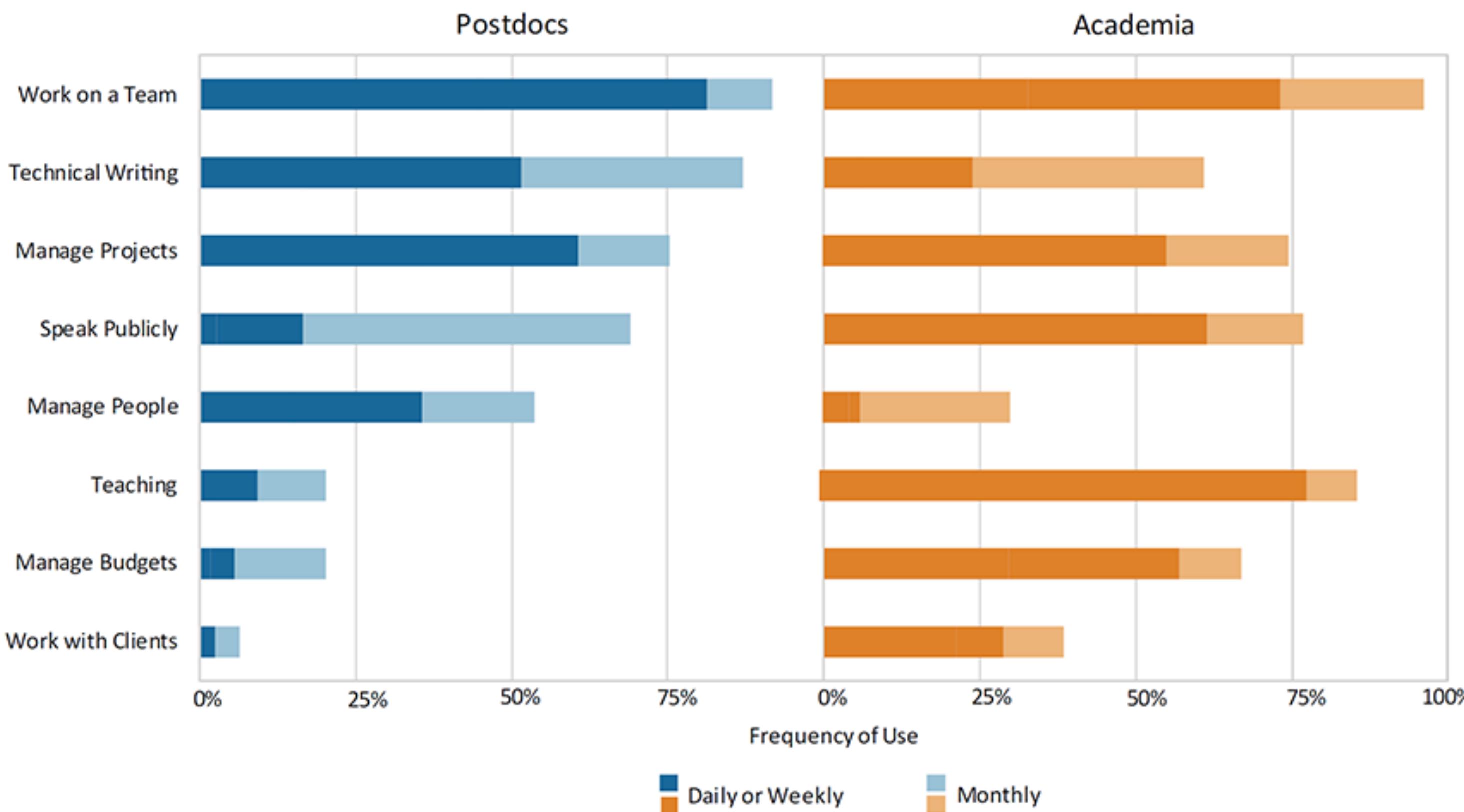
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A wide variety of technical and interpersonal skills are used by employed PhD graduates

## Interpersonal and Management Skills Used by New Physics PhDs Holding Postdocs and Potentially Permanent Positions in Academia, Classes of 2015 & 2016 Combined



Percentages represent the proportion of physics PhDs who chose "daily," "weekly," or "monthly" on a four-point scale that also included "never or rarely." Data only include US-educated PhDs who remained in the US after earning their degrees. Academia refers to physics PhDs holding potentially permanent positions in two- and four-year colleges or universities and university affiliated research institutes. Figure based on 380 postdocs and 52 potentially permanently employed PhDs in academia.

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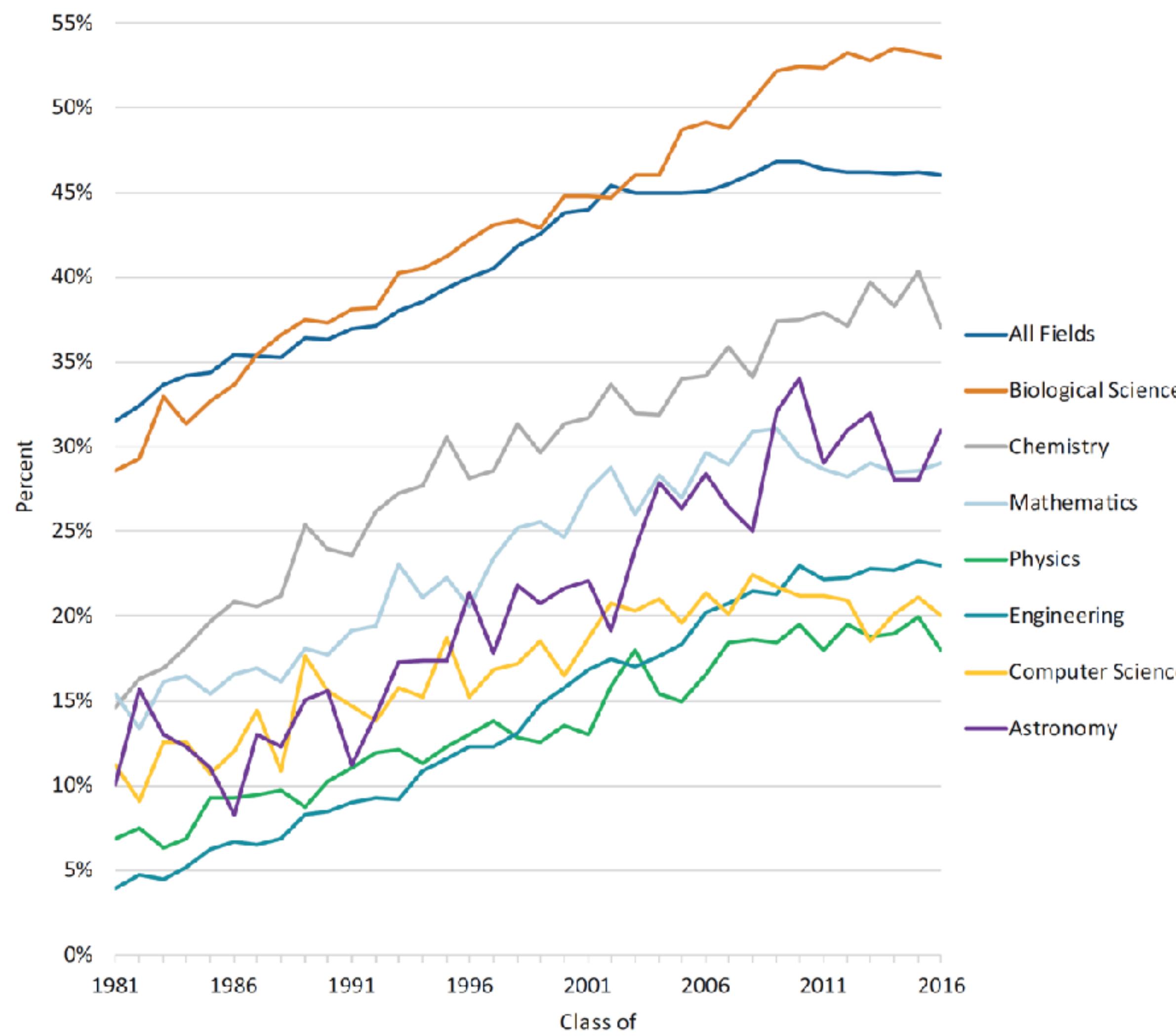
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But earning a PhD is  
not the only marker  
for success!

Percent of PhDs Earned by Women in Selected Fields,  
Classes of 1981 through 2016



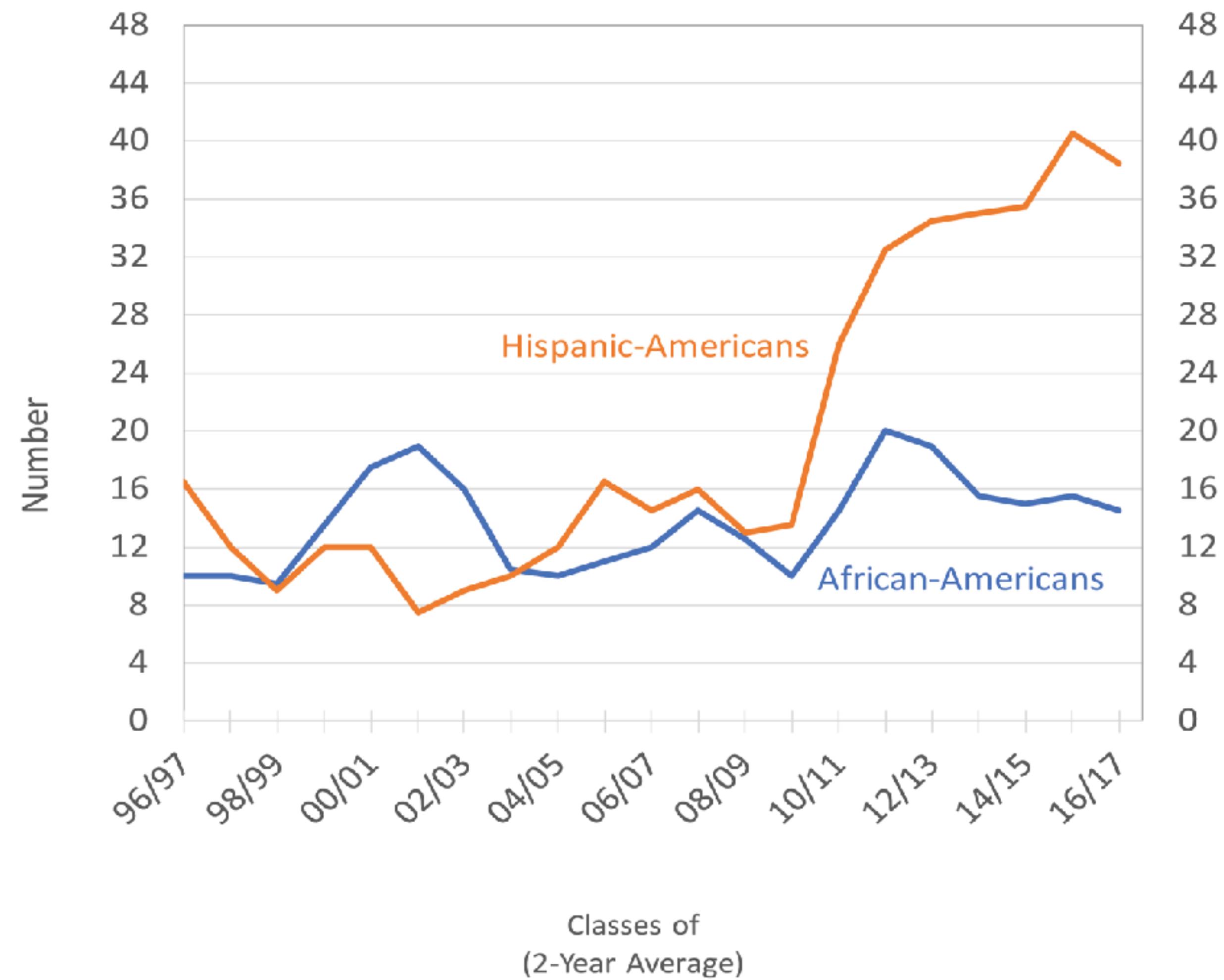
About 20% of PhDs in physics  
are granted to women

More women are earning PhDs  
in physics (and in STEM)

Source: National Science Foundation, National Center for Science and Engineering Statistics. Data compiled by AIP Statistical Research Center.

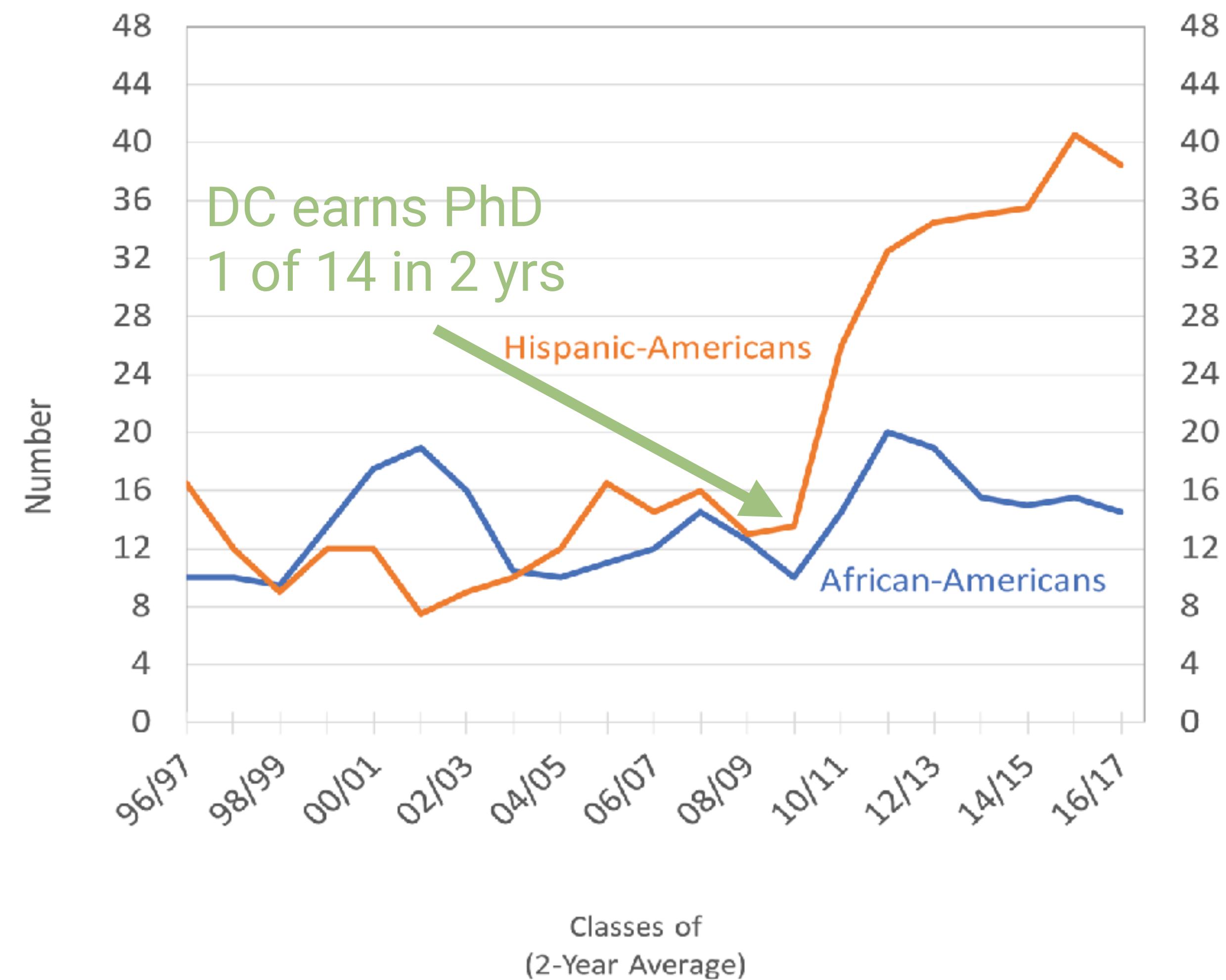
Few PhDs are granted to African-American (~14% of US pop) or to Hispanic-Americans (~20% of US pop)

## Number of Physics Doctorates Earned by African-Americans and Hispanic-Americans, Classes 1996 through 2017.



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Create structures and programs that remove barriers and promote full participation

Reshape the culture of physics to bring traditionally excluded folks into critical activities and decision making

Sustain these changes over the long term

# “DEI”

Summarized from UC Berkeley Division of Equity and Inclusion (<https://diversity.berkeley.edu/>)

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- **Inclusion** - Authentically bringing in traditionally-excluded individuals into activities and decision making. Sharing power and ensuring equal access to opportunities and resources.

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- **Equity** - Changing admissions criteria to remove barriers for applicants; Creating structures that support the transition to graduate physics programs (e.g., the APS Bridge Program)
- **Inclusion** - Creating a governance structure where graduate students participate in and vote on departmental decisions; Implementing a departmental code of conduct and the associated accountability practices

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**Mixed Methods Research:** A research tradition that blends Qualitative and Quantitative approaches to generate complementary evidence

# STEM Education Research

- Studies by STEM professionals of:
  - how students understand STEM (concepts, practice, identity)
  - curricula / pedagogy
  - tools / context
- Theory, experiment, and applied



*learningmachineslab.github.io  
github.com/learningmachineslab*

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The Learning Machines Lab focuses on **generating quantitative evidence** for understanding issues in STEM Education.

