

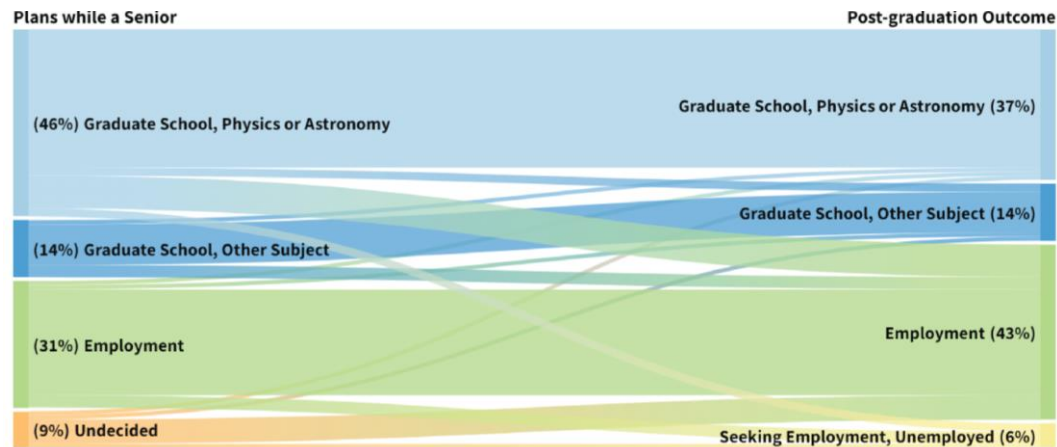
# Toward a More Equitable and Effective Physics Graduate Admissions Process

Nicholas T. Young (he/him/his)  
University of Michigan

*Research supported by the Michigan State University College of Natural Sciences, Lappan-Phillips Foundation, and the University of Michigan's Center for Academic Innovation.*

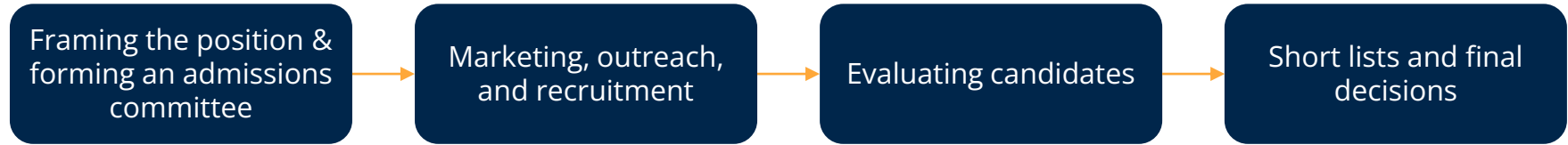
# Graduate school is a popular choice for physics majors

Post-Graduation Plans versus Actual Outcomes for Physics and Astronomy Seniors, Class of 2021

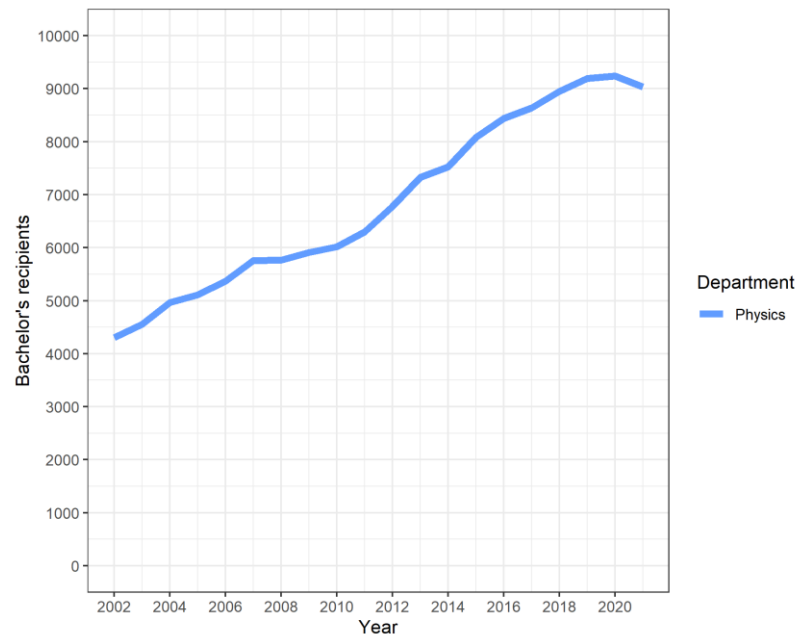
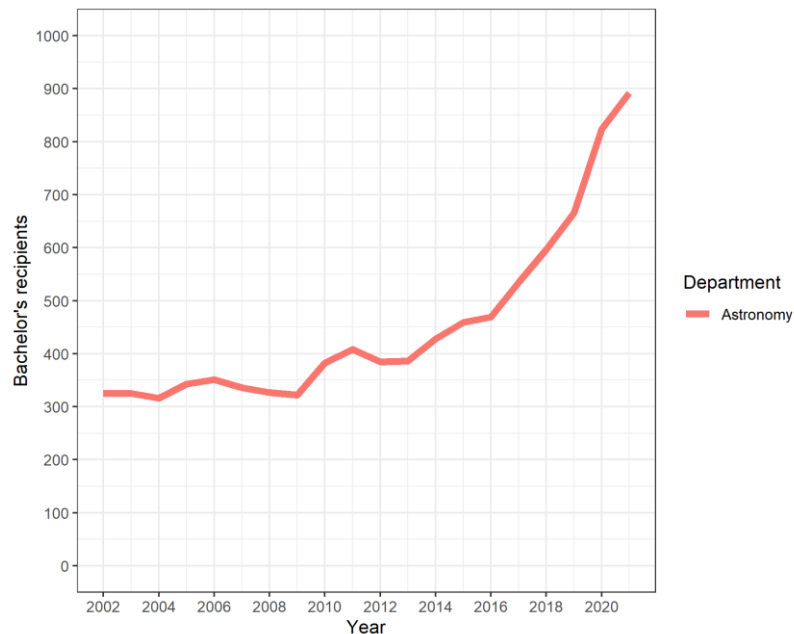


The figure includes only physics and astronomy seniors who graduated in the class of 2021.

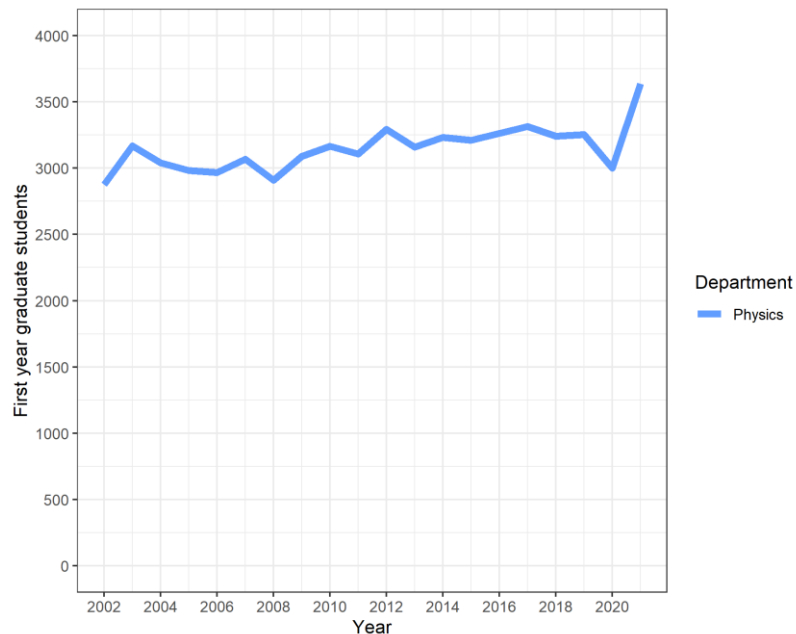
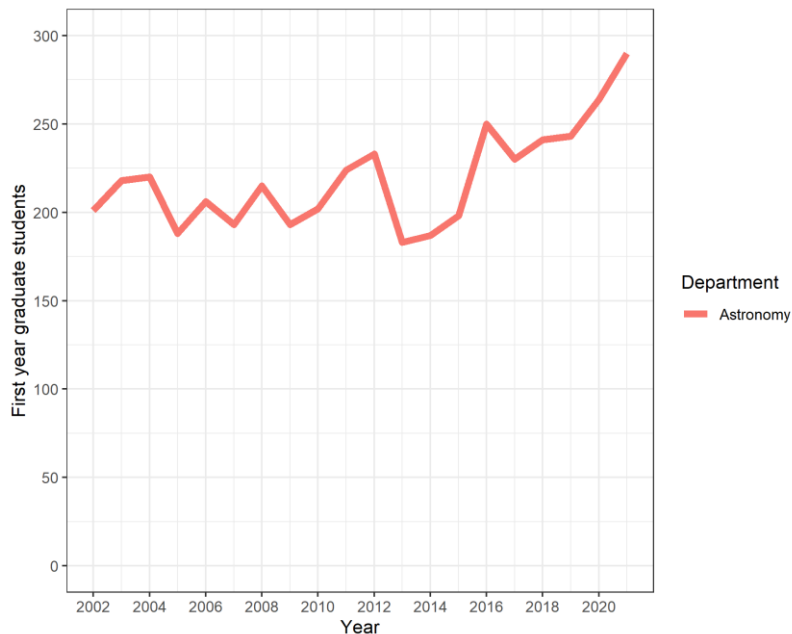
# The Graduate Admissions Process