# A Graduate Program in Physics

Applicants

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Graduate Students

Applicants

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Graduate Students

PhD Graduates

Applicants

# A Graduate Program in Physics

Graduate Students

PhD Graduates

Employed Graduates

# A Graduate Program in Physics

Applicants

Recruiting

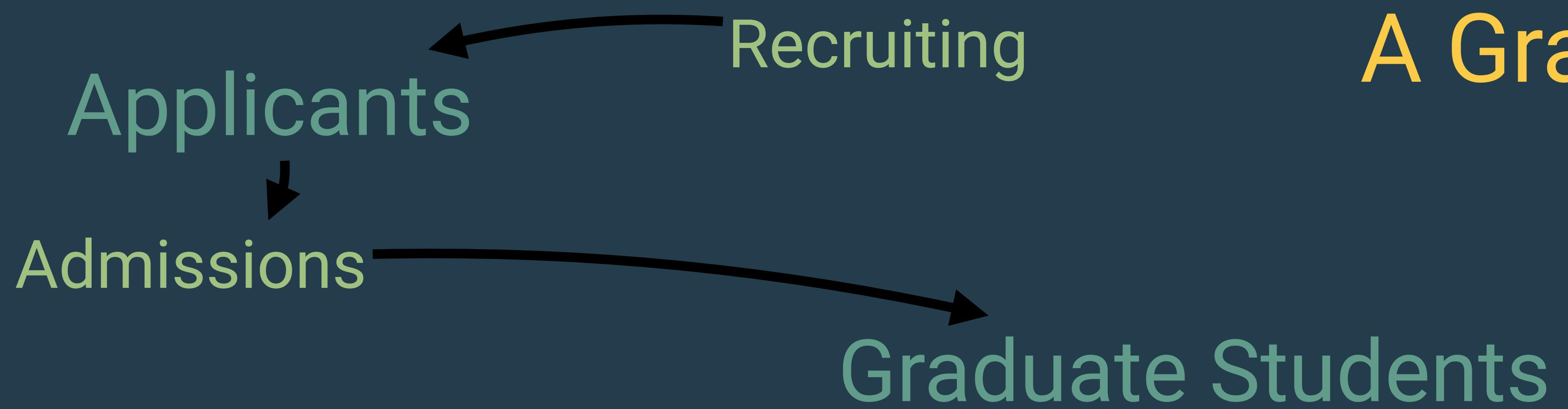
Graduate Students

PhD Graduates

Employed Graduates



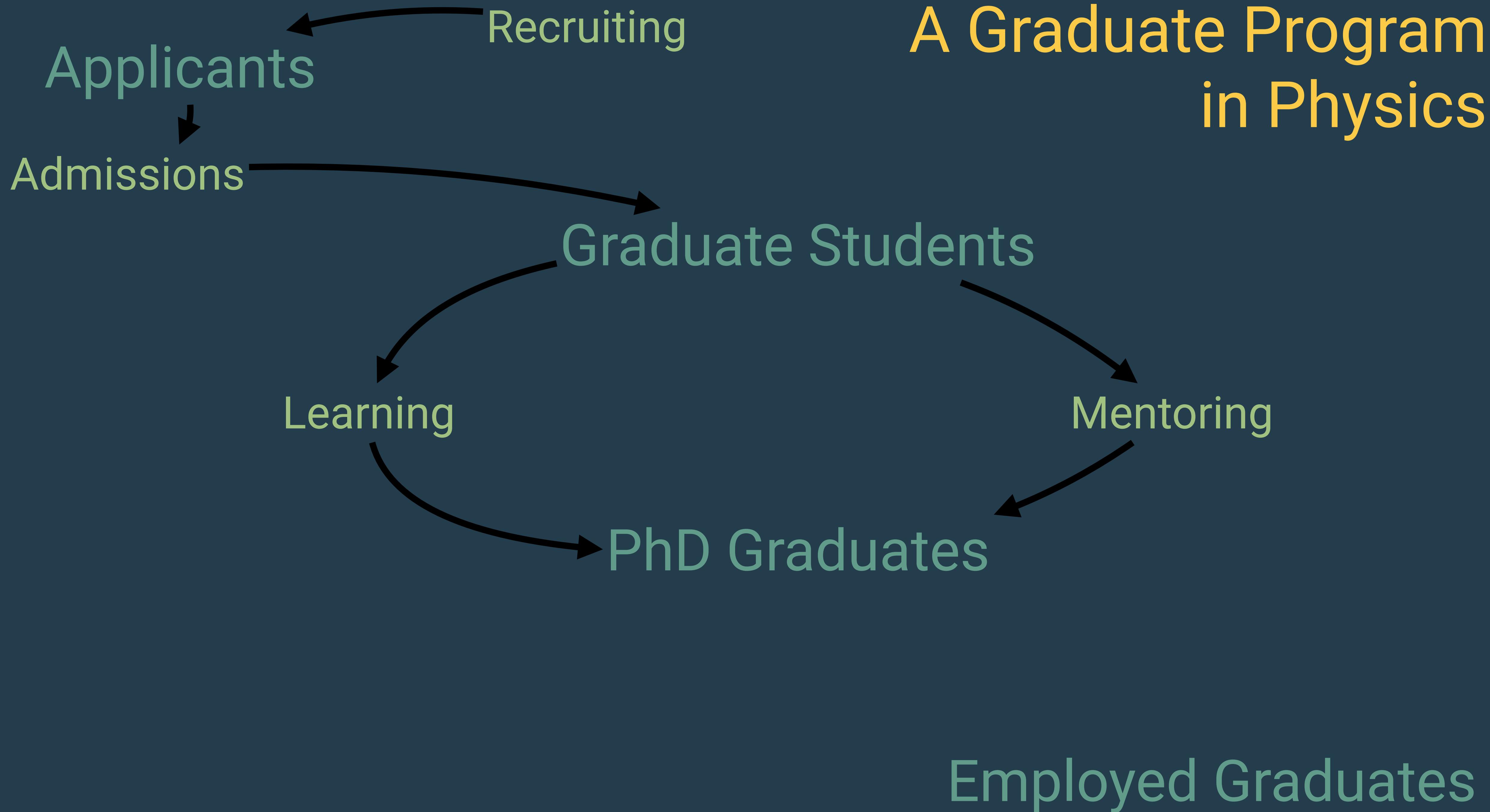
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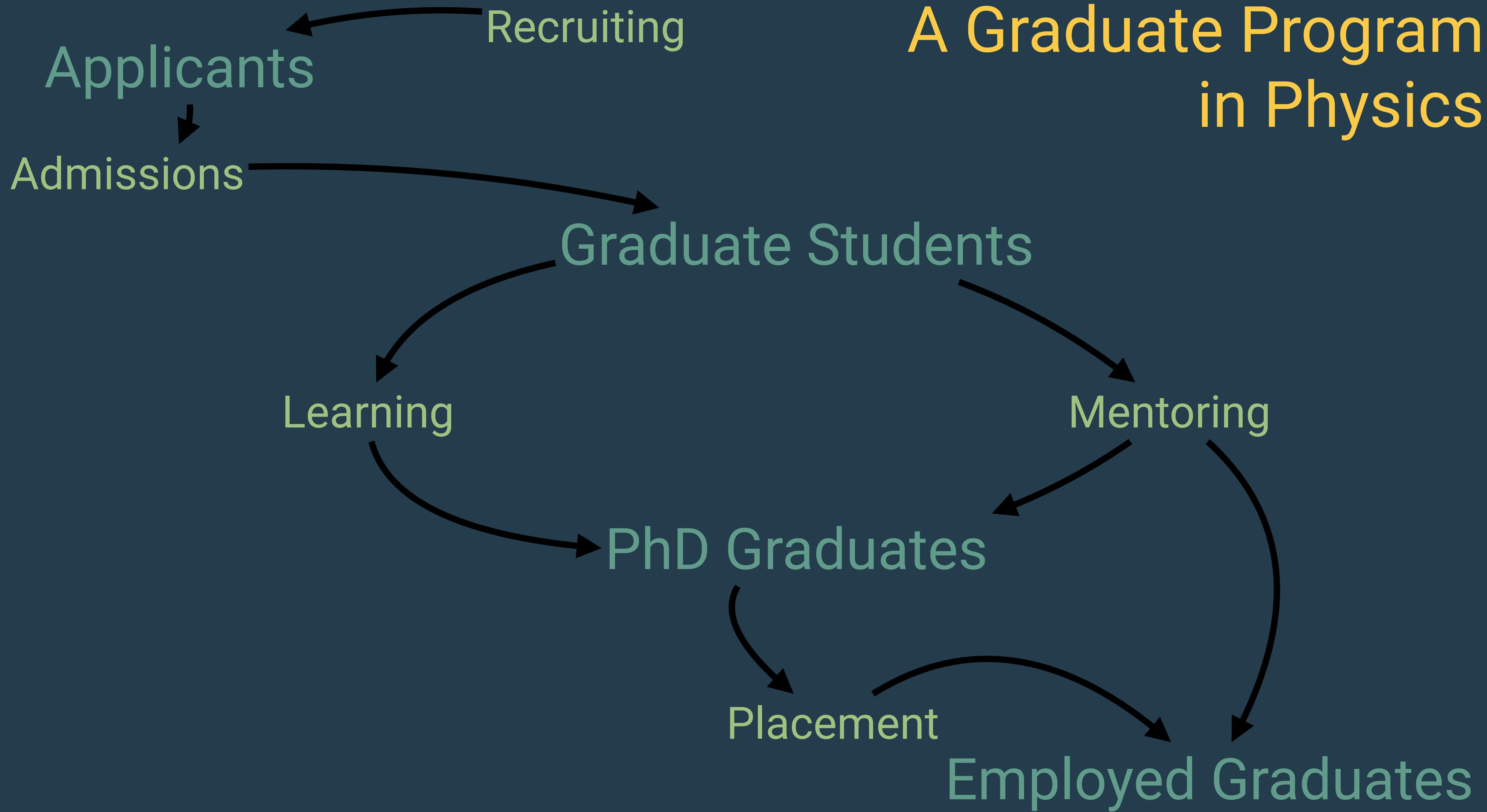
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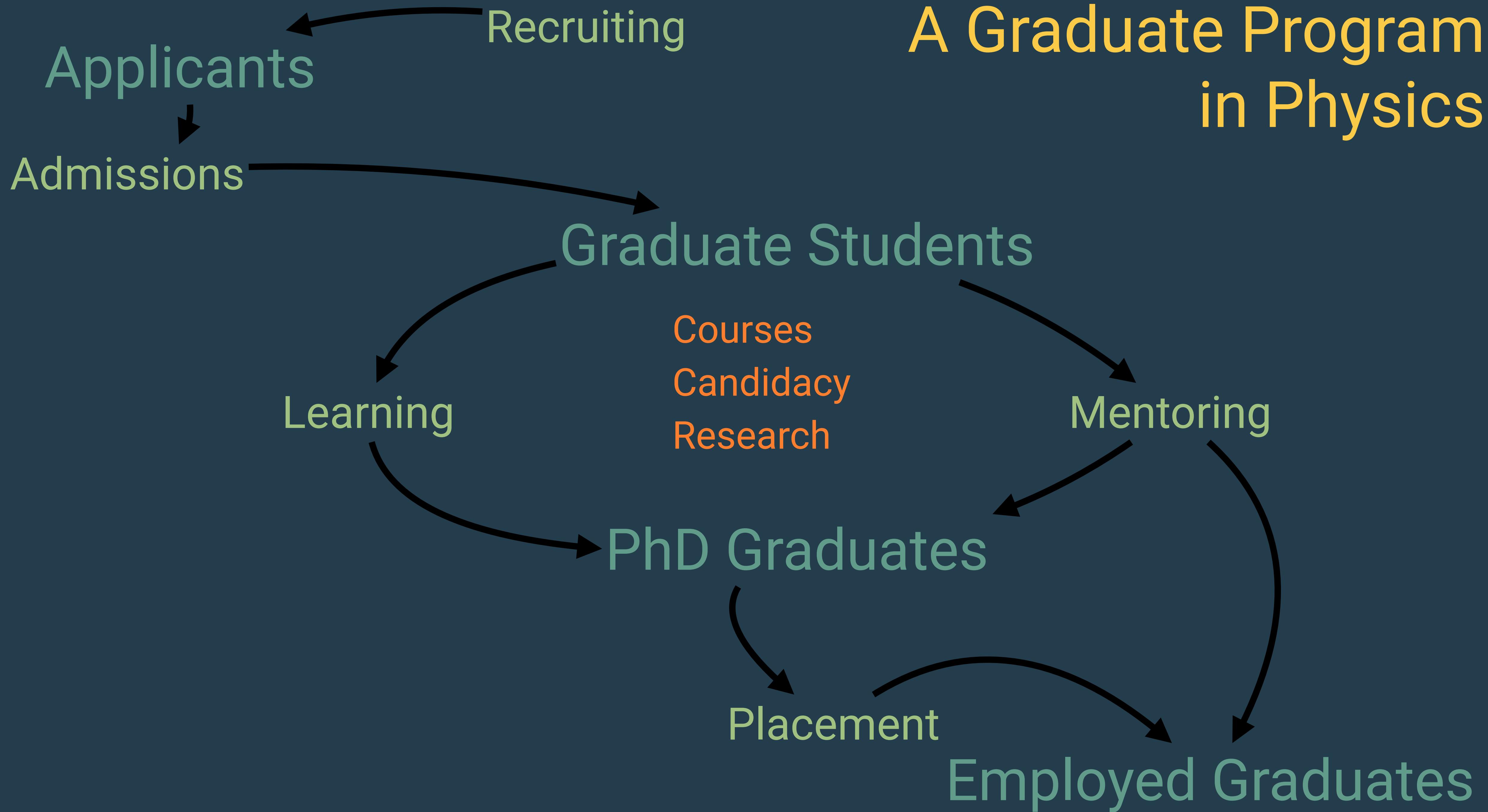
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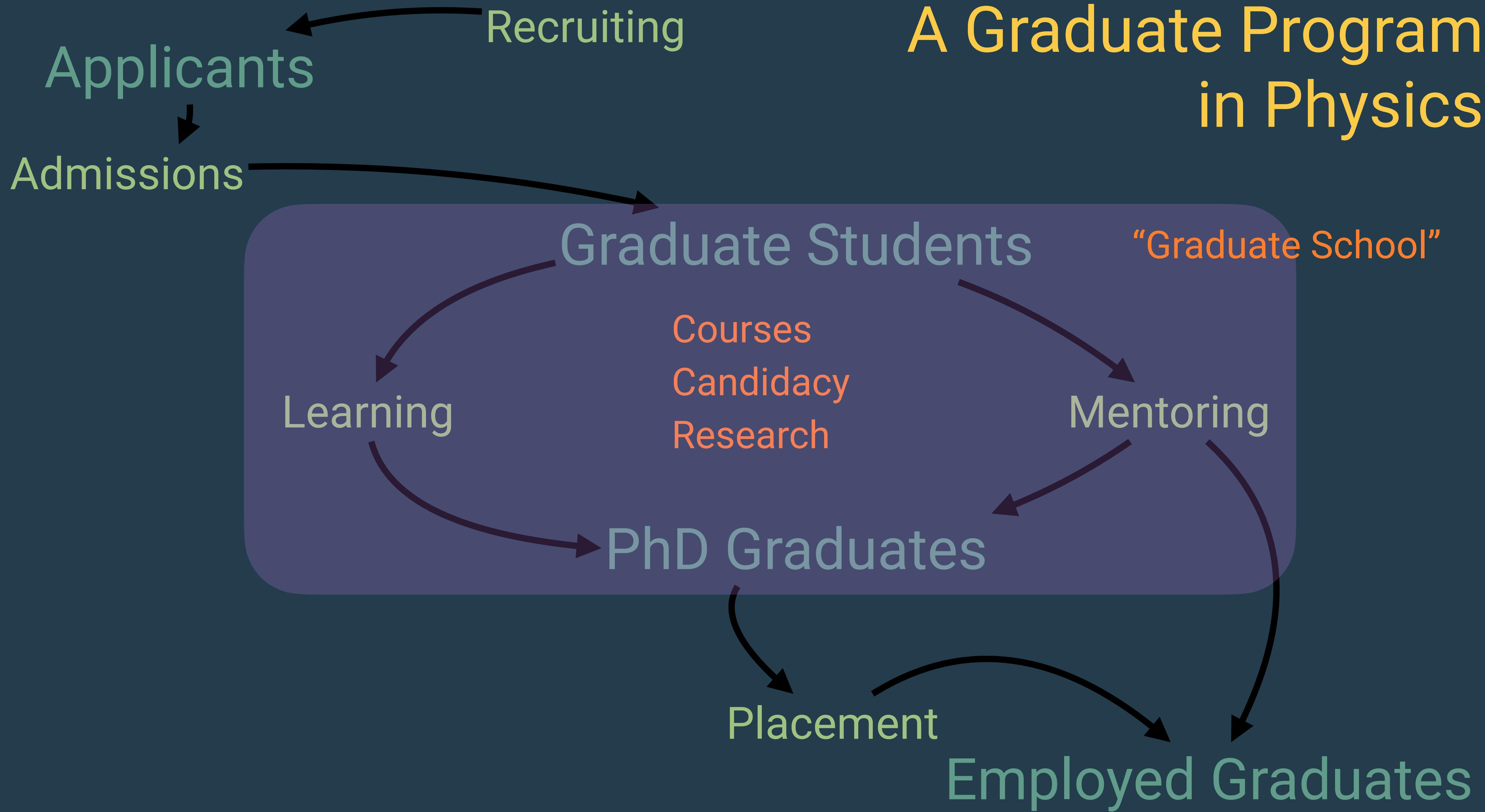
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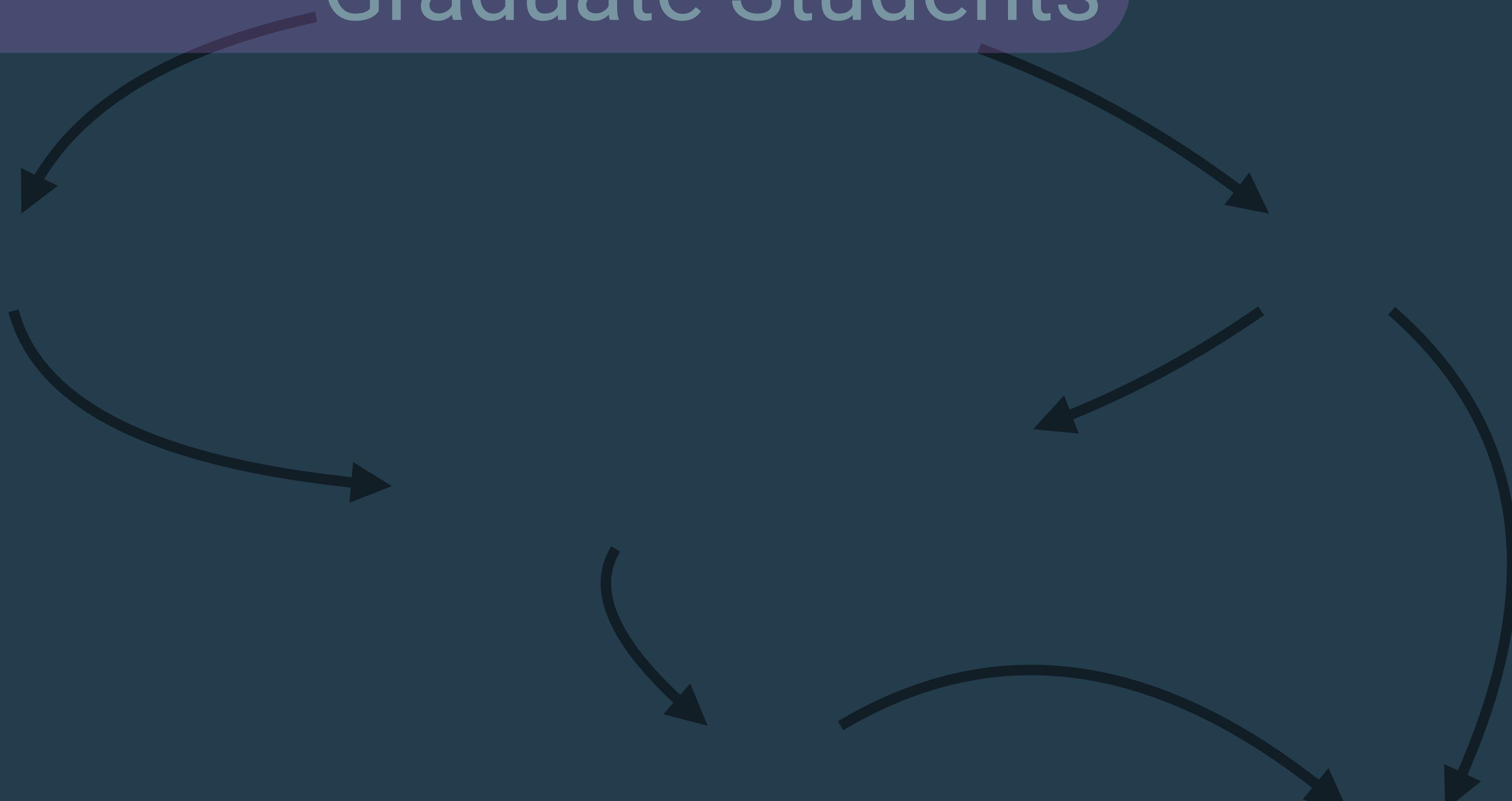
# Holistic Rubric-Based Admissions