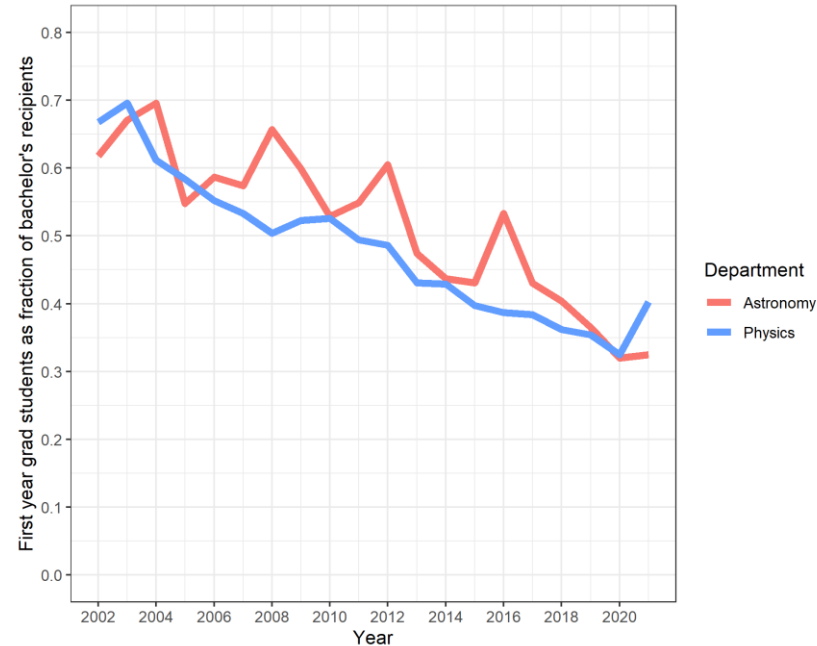
# Larger context: Number of Astronomy and Physics undergraduate degrees awarded are increasing.