Focus for  
Today

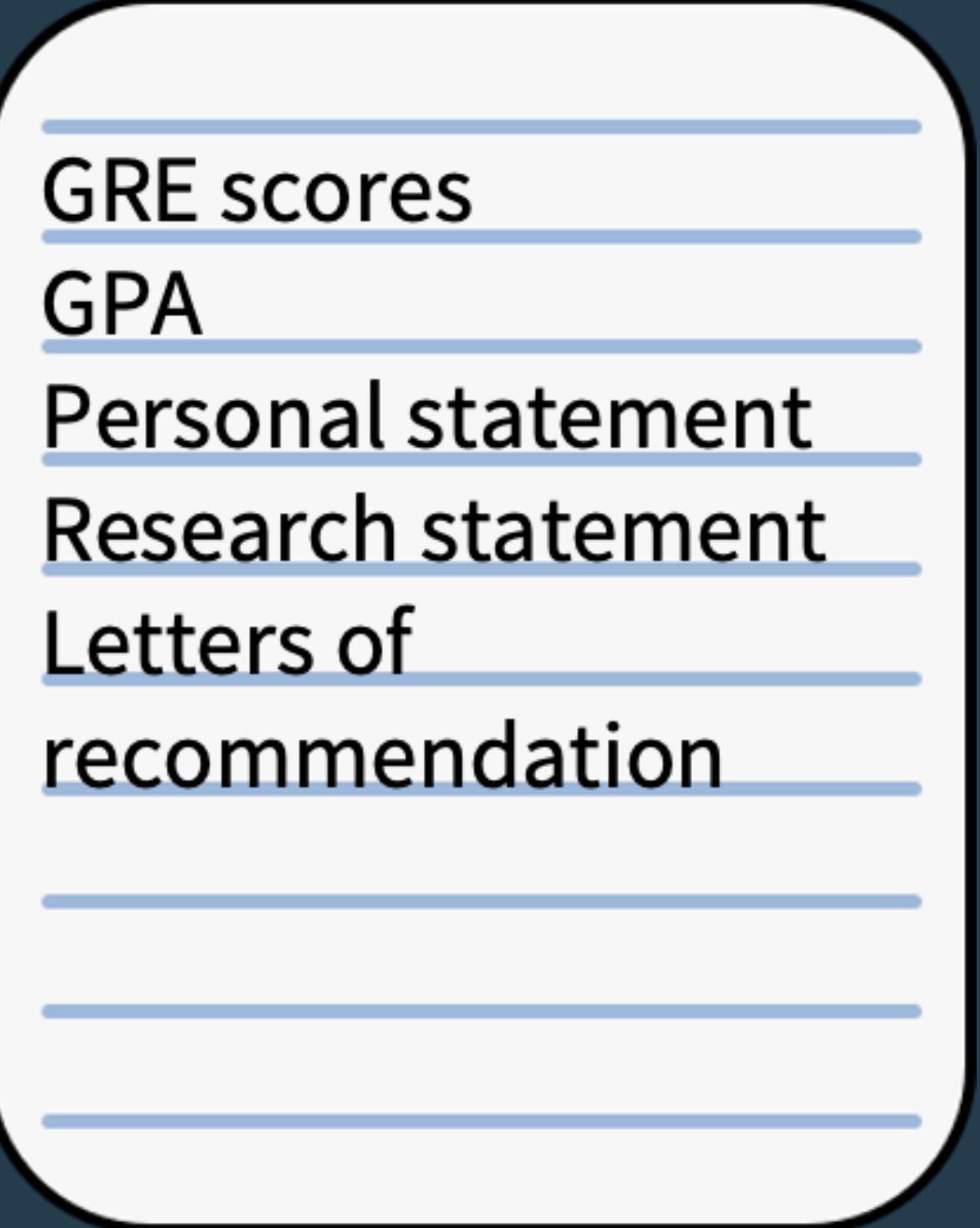
Applicants  
Admissions

Graduate Students

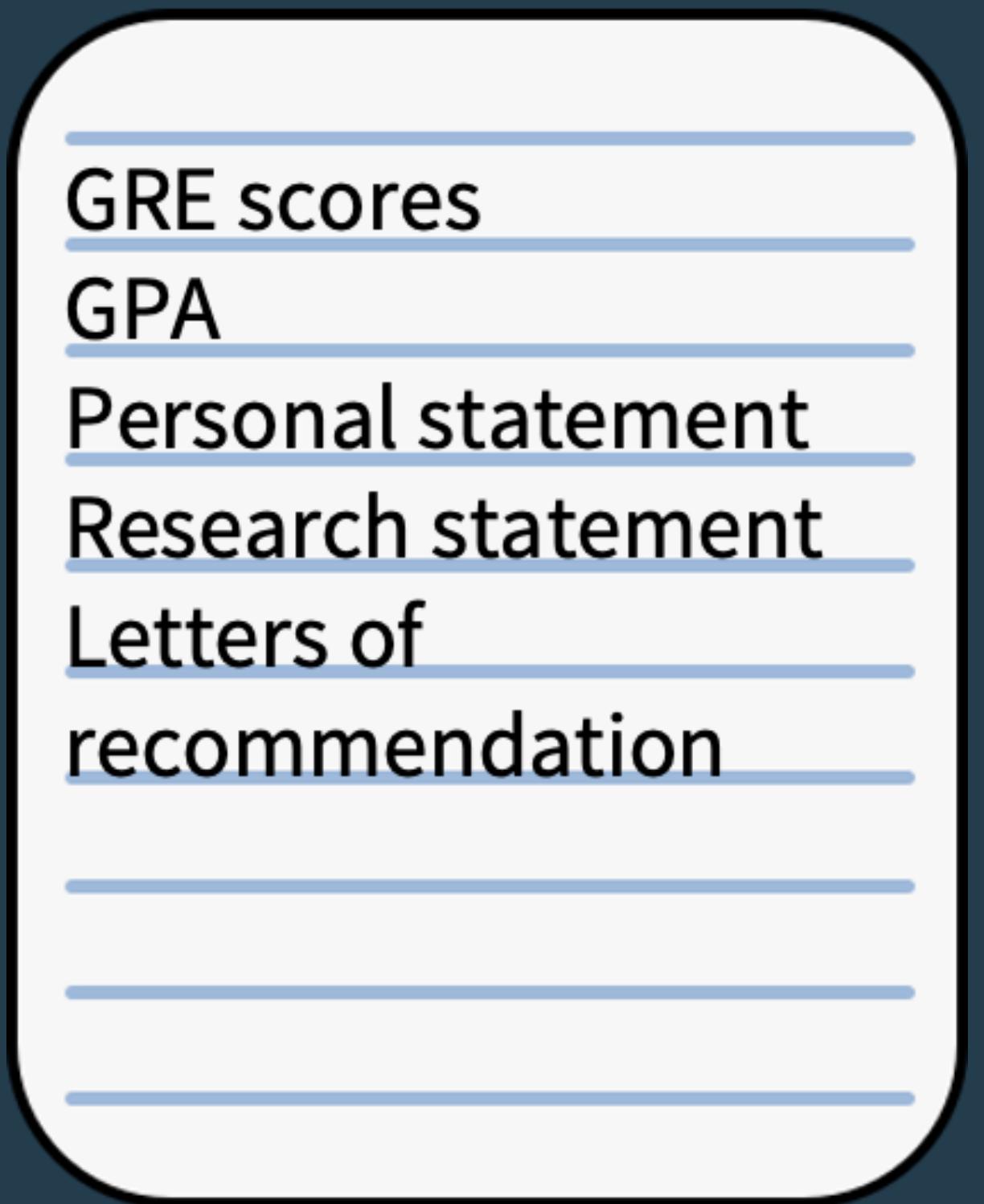
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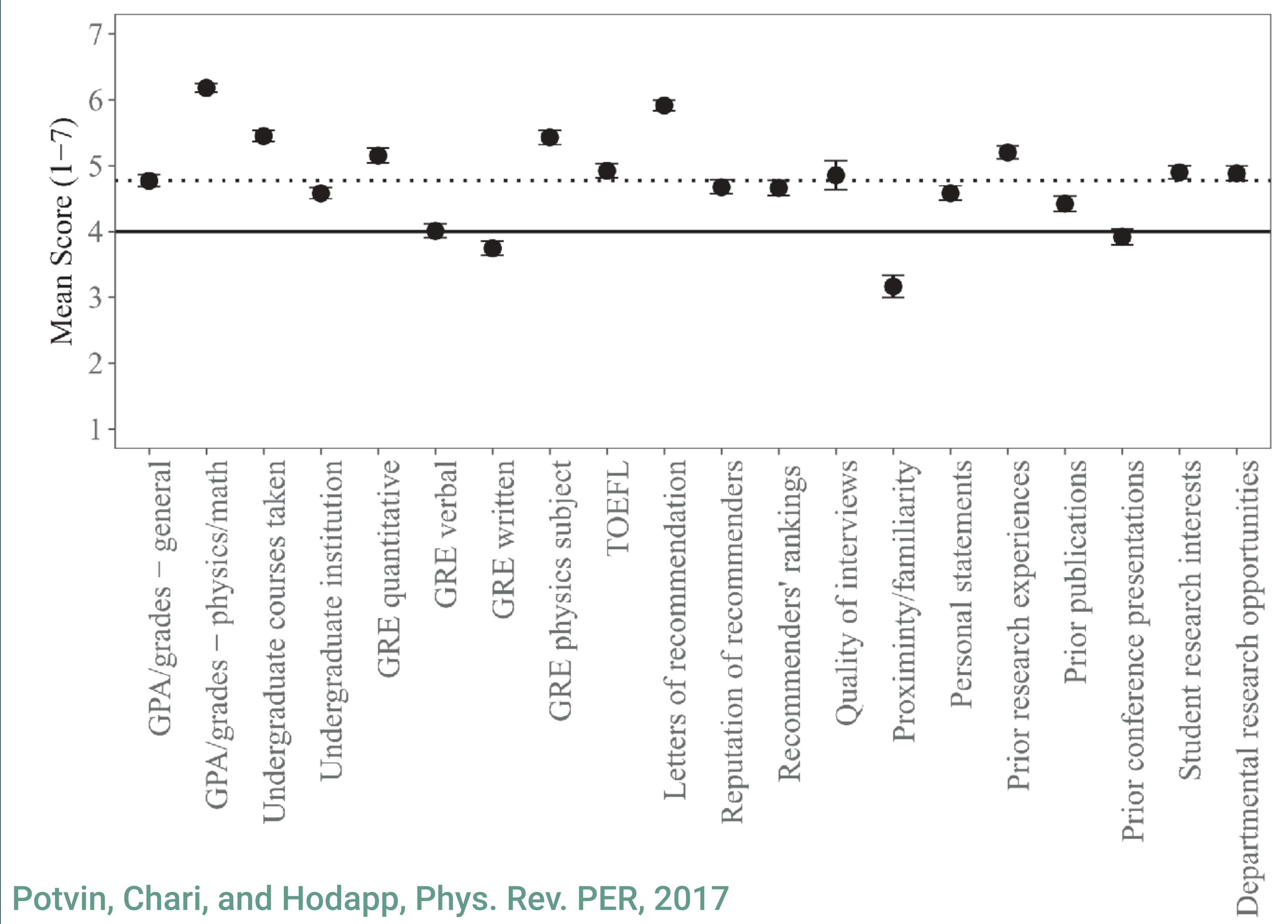
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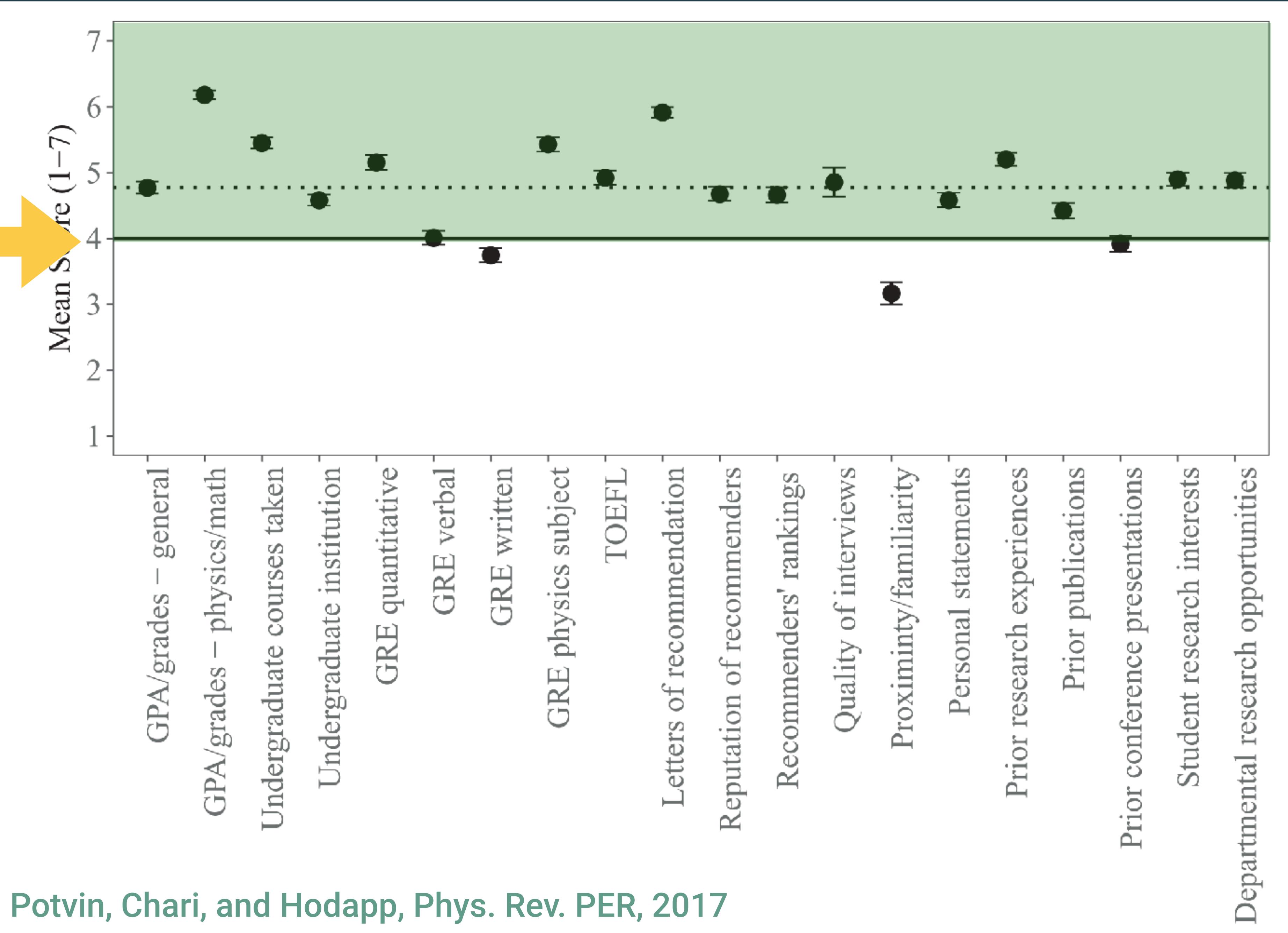


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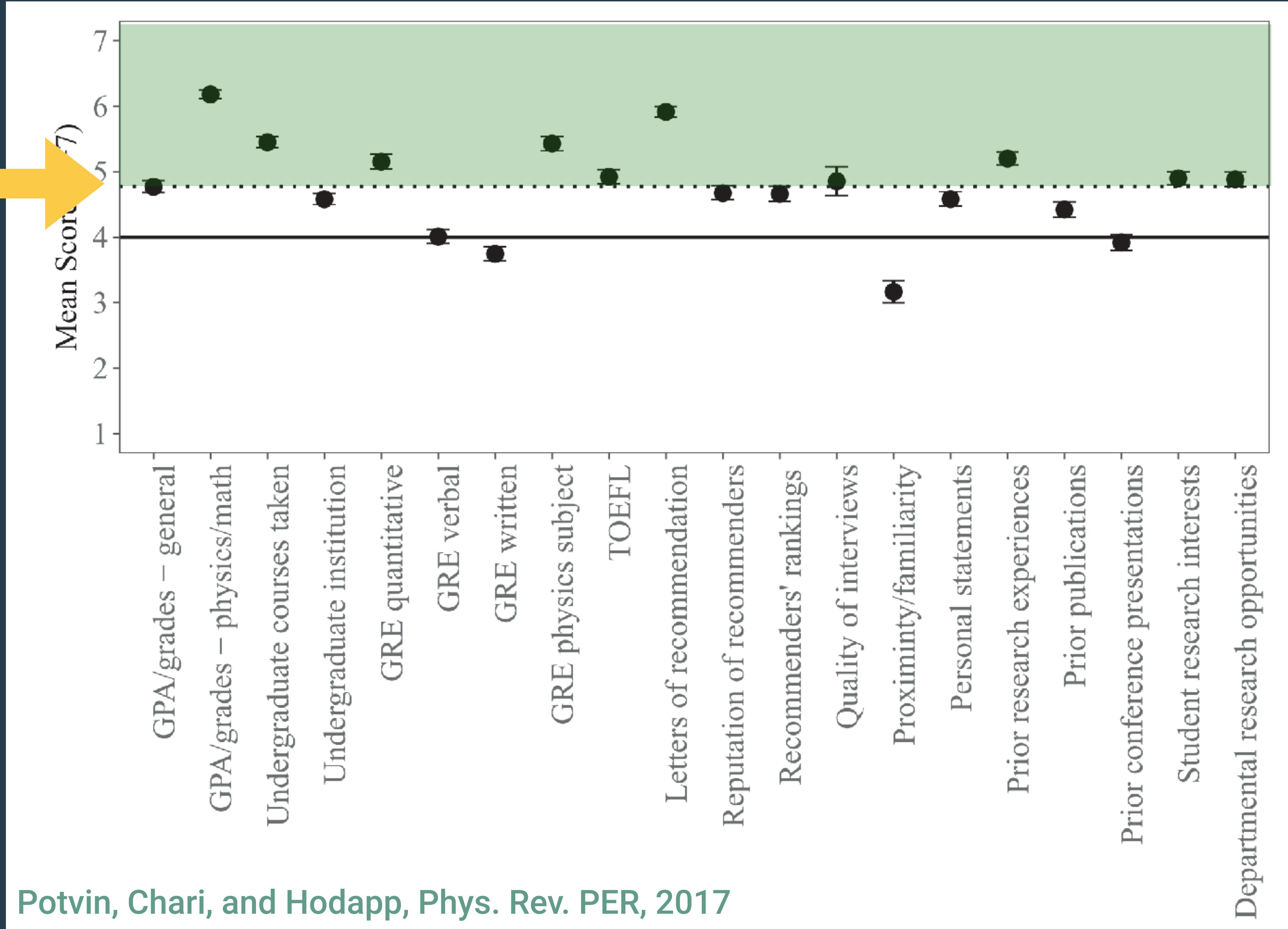
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Moderately Important



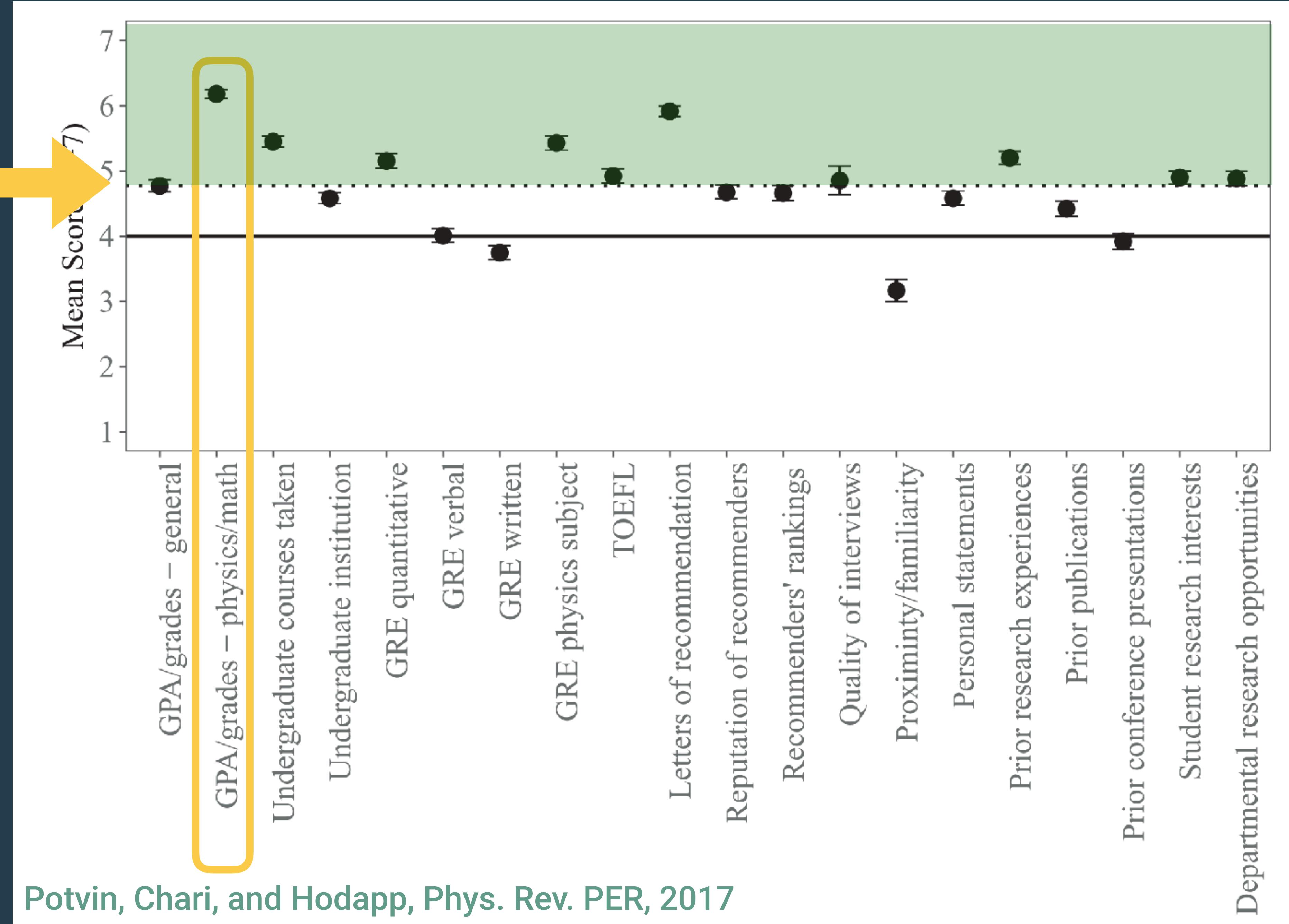
Some parts are more important

Above average importance



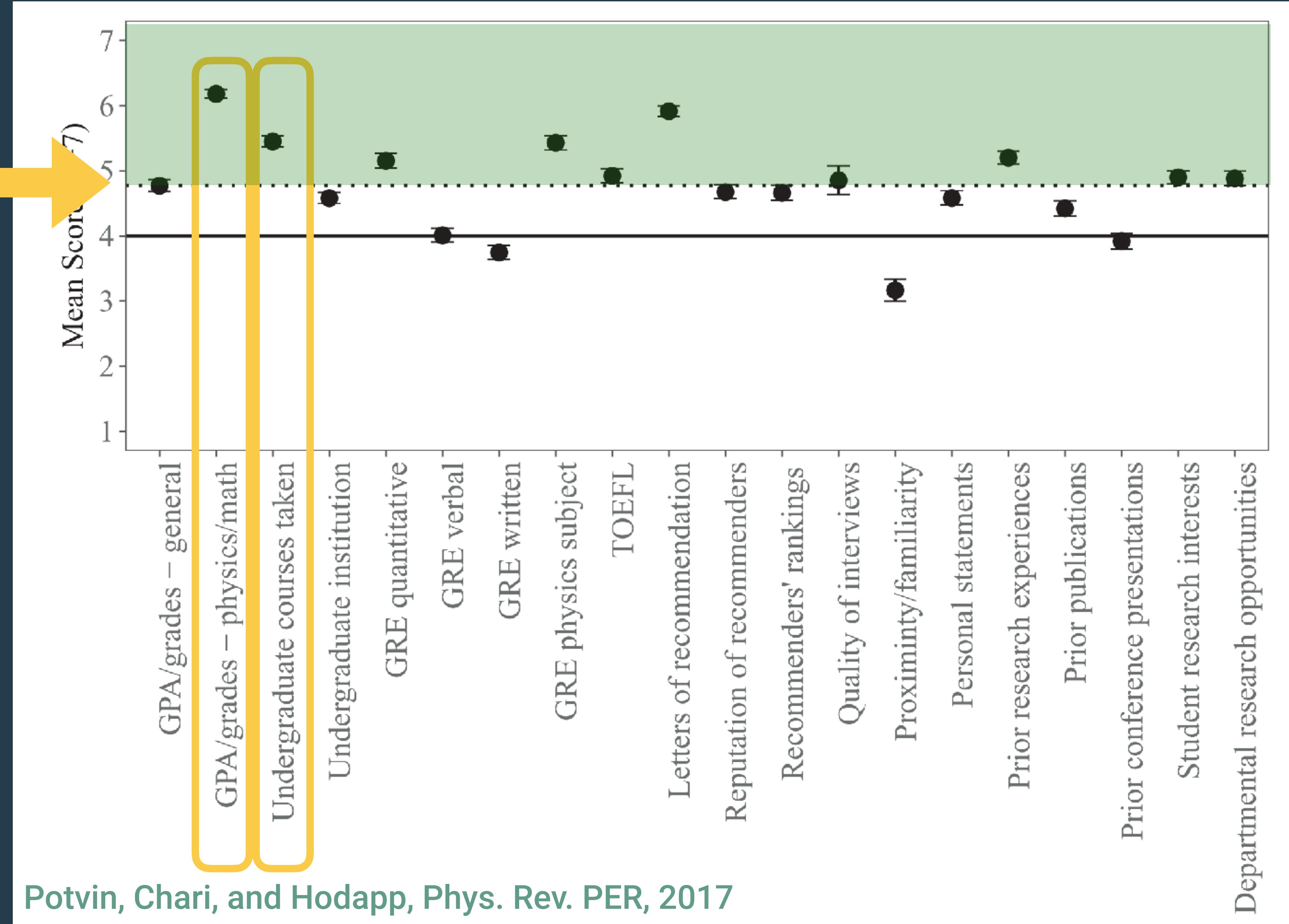
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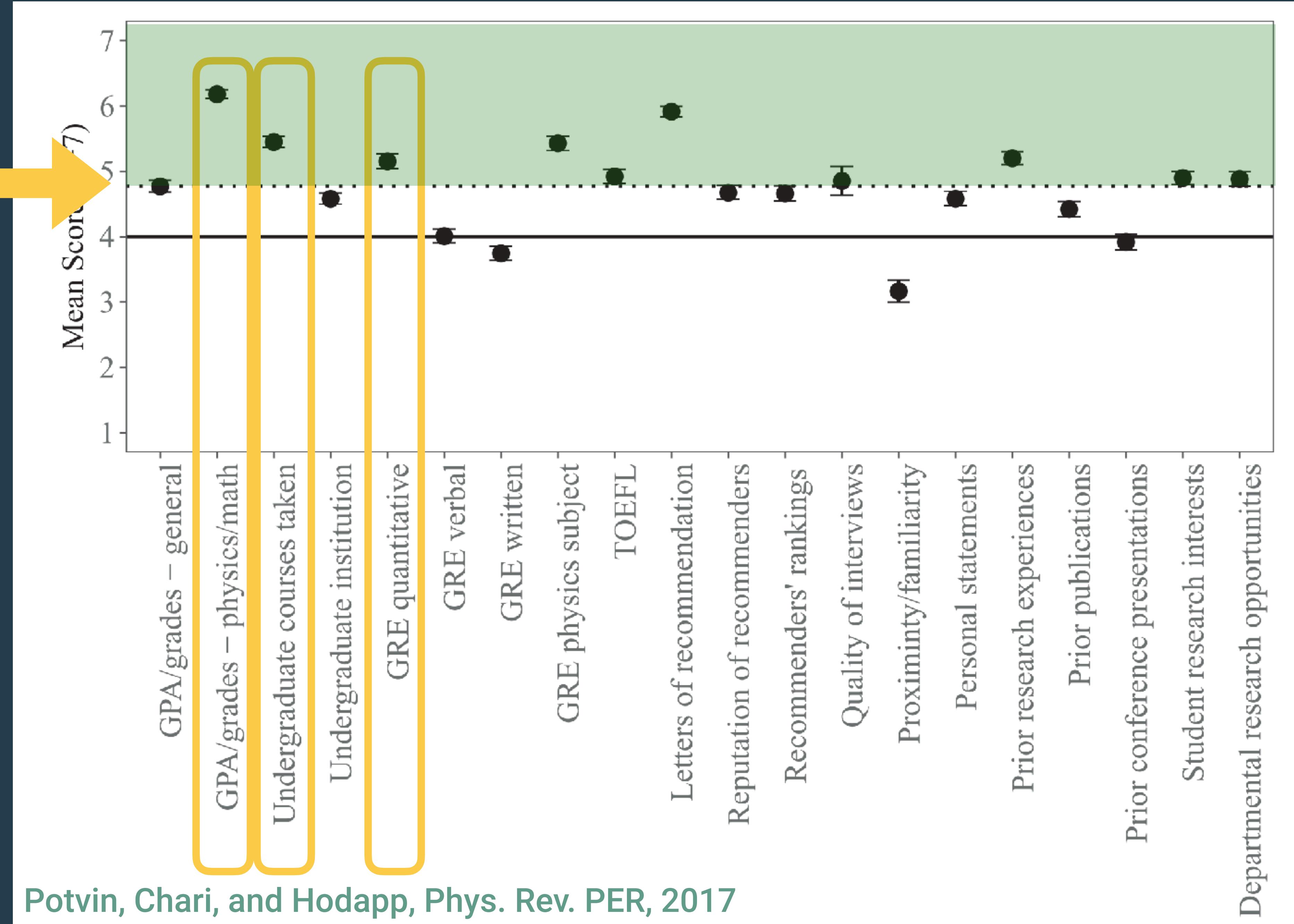
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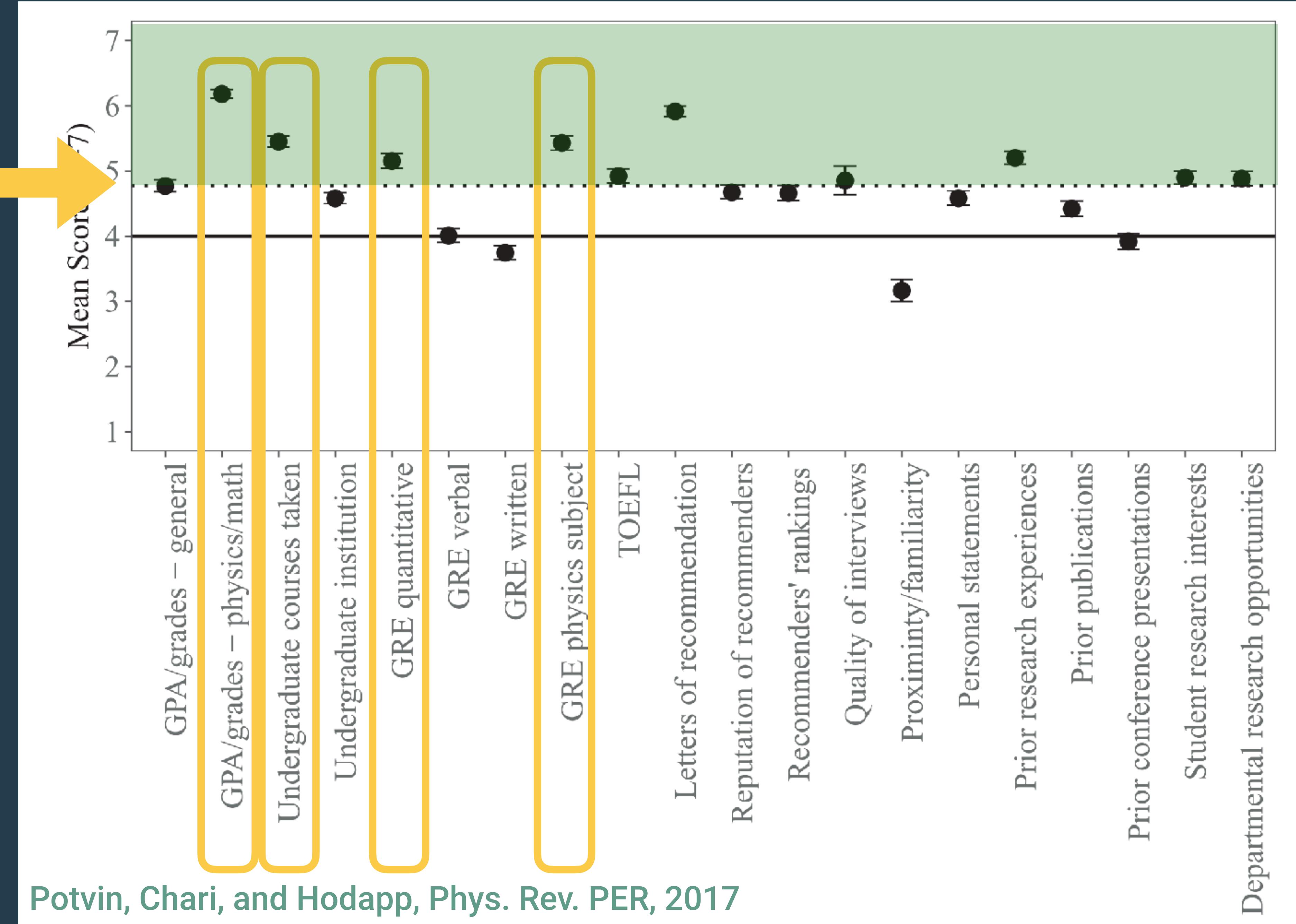
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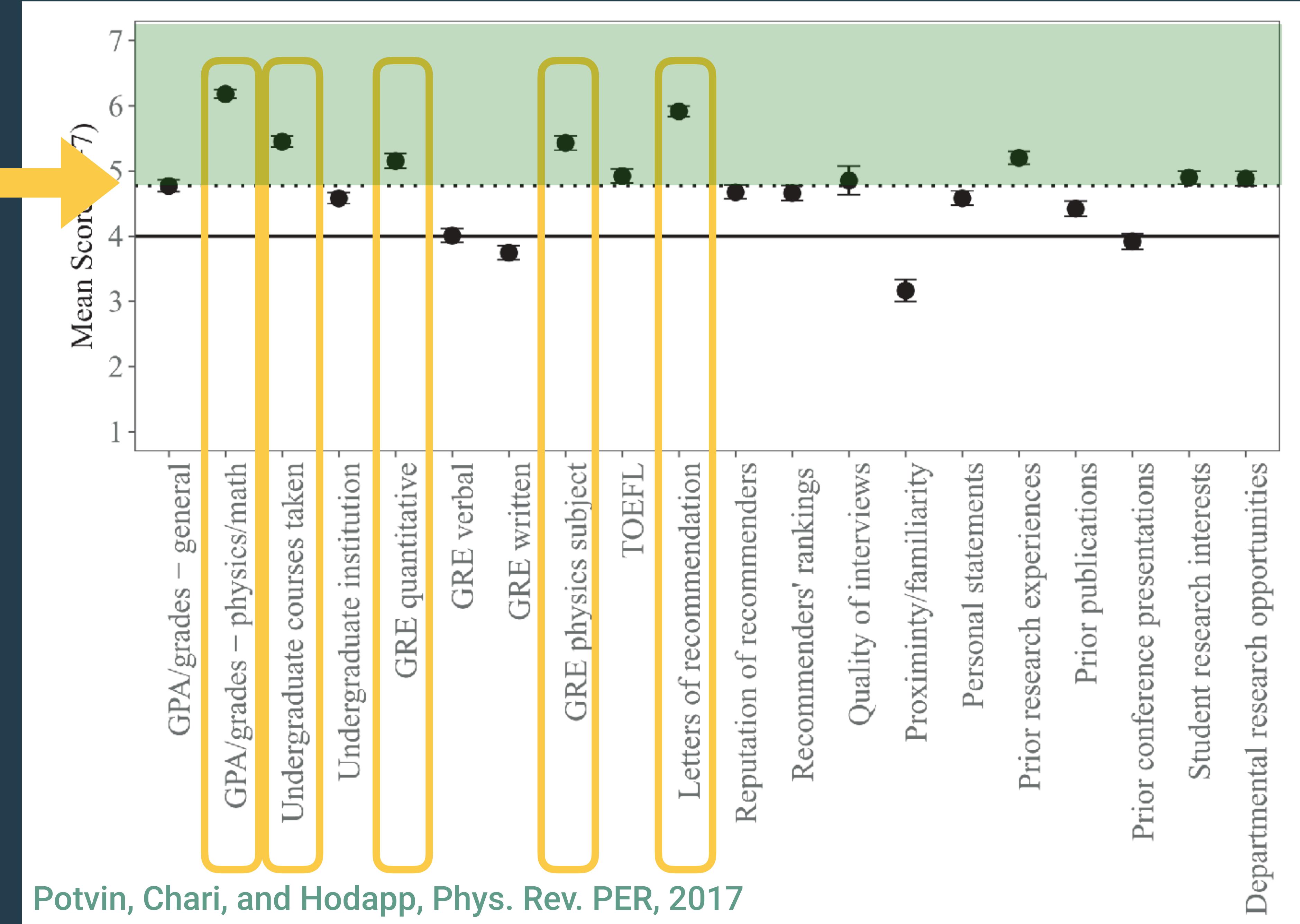
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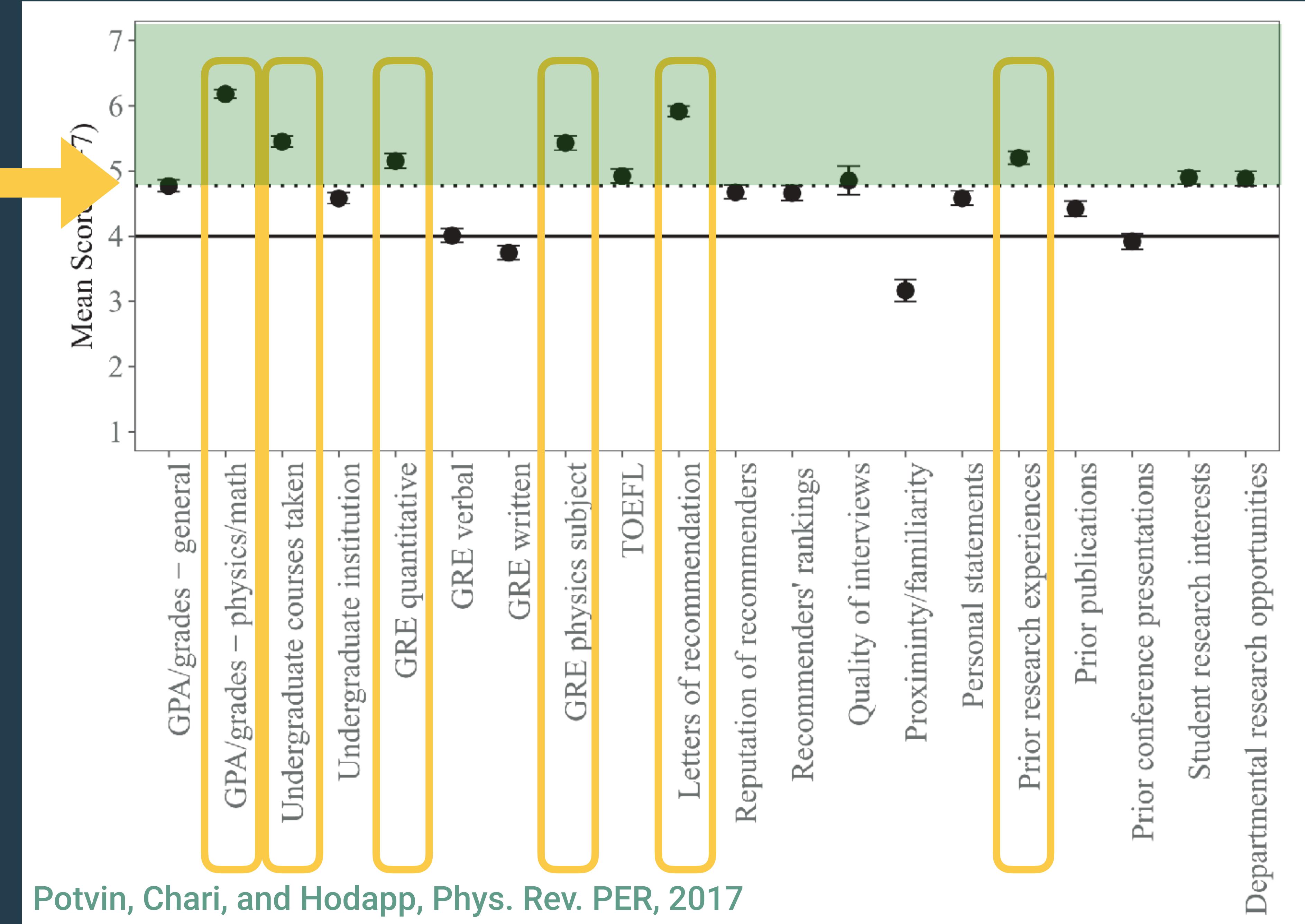
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# INSIDE GRADUATE ADMISSIONS

MERIT, DIVERSITY,  
AND FACULTY GATEKEEPING

JULIE R. POSSELT



In-depth research  
into admissions  
deliberations



# The Graduate Record Exam

## **GRE General Test**

~4 hour test in three parts

Cost: \$205

## **GRE Subject Test (Physics)**

~3 hour, 100 question, multiple-choice

Cost: \$150

Perspective (12% income tax):

\$7.25/hr -> \$6.38/hr (56 hrs)

\$2.13/hr -> \$1.87/hr (190 hrs)

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41. The quantum efficiency of a photon detector is 0.1. If 100 photons are sent into the detector, one after the other, the detector will detect photons
- (A) exactly 10 times
  - (B) an average of 10 times, with an rms deviation of about 0.1
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  - (B)  $c \exp\left(-\frac{r}{a_0}\right)$
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53. A microwave line has a laboratory wavelength of 1  $\mu\text{m}$ . If the Hubble constant  $H \approx 75$  (km/s)/Mpc, the observed wavelength for the line from a galaxy 100 Mpc distant is about
- (A) 250 nm shorter
  - (B) 25 nm shorter
  - (C) the same
  - (D) 25 nm longer
  - (E) 250 nm longer

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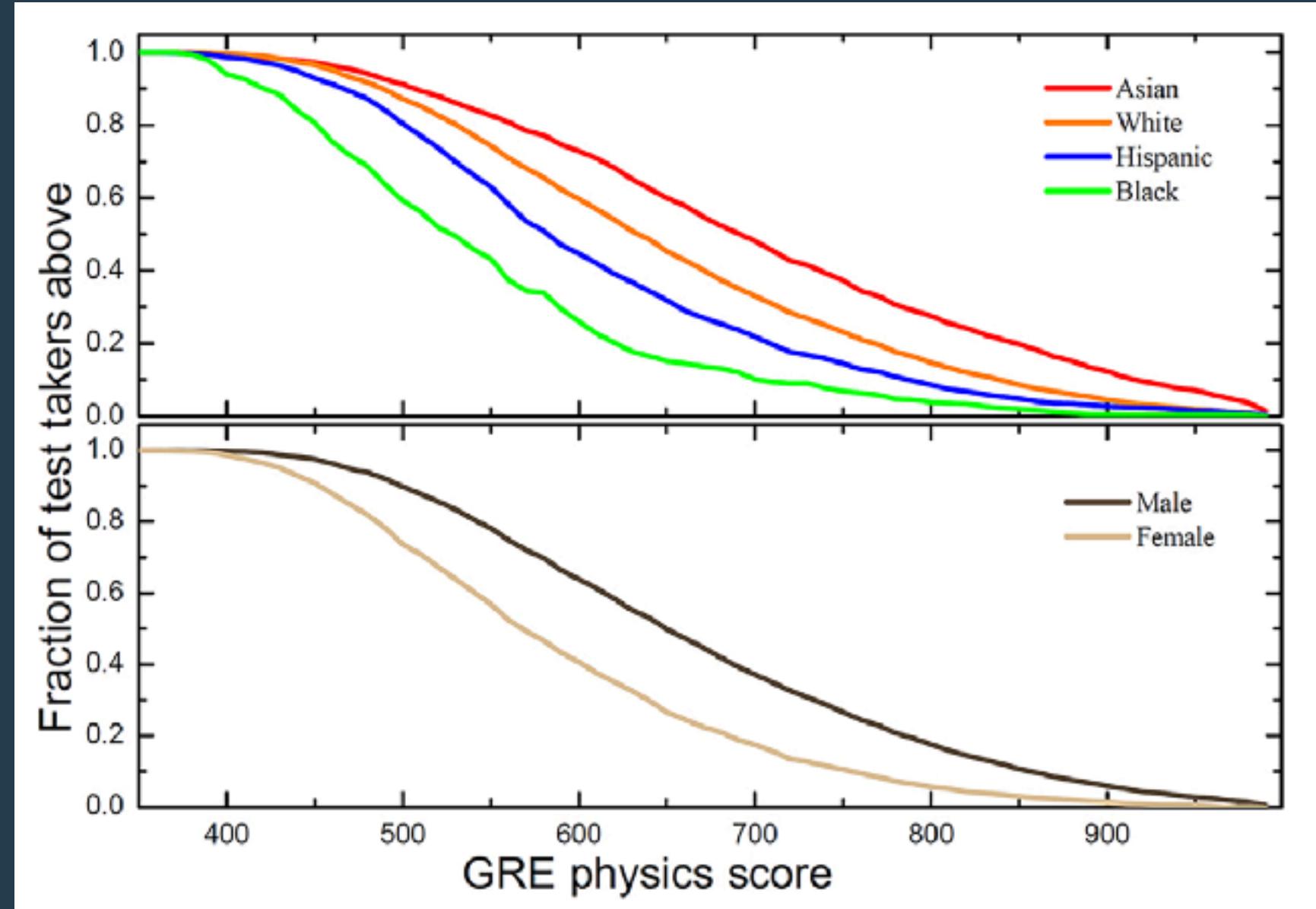
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53. A microwave line has a laboratory wavelength of  $1 \mu\text{m}$ . If the Hubble constant  $H \approx 75 \text{ (km/s)/Mpc}$ , the observed wavelength for the line from a galaxy 100 Mpc distant is about
- (A) 250 nm shorter
  - (B) 25 nm shorter
  - (C) the same
  - (D) 25 nm longer
  - (E) 250 nm longer

NOTE: many students will not have taken upper-level physics courses before taking the PGRE

# Numerical markers used for admission



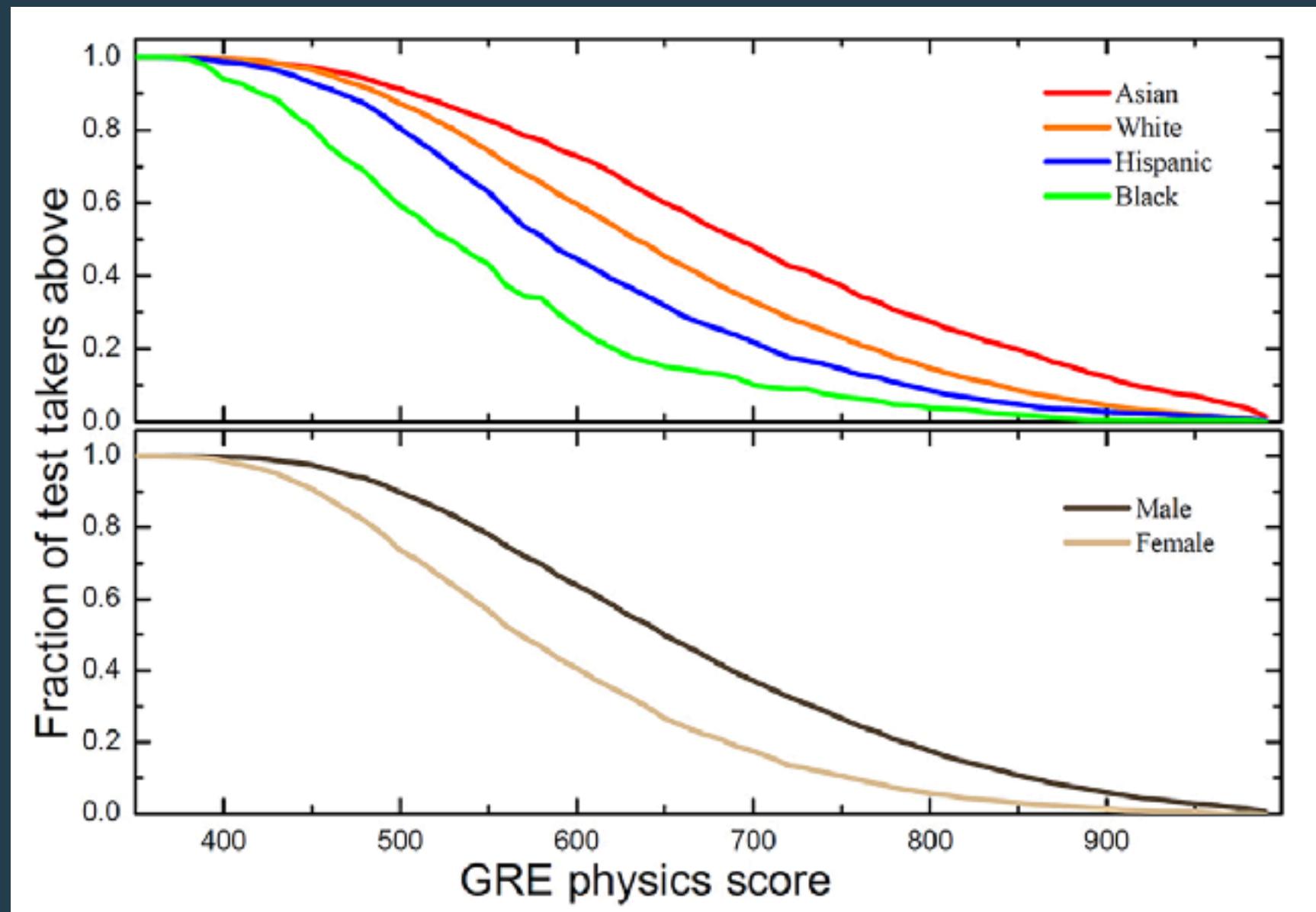
This distribution of GRE scores suggests weighting scores in admissions limits the diversity of potential PhD students [1].