# Larger context: Spots in graduate programs have seen slower growth.



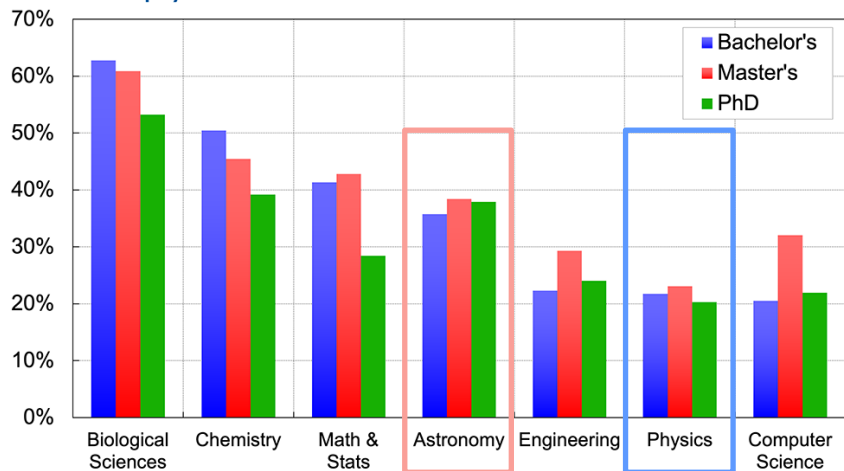
# Larger context: The number of available spots per bachelor's graduate is decreasing.



# Larger context: Physics lags behind other STEM fields in terms of representation



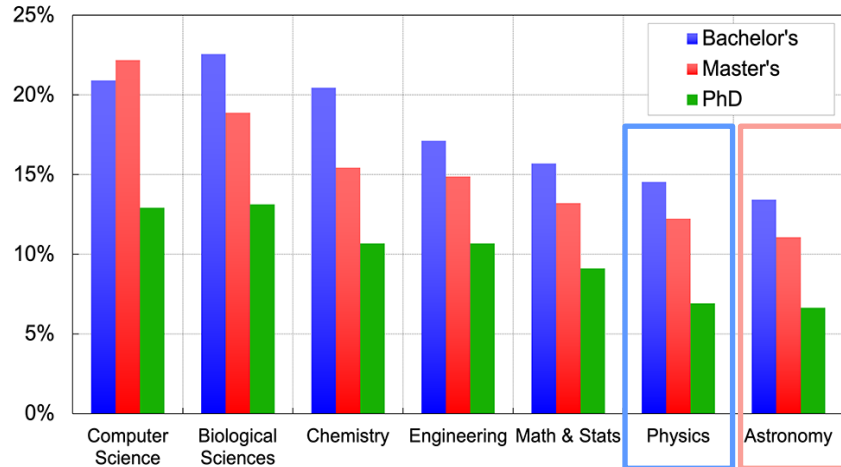
Degrees to Women, by Field  
(5-year average 2016-2020)



Source: IPEDS and APS



Degrees to Individuals Marginalized  
by Race/Ethnicity (5-year average 2016-2020)



Source: IPEDS and APS



**What's inequitable with the way  
we've always done it?**



# The typical admissions package

GRE scores

GPA

Personal statement

Research statement

Letters of  
recommendation

# The typical admissions package

GRE scores

GPA

Personal statement

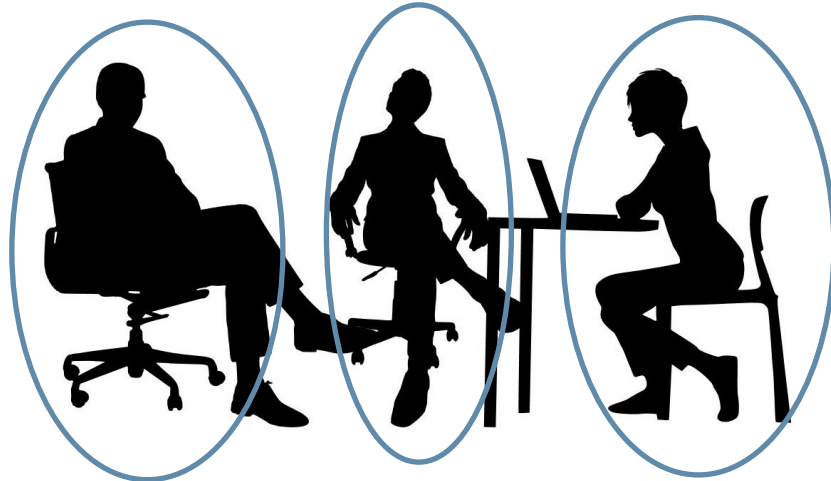
Research statement

Letters of  
recommendation



# The typical admissions package

GRE scores  
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Chari and Potvin, 2019  
Potvin et al. 2017