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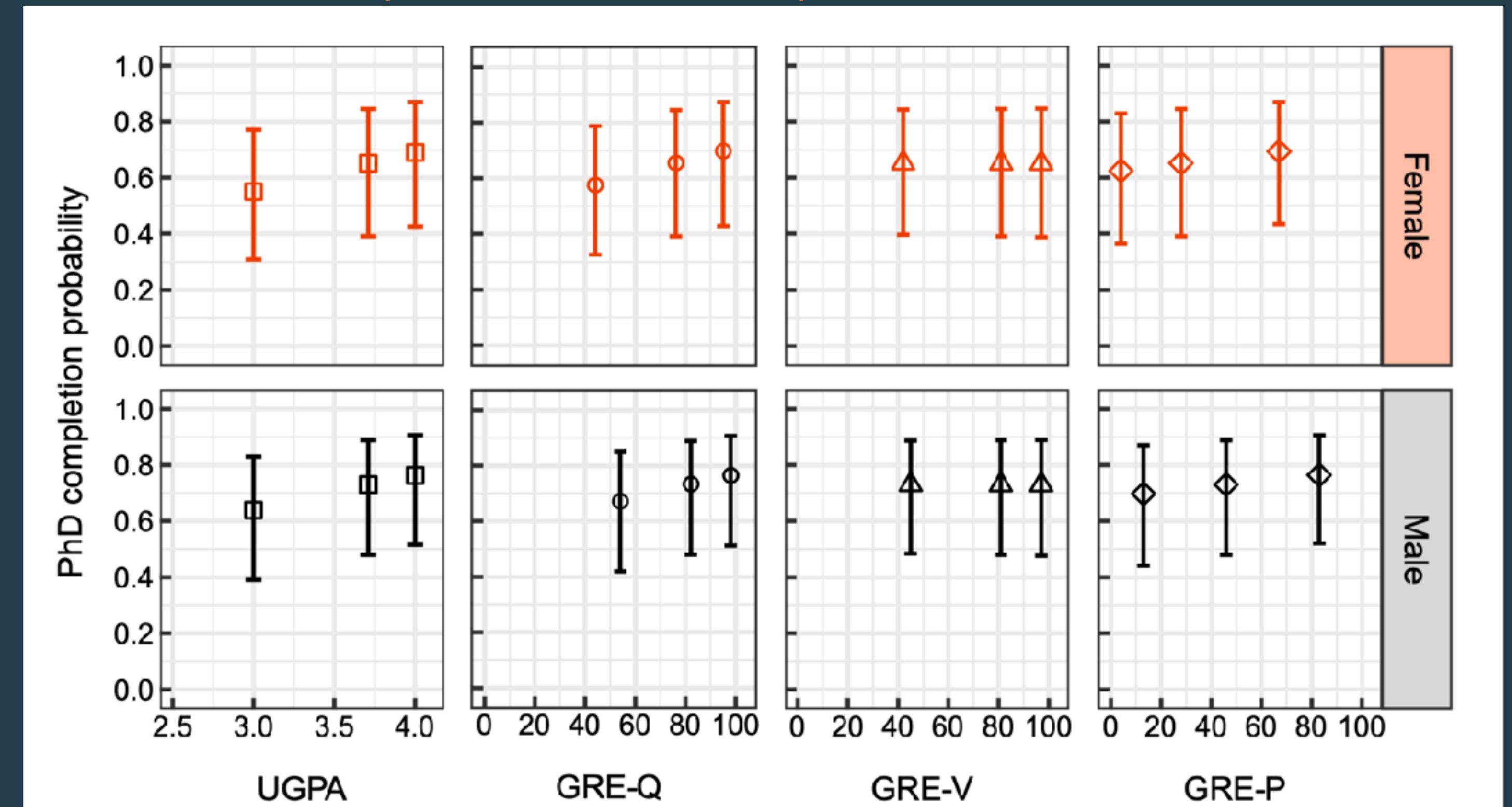
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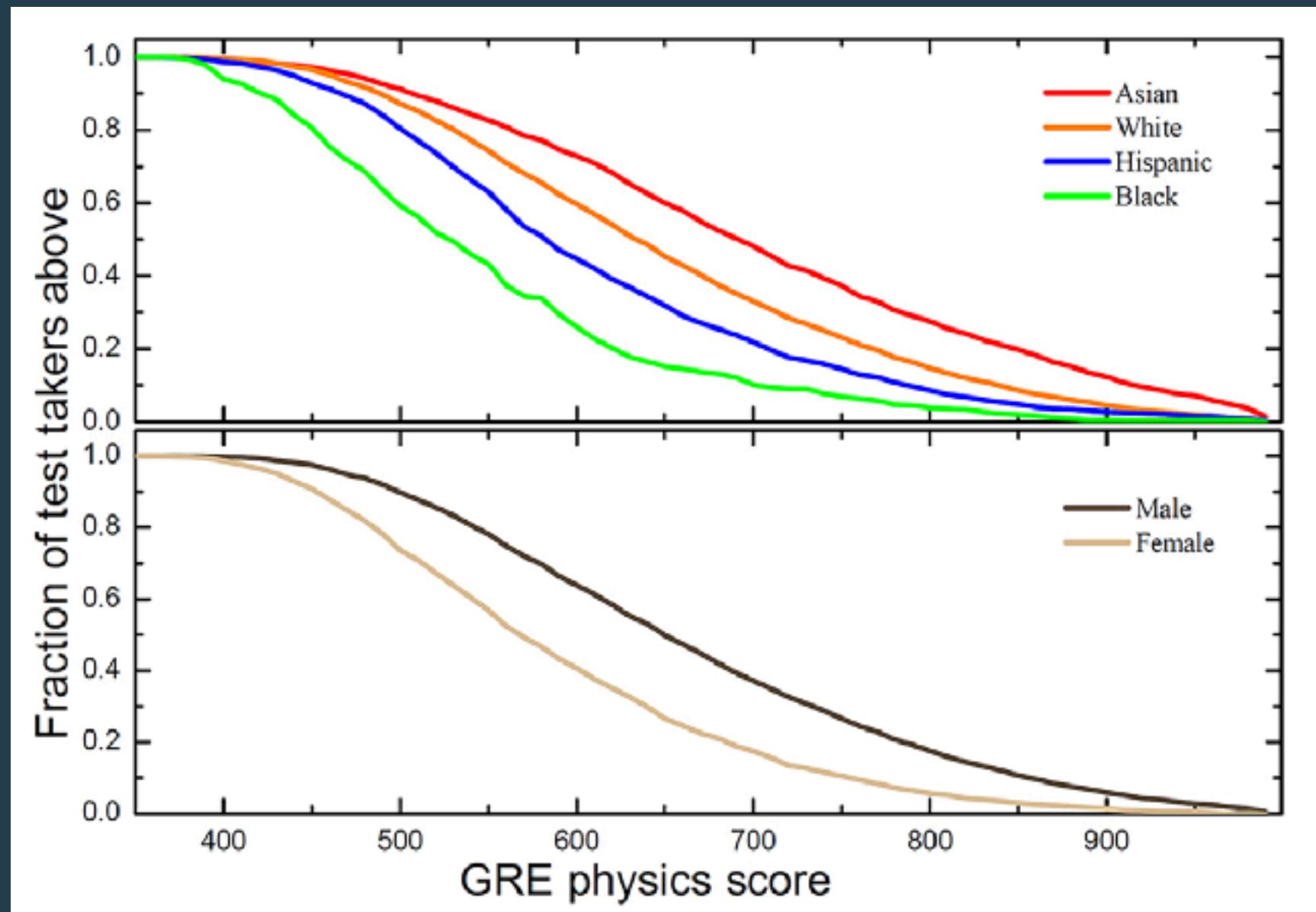


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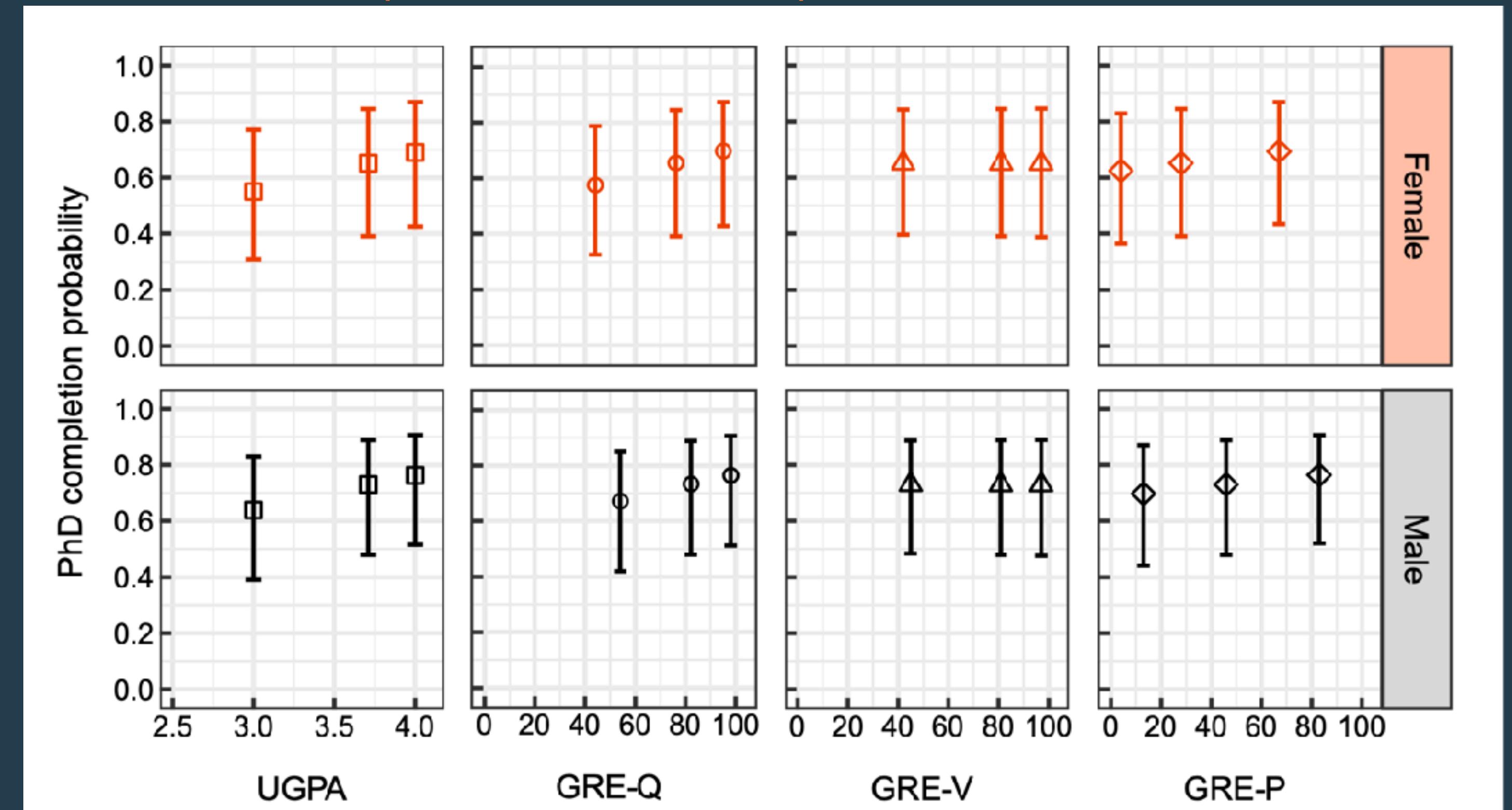
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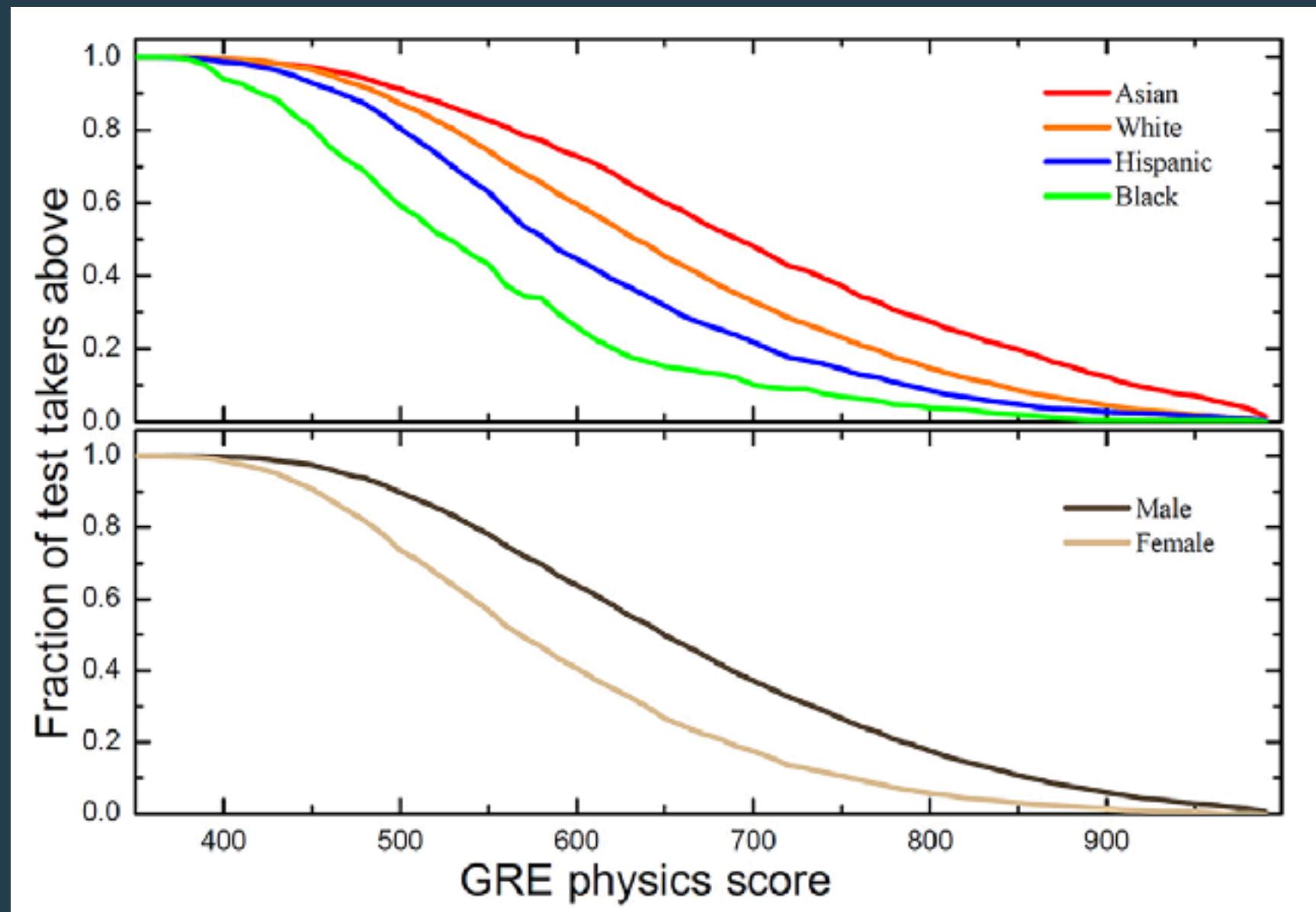


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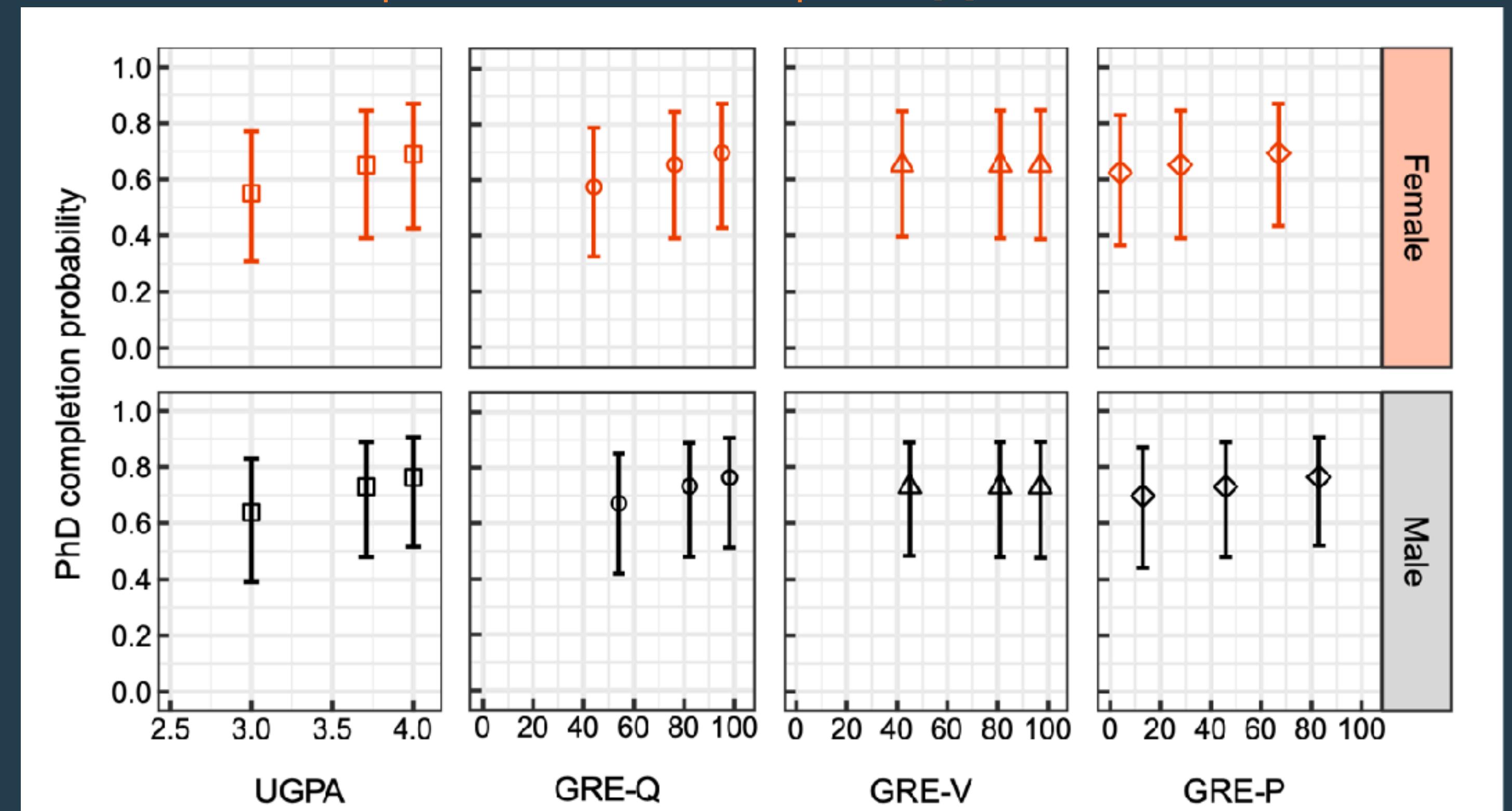
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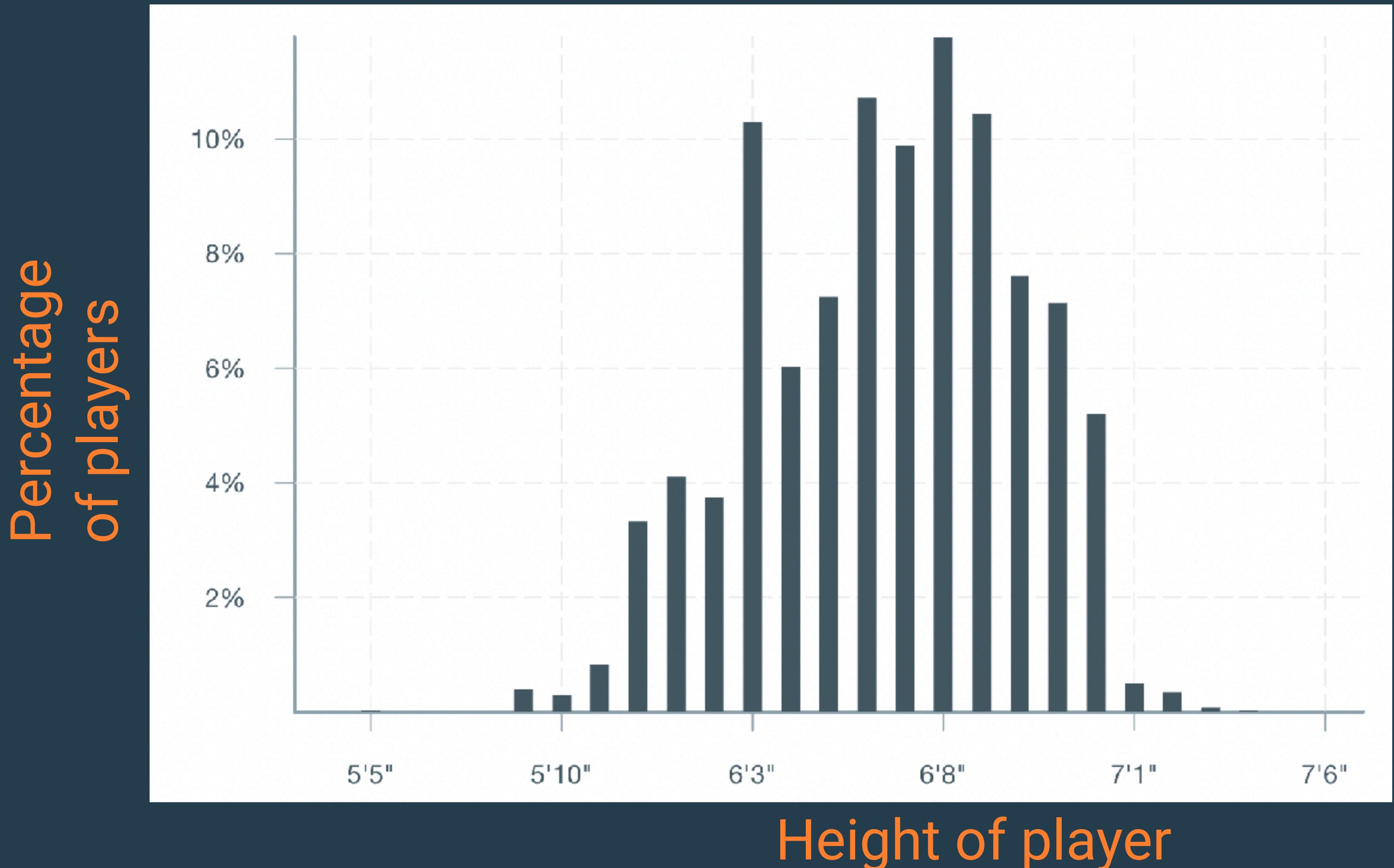
Reminder: PhD completion should not be our only marker of success