# The typical admissions package

GRE scores  
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Chari and Potvin, 2019  
Potvin et al. 2017

Posselt, 2016

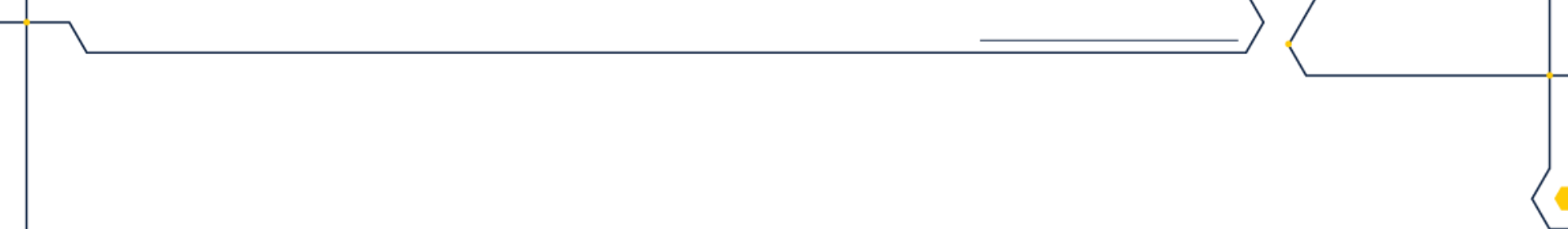
# The typical admissions package

GRE scores  
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Personal statement  
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Letters of  
recommendation



Chari and Potvin, 2019  
Potvin et al. 2017

Posselt, 2016



**Research Goal: Determine which application components are most predictive of an applicant being admitted to a physics graduate program.**