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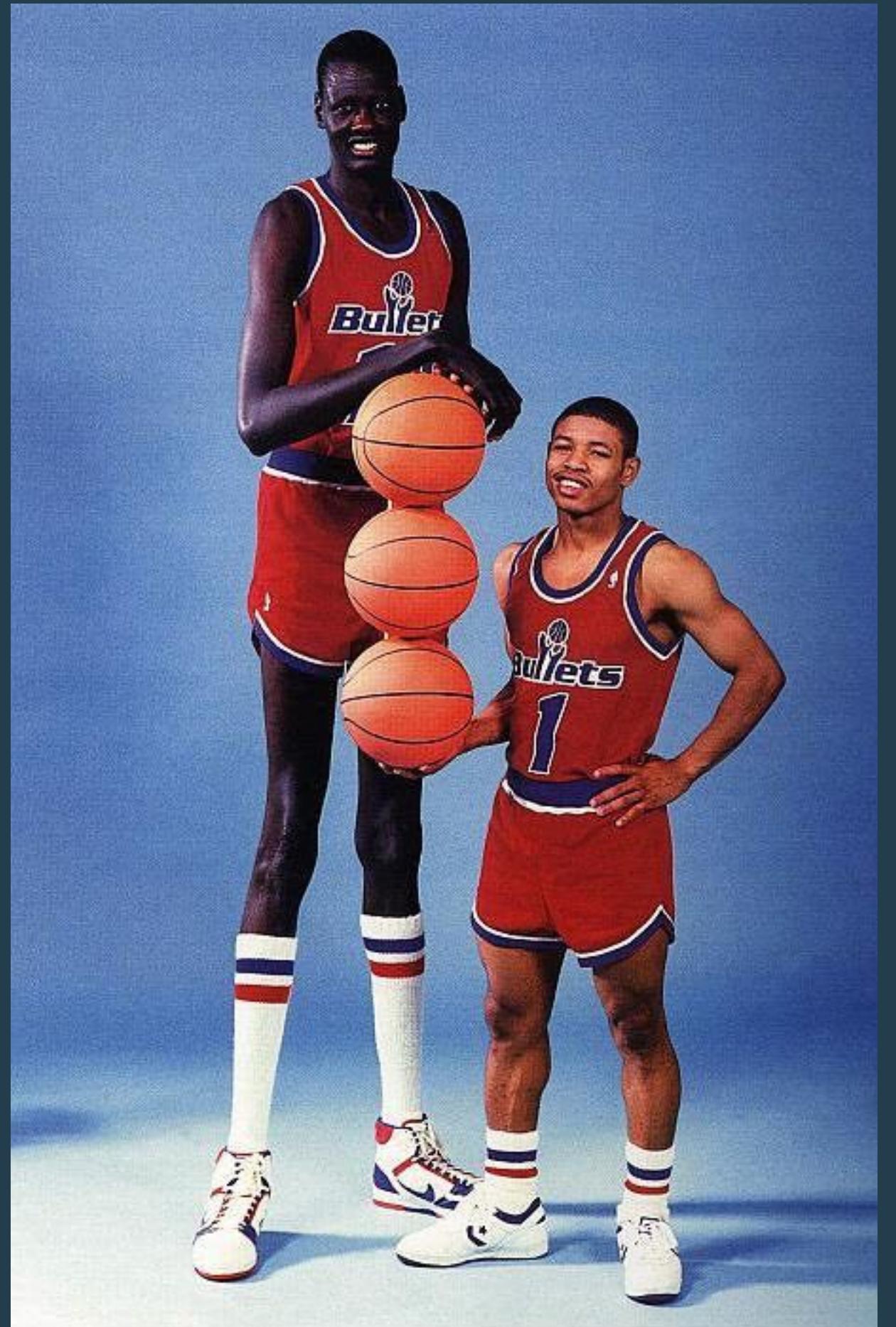
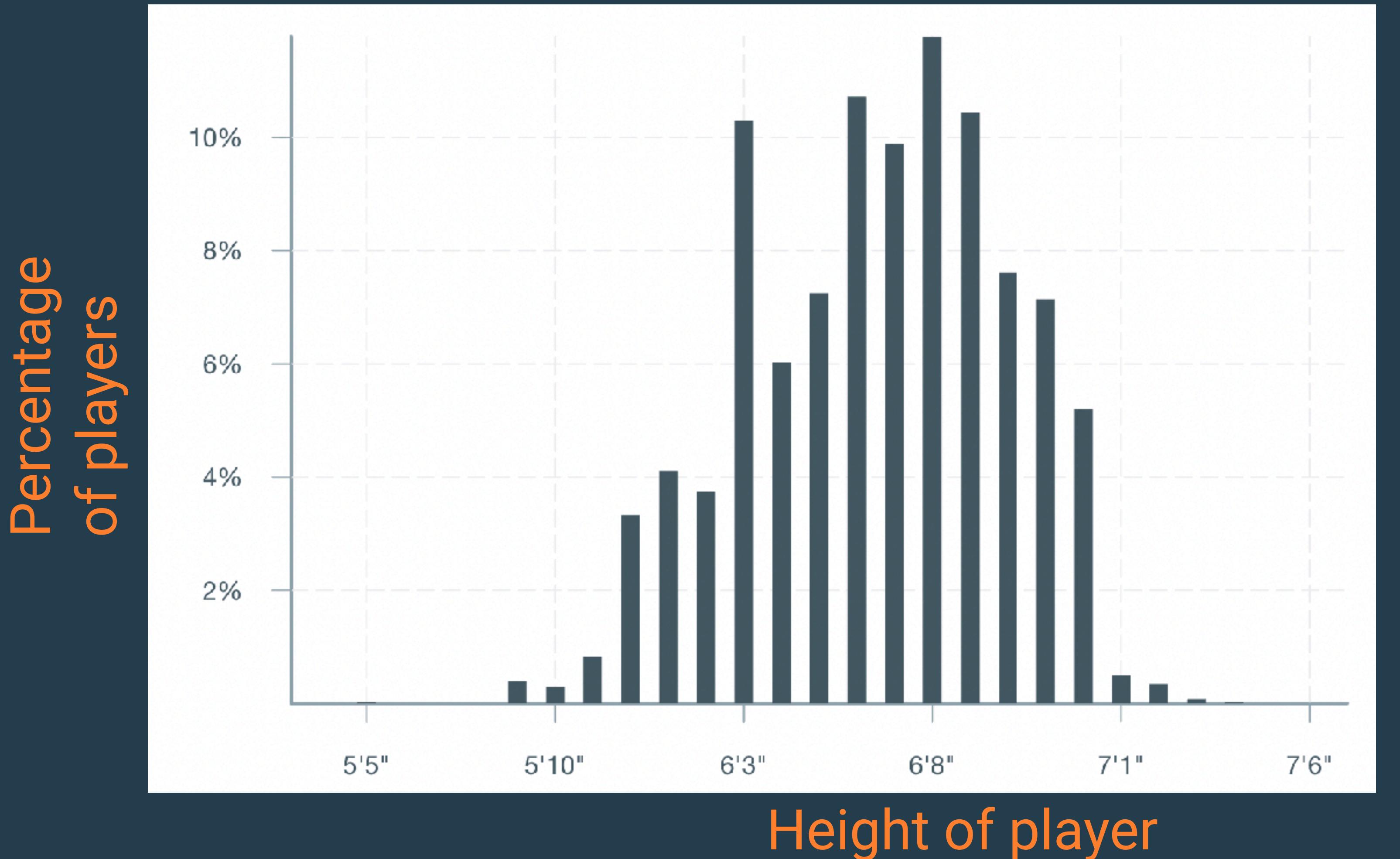
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# Distribution of NBA player heights (last 10 years)



# Distribution of NBA player heights (last 10 years)



Mr. Bol (7' 7") and Mr. Bogues (5' 3")

# “The GRE helps students stand out”

[4]

## What Are the Subject Tests?

The *GRE*® Subject Tests are achievement tests that measure your knowledge of a particular field of study.

Show what you know about a specific subject and graduate schools will take notice. The Subject Tests can help you stand out from other applicants by emphasizing your knowledge and skill level in a specific area.

[4] <https://www.ets.org/gre/subject/about>  
[5] Young & Caballero, Phys. Rev. PER, 2021

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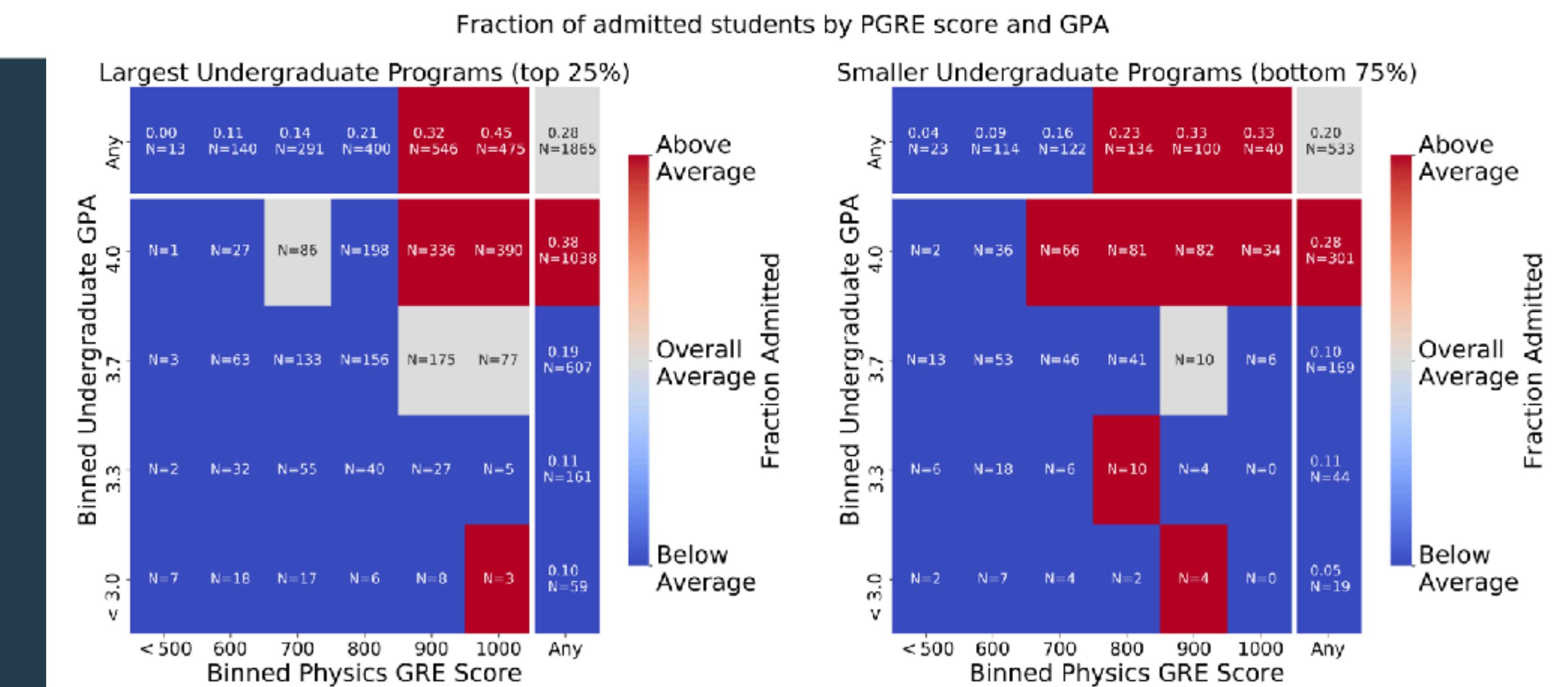
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“...scoring highly on the physics GRE does not help applicants from small or less selective schools or applicants with a low GPA ‘stand out.’” [5]



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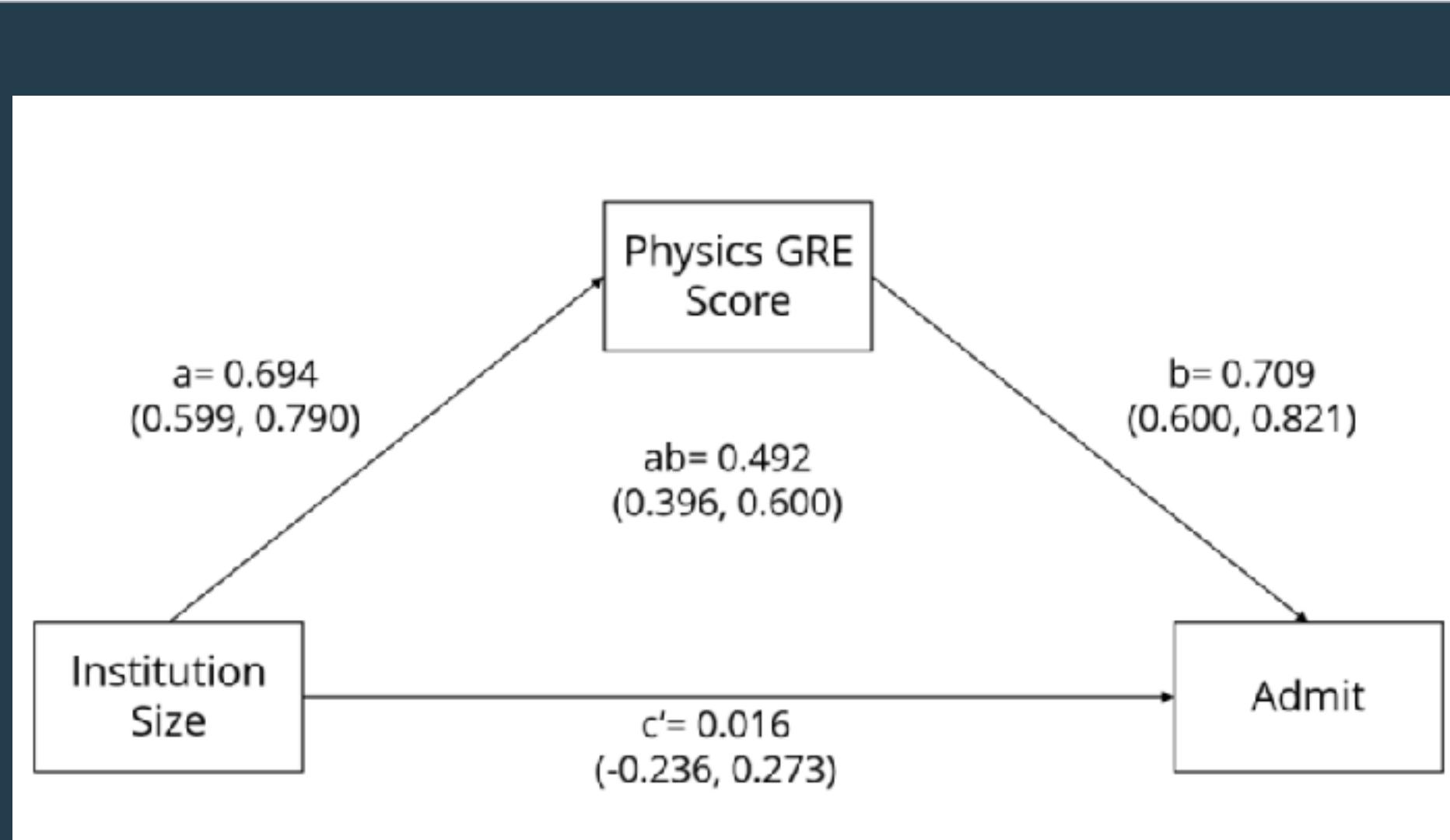
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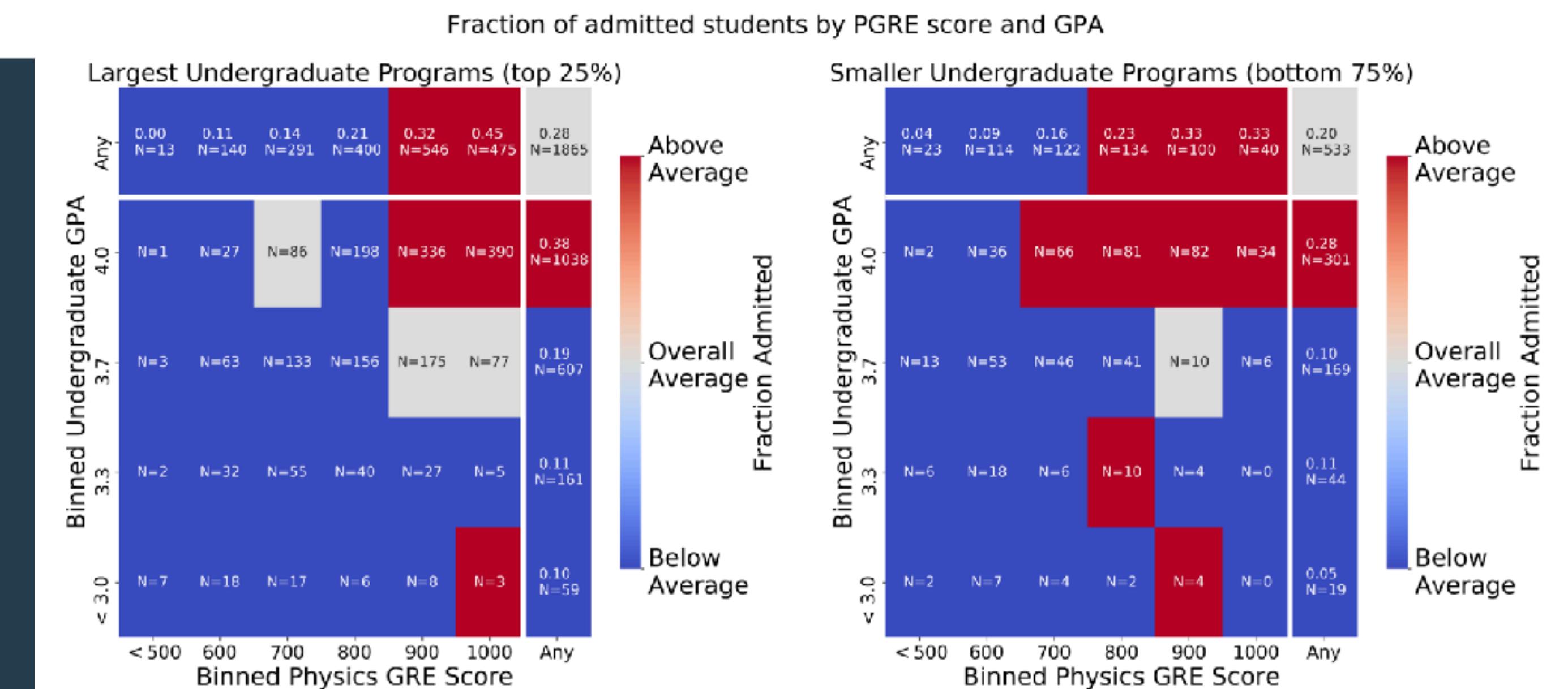
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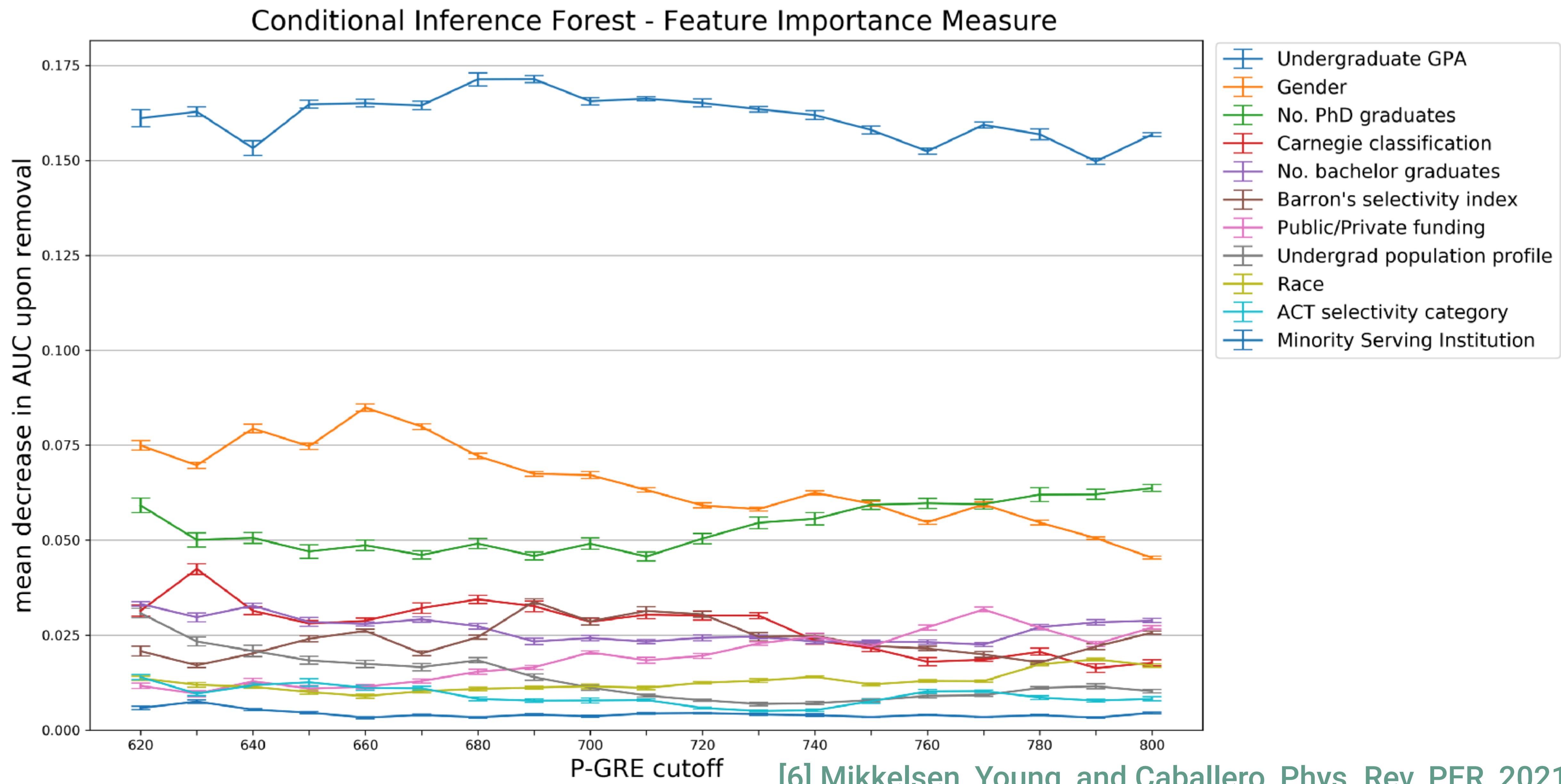
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# GRE cutoffs favor high GPAs, large schools, and men<sup>[6]</sup>



# Michigan State as a Case for Change

68 Faculty and Teaching Staff  
~200 Graduate Students

Physics and Astronomy



NSCL/FRIB



# Michigan State as a Case for Change

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~200 Graduate Students

~300 PhD Applicants/yr  
~60 Admitted PhD Students/yr  
~30 New PhD Students/yr

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MSU Physics and Astronomy is a large, high research activity program.

## Physics and Astronomy



NSCL/FRIB

# Admissions Process (Pre 2018)

- Applicants submitted transcripts, GRE scores, statements, letters
- Spreadsheets organized applicant materials and a large (10+) committee reviewed applicants
- Soft cut-offs for GRE were used

**Michigan banned Affirmative Action programs by ballot initiative in 2006.**

The University of Michigan, Michigan State University, Wayne State University, and any other public college or university, community college, or school district **shall not discriminate against, or grant preferential treatment to**, any individual or group on the basis of race, sex, color, ethnicity, or national origin in the operation of public employment, public education, or public contracting.