# Data

GRE scores

GPA

Undergrad school

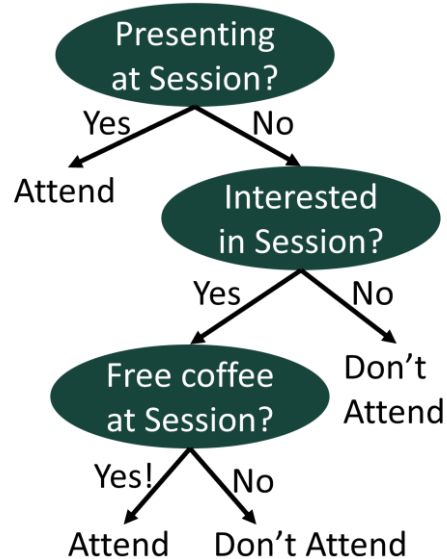
N=512 domestic  
applications



Michigan State University  
2014-2017

# Machine Learning

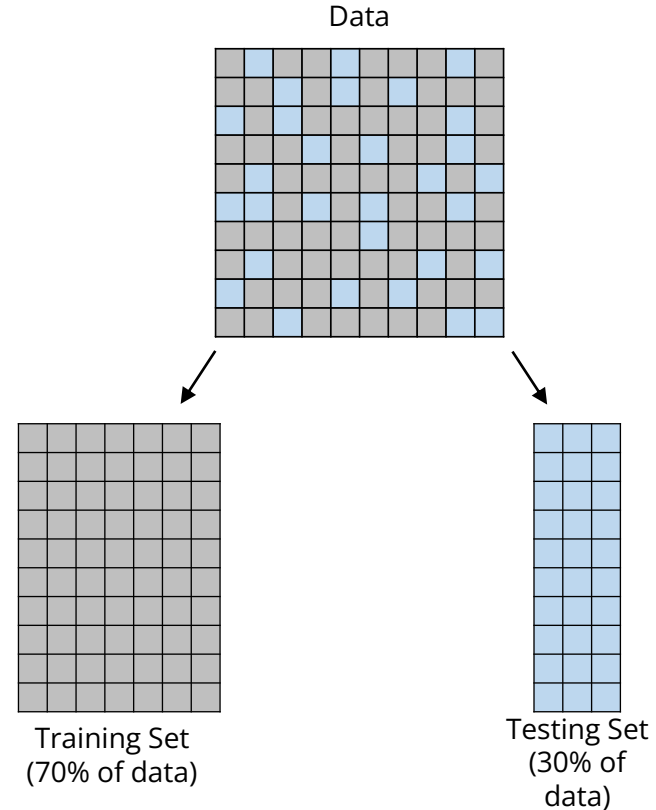
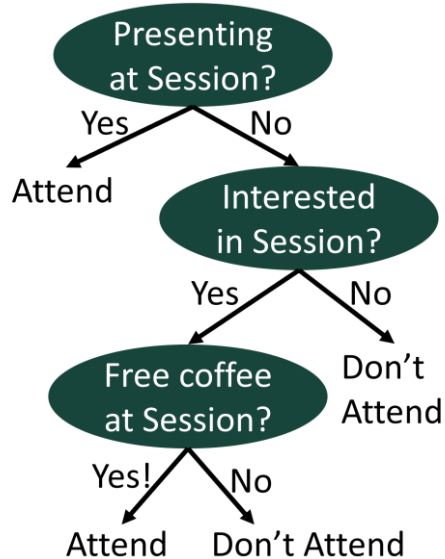
Hypothetical Example: Do you attend an 8am conference session?





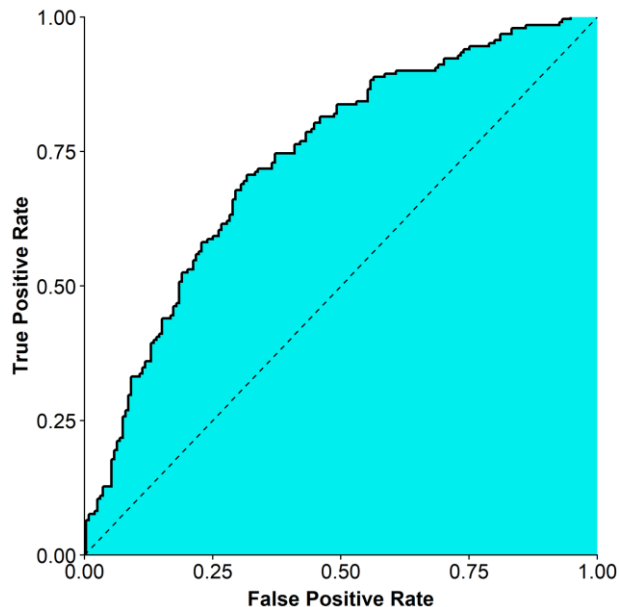
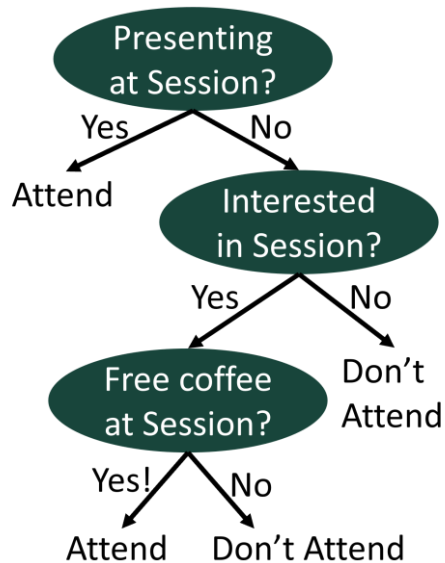
# Machine Learning

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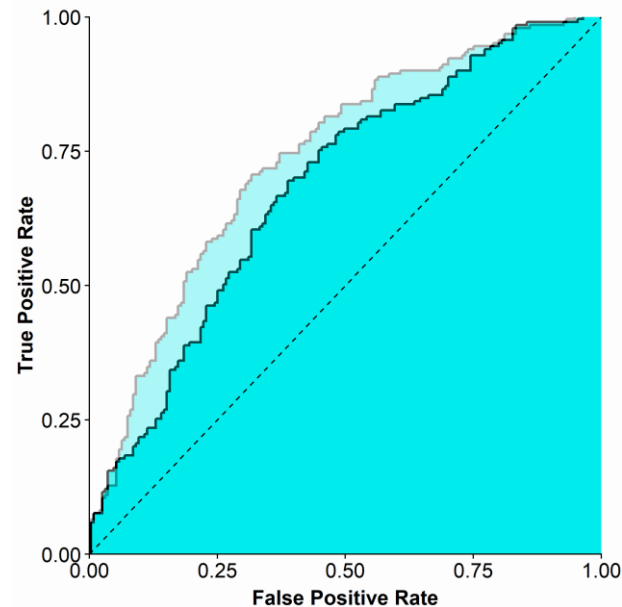
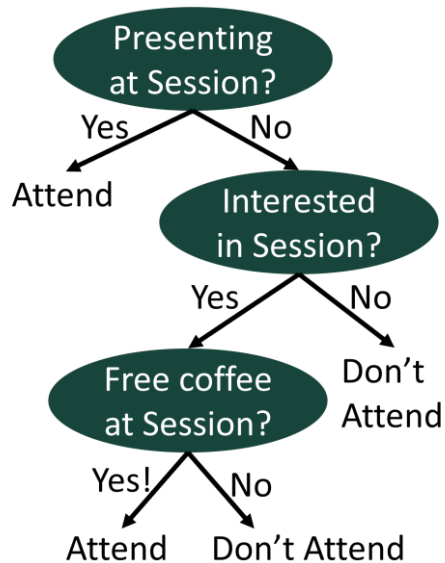
# Machine Learning

Hypothetical Example: Do you attend an 8am conference session?



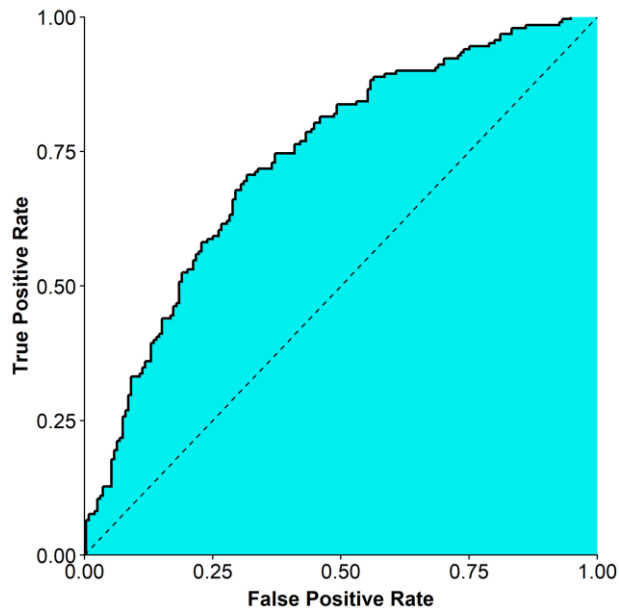
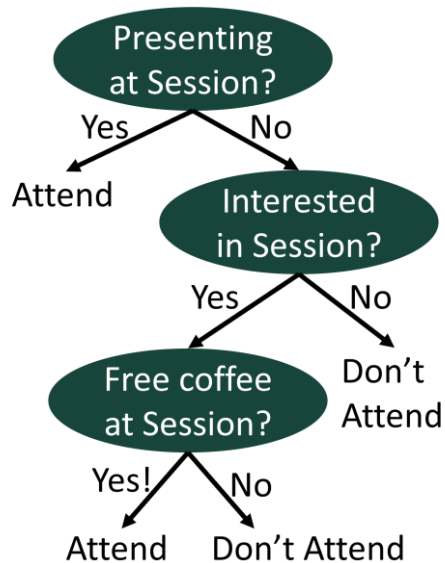
# Machine Learning

Hypothetical Example: Do you attend an 8am conference session?



# Machine Learning

Hypothetical Example: Do you attend an 8am conference session?