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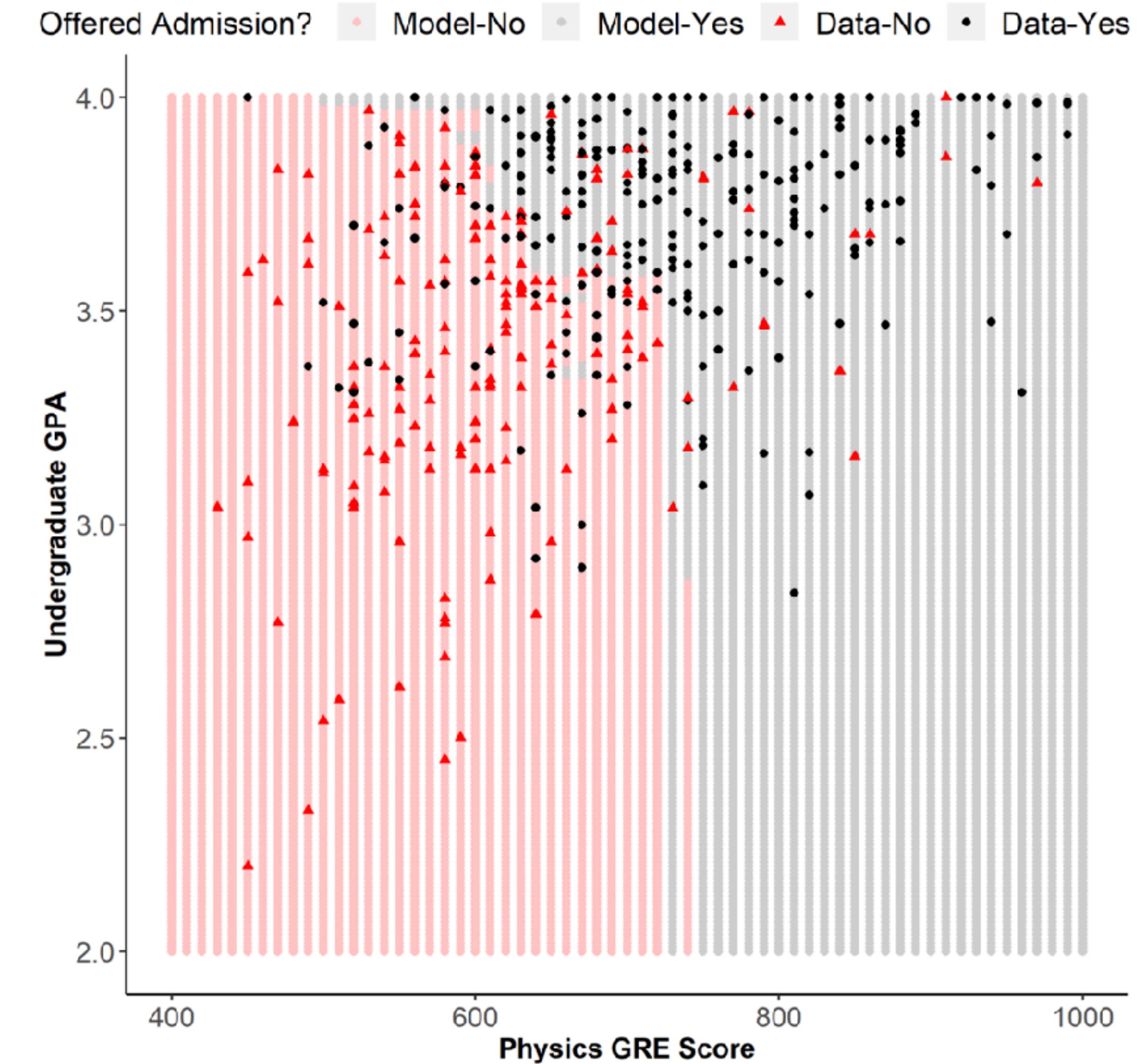
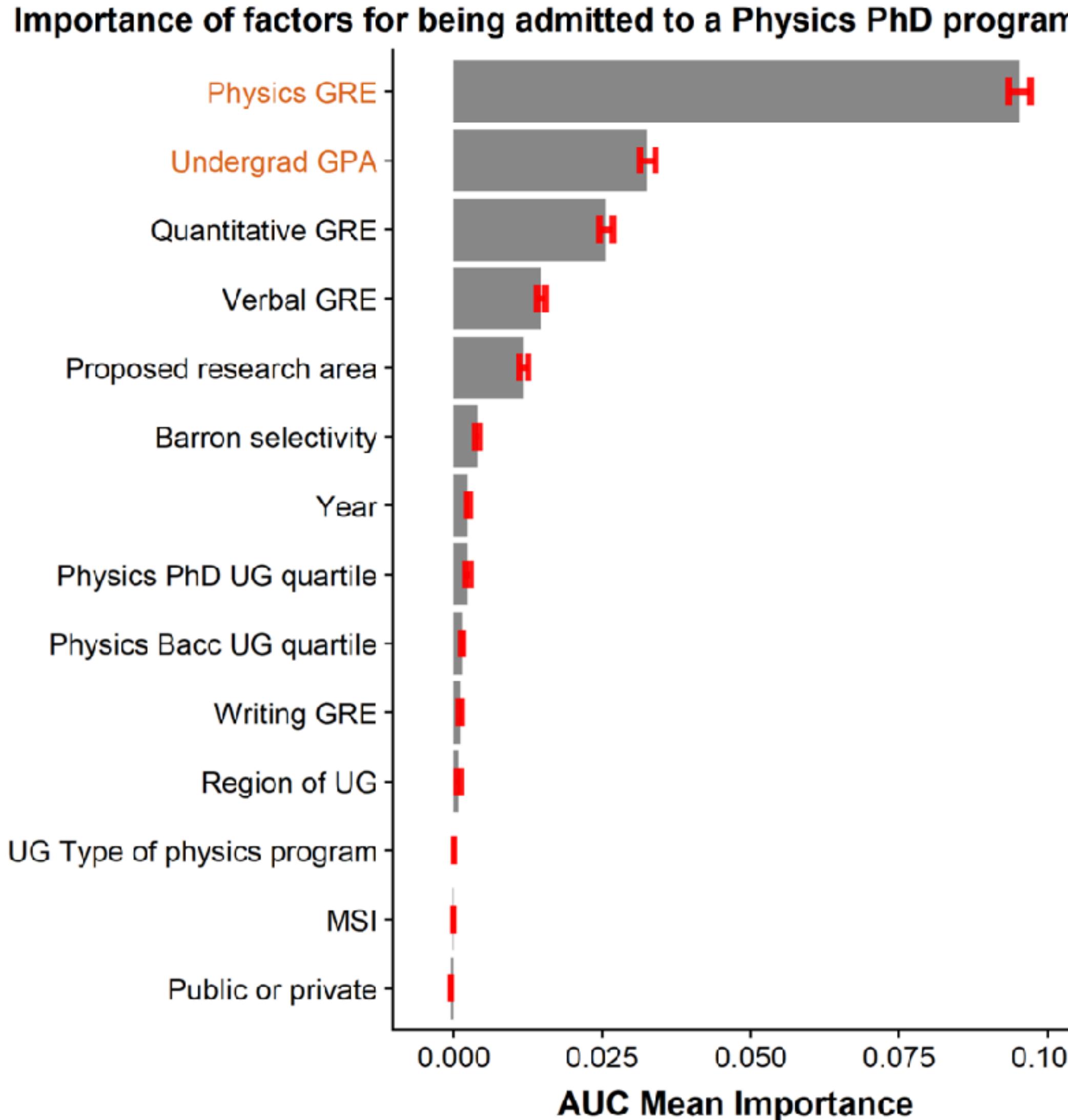
## Admitted Student Population

	Women	Racial/Ethnic Minorities
Fall 2016 and before	Not Recorded	
Fall 2017	5%	13%

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# Can predict ~80% of admitted students with PGRE and UGPA [7]

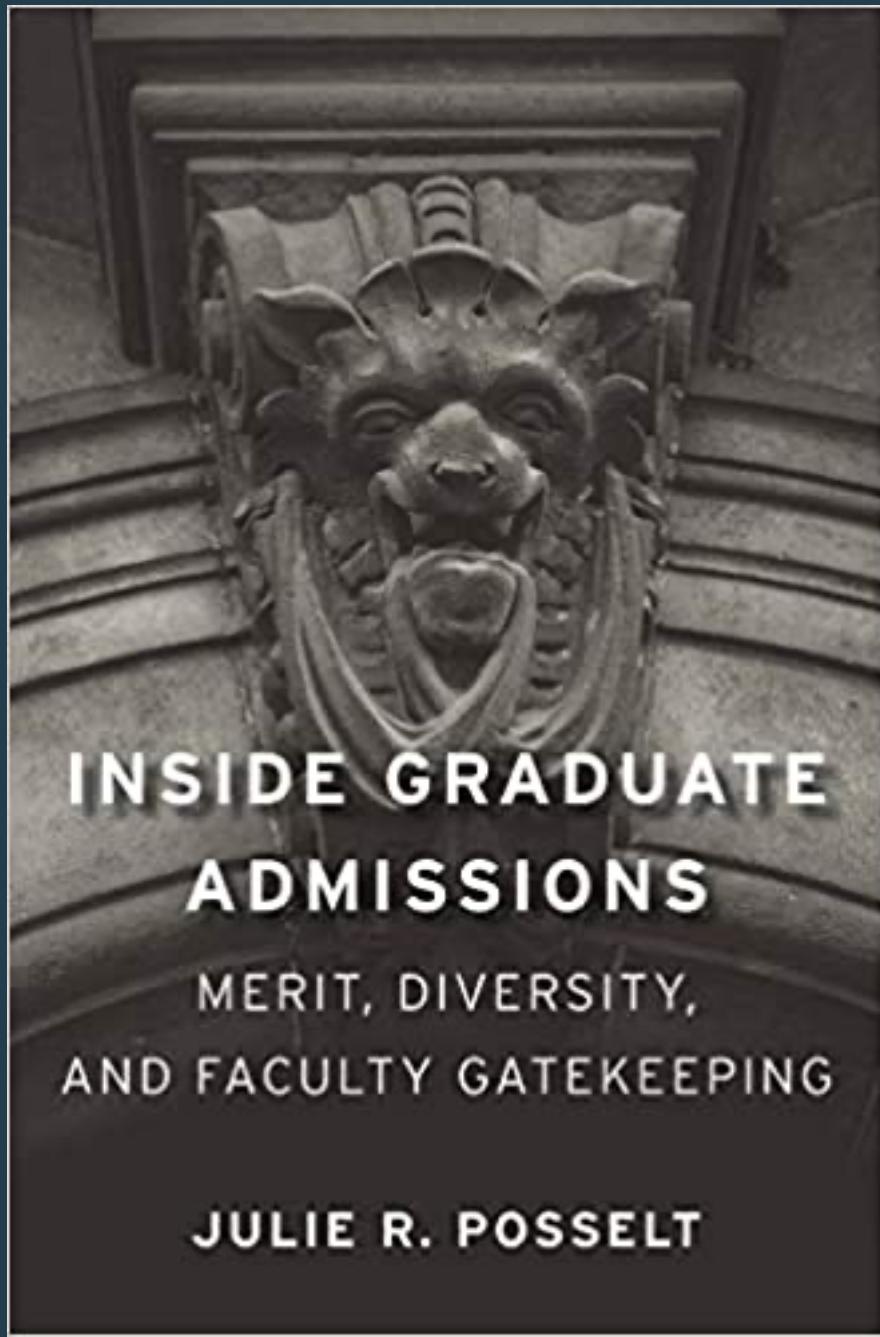


# Changes to Process

- [8] Posselt, Inside Graduate Admissions, Harvard University Press, 2016
- [9] IGEN; [pullias.usc.edu/igen/](http://pullias.usc.edu/igen/)

# Changes to Process

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  - With Casey Miller (RIT), JP runs workshop on Graduate Admissions Rubrics [8,9]
  - Graduate Program Committee develops initial rubric

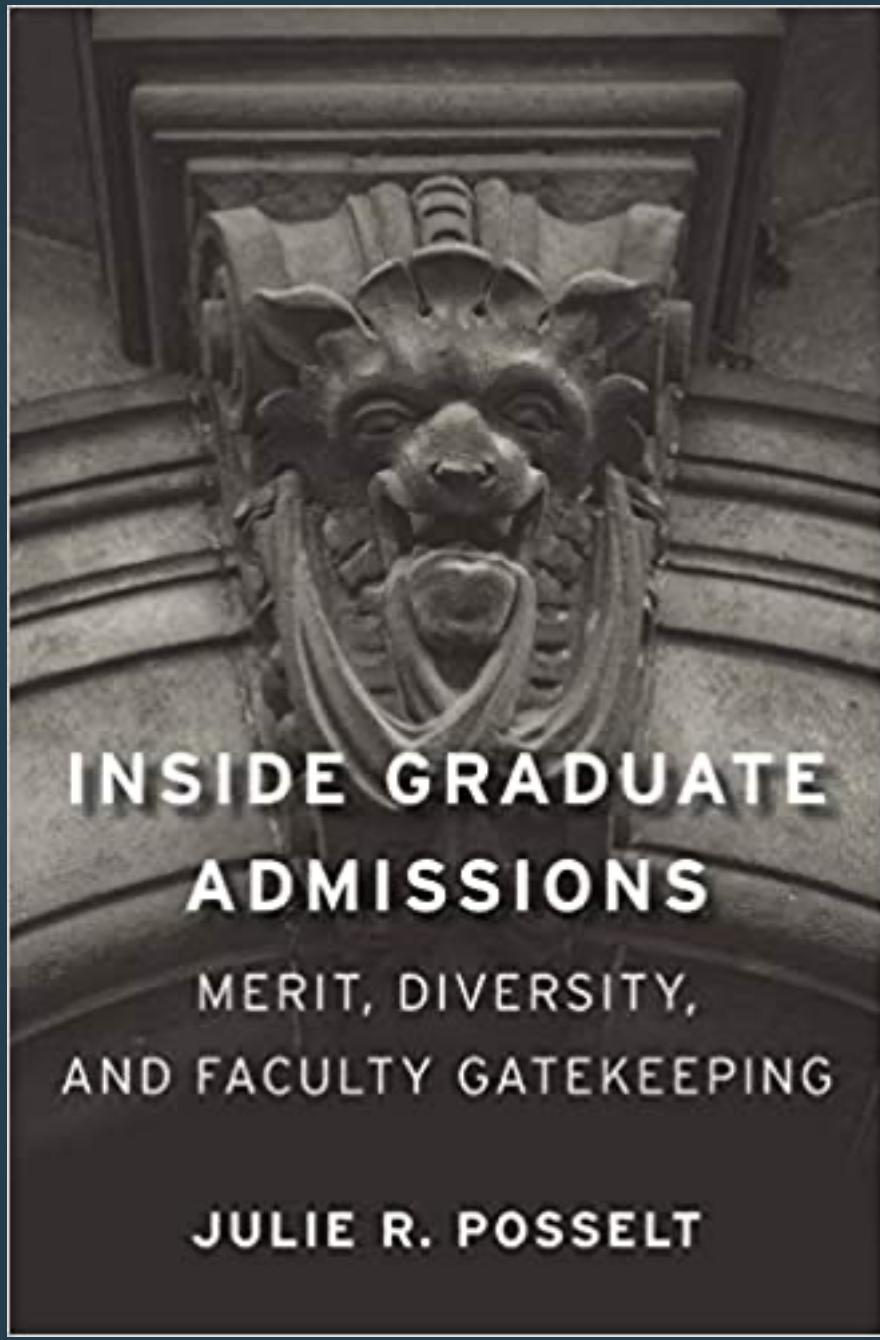


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- Spring 2018
  - First class of students admitted using rubric



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item	subitem	High	Medium	Low
Academic Preparation (25%)	Physics Coursework	GPA>=3.7 (A-) in all core subjects: CM1&2, EM1&2, QM1&2, SM1, if not taken 2nd semester courses yet are they planning on taking them?	GPA >=3.3 (B+) in all core: CM1&2, EM1&2, QM1&2, SM1; OR GPA>=3.7 (A-) in CM1, EM1, QM1, SM1 if no 2nd semester courses taken	GPA>=3.7 (A-) in EM1 and CM1; GPA>=3.0 (B) average in other advanced courses; any grades <2.7 (B-) without explanation
	Math Coursework	Real and Complex Analysis, Group Theory with GPA>=3.5 (A) grades	DiffEq, Linear, and a Math Methods course, all with >=3.5 (A) grades; or more than this with GPA>=3.0 (B or A) grades	Bare bones math prep (e.g., up to DiffEq), or low grades regularly on math
	Other Coursework	Consistently 3.5 (A) grades	Consistently 3.0 (B) grades with nothing below a 2.5 (B-/C+)	One or more 2.5s (B-/C+)
	Academic honors and/or recognitions	multiple honors, e.g., Dept/University Honors; Phi Beta Kappa, etc	one academic award/recognition	No academic honors in college documented in the application
Research (25%)	variety/duration	two years in research	one year in research; only REUs	nothing more than coursework laboratories
	quality of work	multiple indications of excellence	clearly made significant contributions to the project	limited intellectual or technical contribution to projects; "button pusher"
	technical skills	a variety of experiment, theory, and/or computational skills	has developed only one class of skill (exp or theory or comp)	nothing more than coursework laboratories
	dispositions	clear commitment to and enthusiasm for research; AND understands what the process entails	clear commitment to and enthusiasm for research; OR understands what the process entails	not clear if they know what they are getting into with a PhD; seems lukewarm about research
Non-Cognitive Competencies (25%)	Achievement Orientation	Consistently strives to improve or meet a high standard of excellence in all areas	Has demonstrated a high standard of excellence in selected areas	No evidence of striving for excellence provided in application or student record
	Conscientiousness	Takes responsibility for personal performance, both the good and the bad; AND demonstrates efficiency and organization	Takes responsibility for personal performance, both the good and the bad; OR demonstrates efficiency and organization	No evidence of taking responsibility for performance AND minimal evidence of efficient, organized work
	Initiative	Consistently seeks out or acts on opportunities AND takes leadership	Consistently seeks out or acts on opportunities OR takes leadership	Has not sought out or taken advantage of opportunities AND does not have a record of leadership
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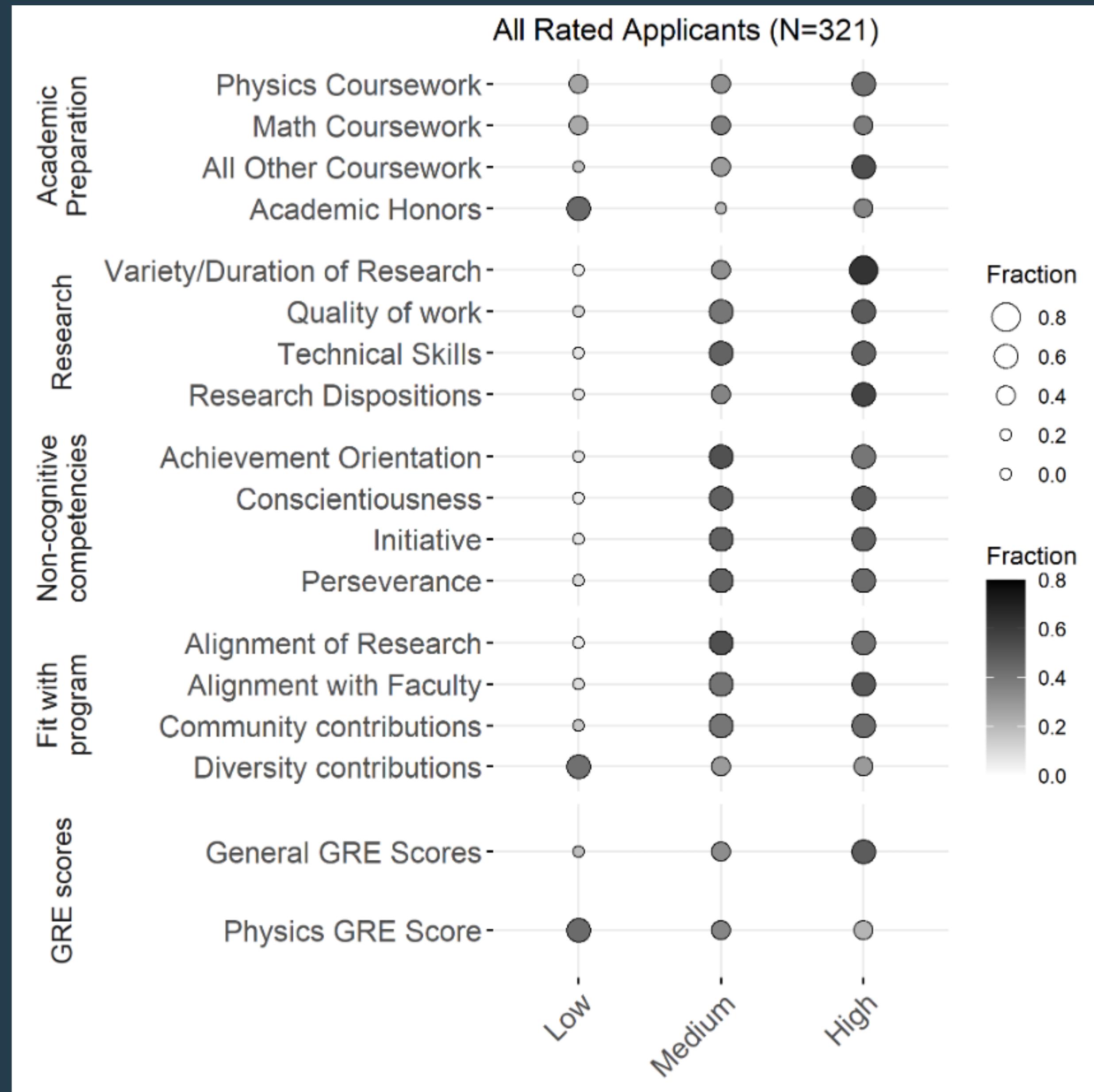
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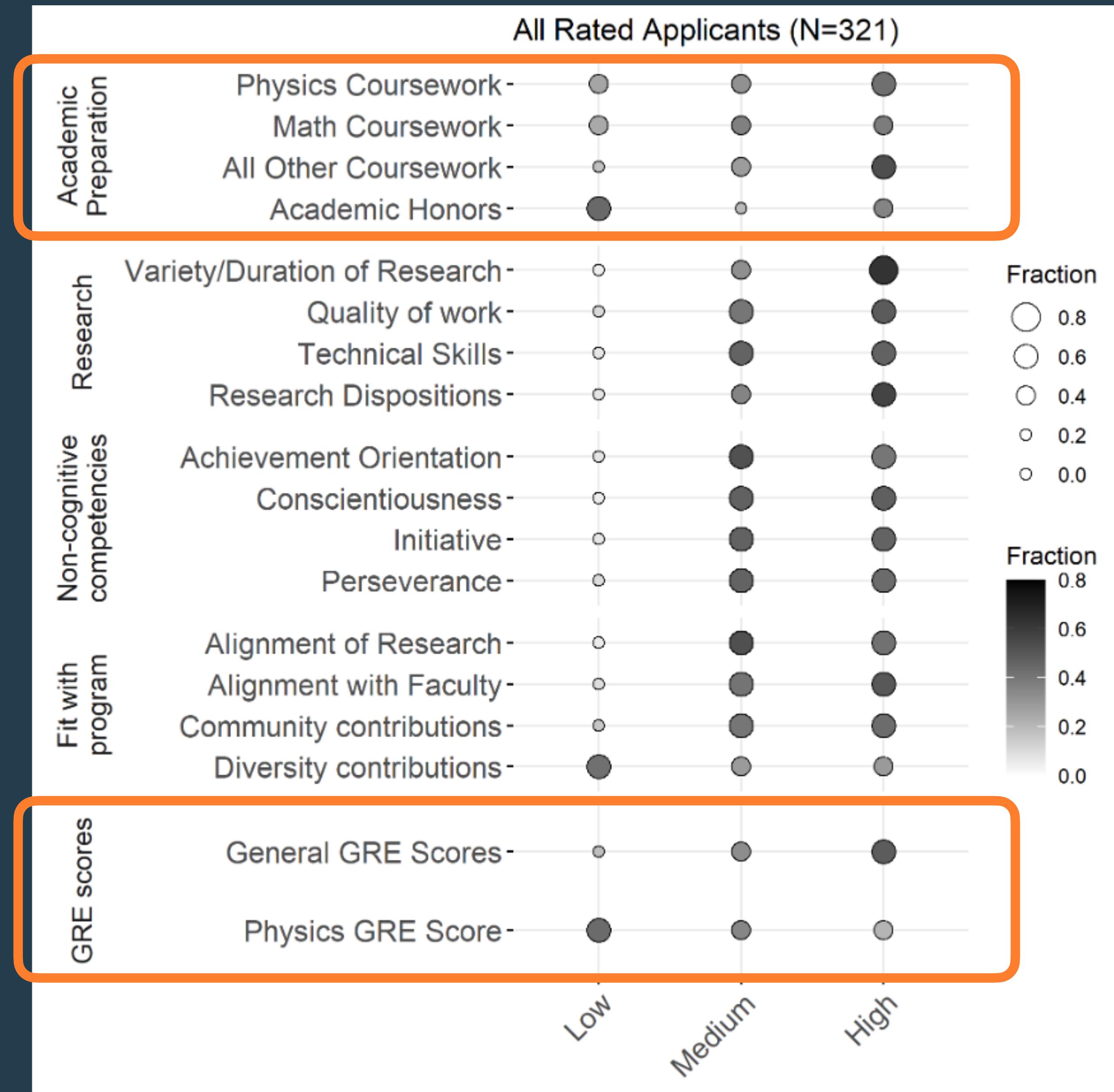
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	community	has clearly contributed positively to prior department/school culture, and would do the same for our program	some evidence of participating in service activities	applicant only discusses him/herself; no evidence of engagement in department or university activities
	diversity	applicant has been an active advocate for diversity in physics	belongs to an underrepresented identity group; first generation in college or low SES; and/or contributes to another type of diversity the department seeks	contributions to diversity are unclear from the application
GRE Scores (10%)	General GRE	Verbal(V) and Quantitative(Q) scores >=75% (or 157 for V and 160 for Q) AND Analytical Writing (AW) >=4.0	V & Q scores >=75% (or 157 for V and 160 for Q) BUT AW<4.0	V or Q score <75% and AW<4.0
	Physics GRE	>=75%	50-74%	<49%

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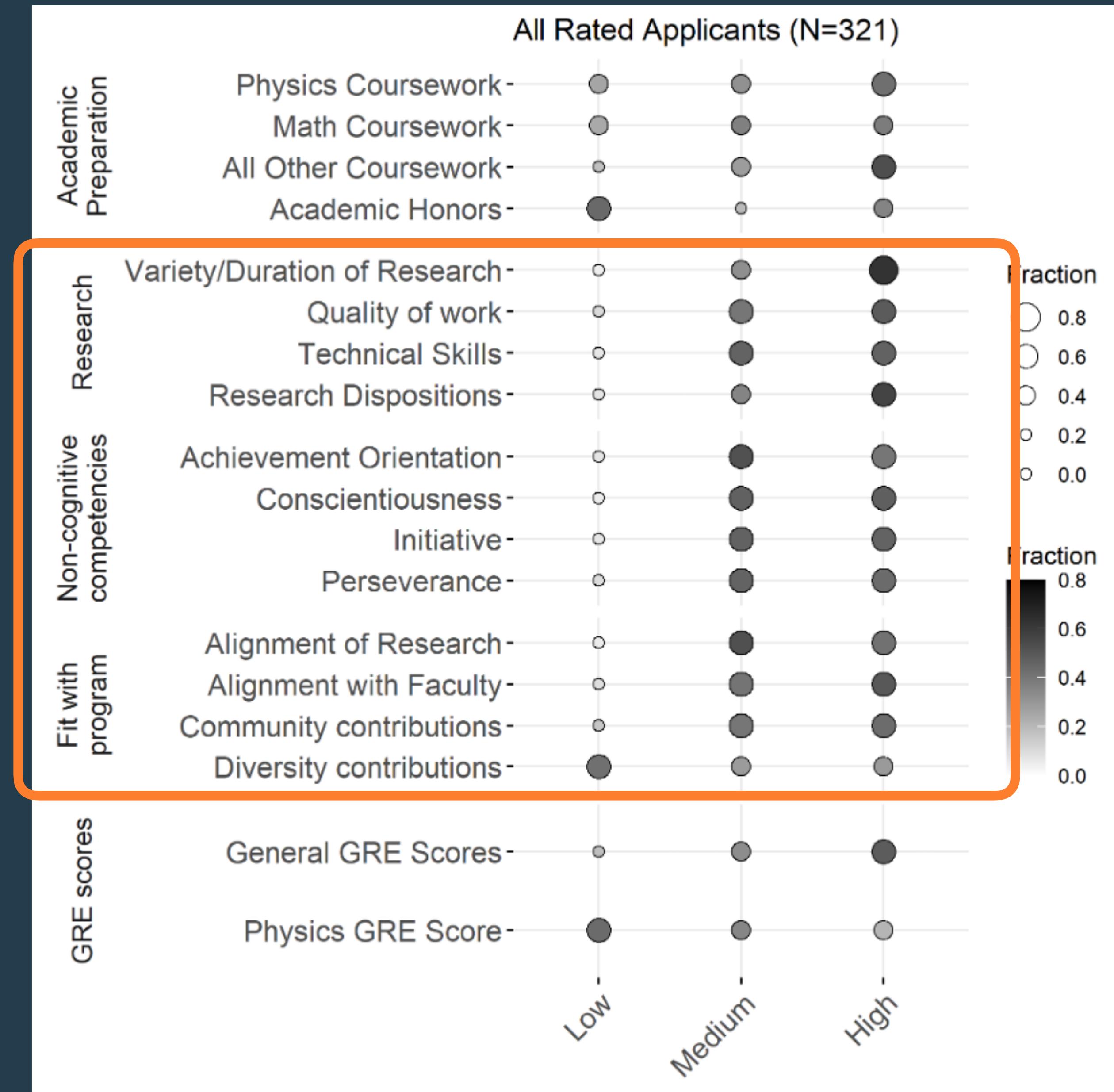
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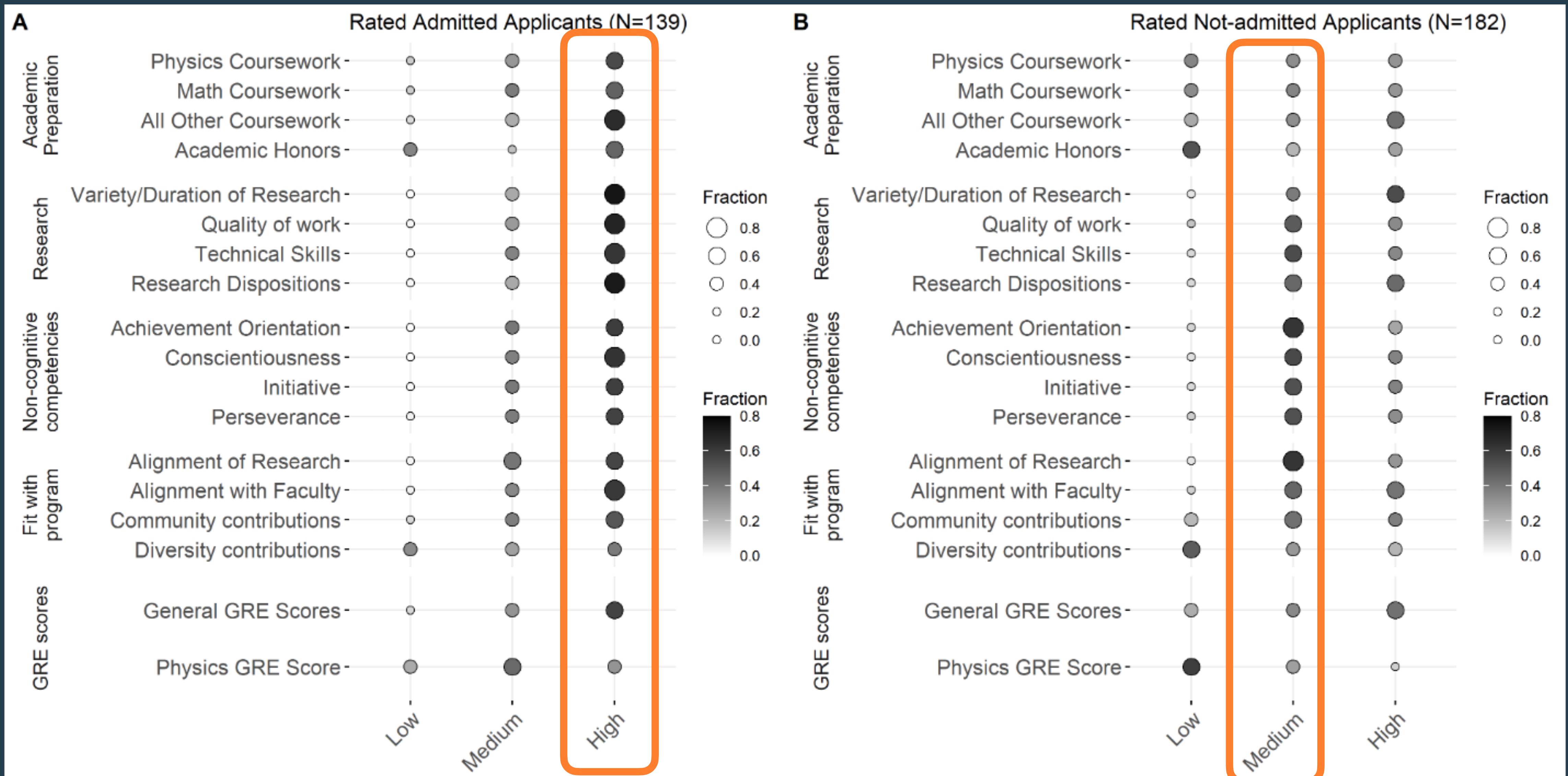


# Some criteria have ratings across rubric levels

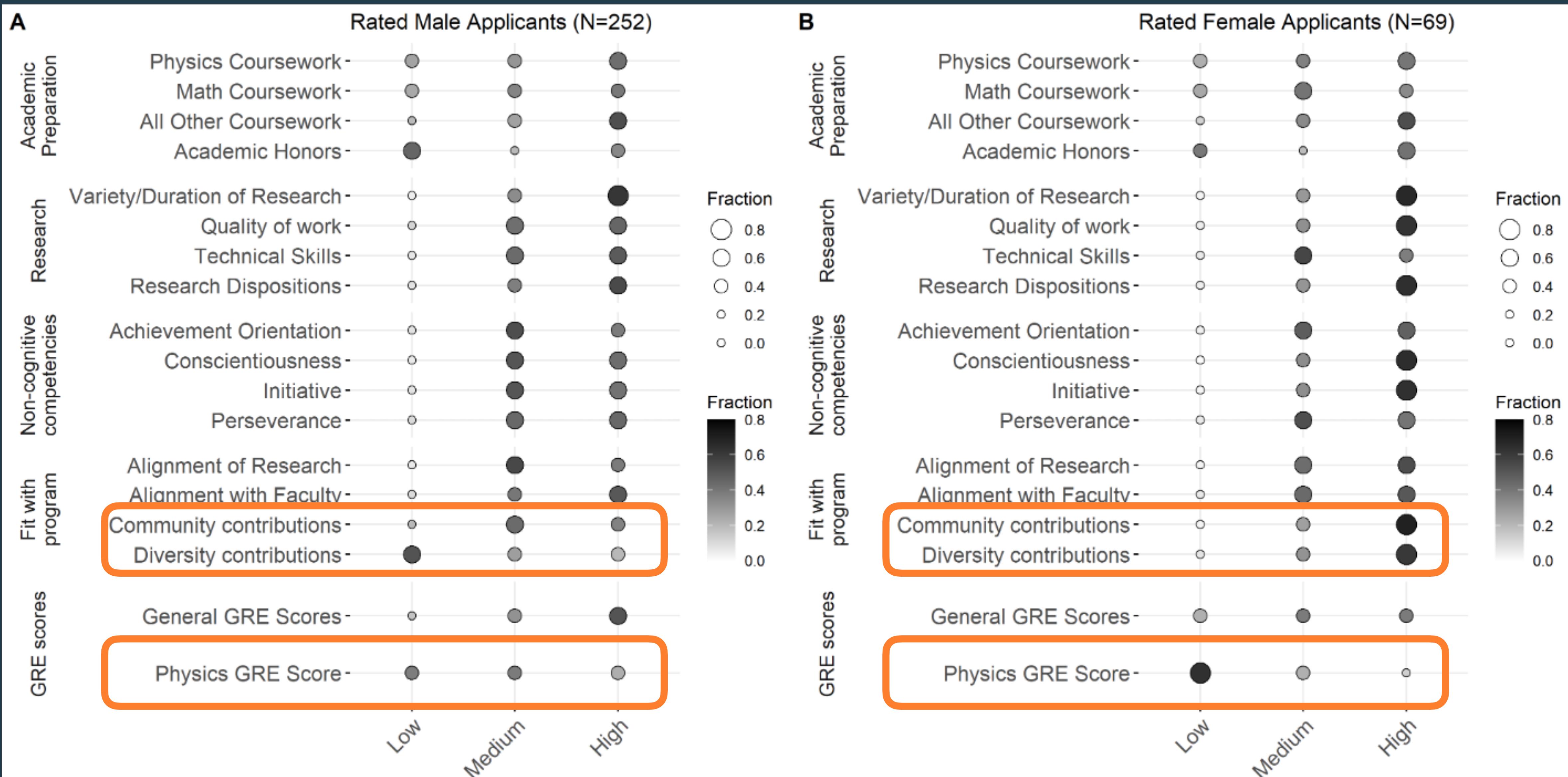


Some criteria have concentrated medium and high ratings

Admitted applicants score “high”; rejected applicants score “medium”



# Only differences in ratings between male & female identified applicants Physics GRE scores and service/diversity contributions.



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  - coursework; grades; honors

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- Academic Preparation (25%)
  - coursework; grades; honors
- Research (25%)
  - experience; quality of work; skills
- Non-cognitive Competencies (25%)
  - contentiousness; initiative; perseverance
- Fit with Program (15%)
  - research field; group needs; advocacy for diversity

# Admissions Rubric (2018 onward)

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Reminder

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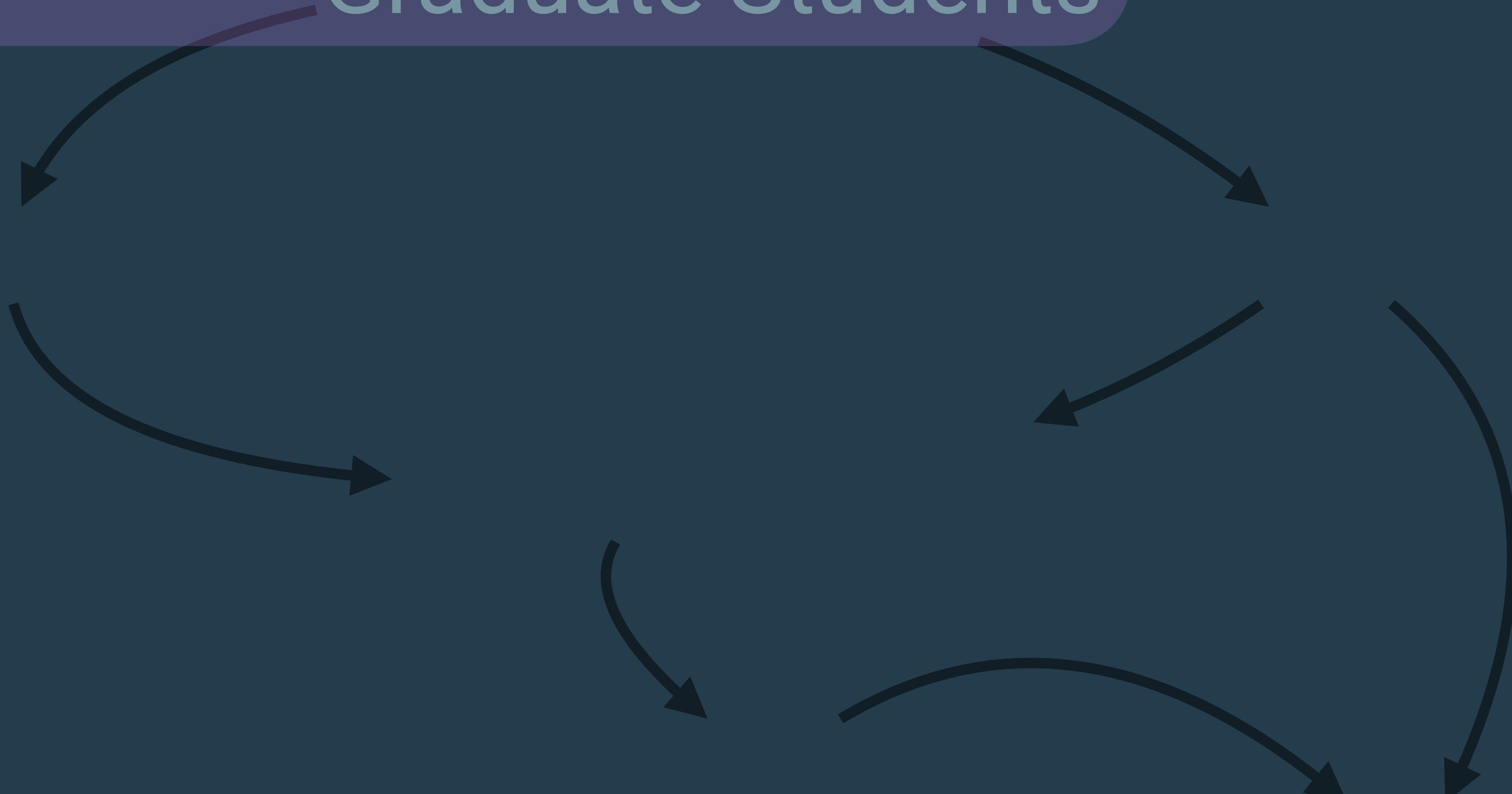
# Holistic Rubric-Based Admissions

Focus for  
Today

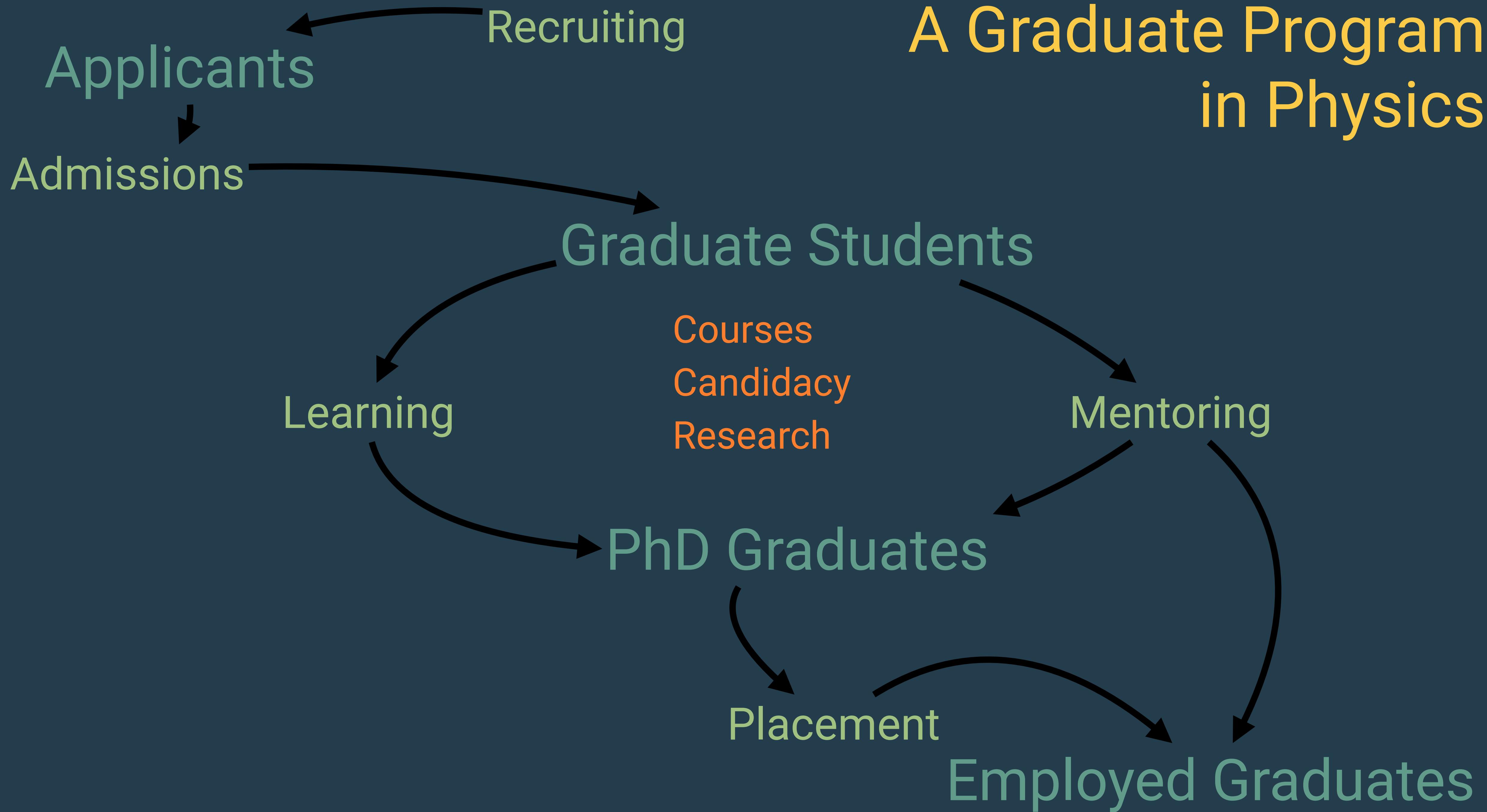
Applicants  
Admissions

Graduate Students

Recruiting



# A Graduate Program in Physics



# There's lots of work to do

- First year experience is being retooled; focus on transition to graduate school
- Pathways to PhD candidacy requires reflecting on goals and offering alternatives
- We must address systemic sexism[10] and racism throughout our program
- MSU joined the APS Inclusion, Diversity, and Equity Alliance (APS-IDEA)

[10] Aycock et al, PRPER 15, 010121 (2019)

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    - Can earn good grades in courses or subject exams (per course choice)
- Shifting graduate instructional culture
  - Subject exam committees design and grade exams collaboratively
  - Grad course help desk for all first year courses
  - Grad course instructors use evidenced-supported group work activities

# Take-Aways

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- The GRE does not help students standout [4,5]
  - And cutoffs (even soft ones) are problematic [6,7]
- Admissions rubrics codify what we value, and can help increase diversity [8,9]
- There's still lots of work to do (re: equity and inclusivity)

# Thank you!

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