# Test scores & GPA are most predictive of admission

## All Variables

Average Testing Accuracy:

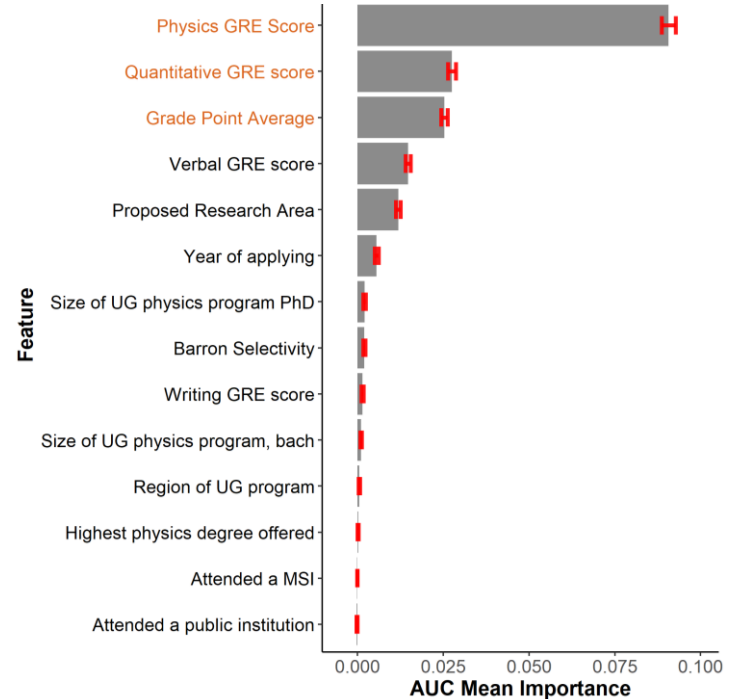
$75.6\% \pm 0.6\%$

Null accuracy: 52.7%

Average Testing

Area Under the Curve (AUC):

$0.756 \pm 0.006$



# Why the Physics GRE is inequitable



Cost



Score discrepancies



Limited predictive ability

## About the GRE® Subject Tests

### General Test

### Subject Tests

#### > About the Tests

[Test Content and Structure ▼](#)[ScoreSelect Option](#)[Test Fairness and Validity](#)[Fees ▼](#)[Bulletin and Forms](#)[Tools for Success ▼](#)[Registration, Test Centers and Dates](#)[Prepare for a Test](#)[On Test Day](#)[Scores](#)[Frequently Asked Questions](#)

### 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.

Each Subject Test is intended for students who have an undergraduate major or extensive background in one of these six disciplines:



The GRE® Biology Test and the GRE® Literature in English Test will be discontinued after the April 2021 administration. Scores on both tests will continue to be reportable for five years per [GRE® score reporting policy](#).

- [Biology](#)
- [Chemistry](#)
- [Literature in English](#)
- [Mathematics](#)
- [Physics](#)
- [Psychology](#)

**Note:** The GRE Biochemistry, Cell and Molecular Biology Test was discontinued in December 2016. Scores will continue to be reportable per [GRE score reporting policy](#).

### Who Takes Them?

Prospective graduate school applicants take the Subject Tests. Applicants come from varying educational and cultural backgrounds and the GRE Subject Tests provide a common measure for comparing candidates' qualifications.

GRE Subject Test scores are used by admissions or fellowship panels to supplement your undergraduate records, recommendation letters and other qualifications for graduate-level study. Some Subject Tests yield subscores that can indicate the strengths



Ready to take a GRE® Subject Test?

[Register Now](#)

### Send Only Your Best Scores

Approach test day with more confidence, knowing you can send the scores that show your personal best — only with the ScoreSelect® option.

### Official Test Prep from ETS

Nobody knows our tests better than we do. We offer free practice tests and tips to help you prepare for your GRE Subject Test. Check them out today.

HOME **GRE** PRAXIS TOEIC TOEFL ALL PRODUCTS ENGLISH CONTACT Login / Register

**ETS GRE** RESOURCES REGISTRATION TEST DAY SCORES Q

ETS Home > GRE > Test Takers > Learn About GRE > **Learn About GRE**

## The GRE<sup>®</sup> Subject Tests

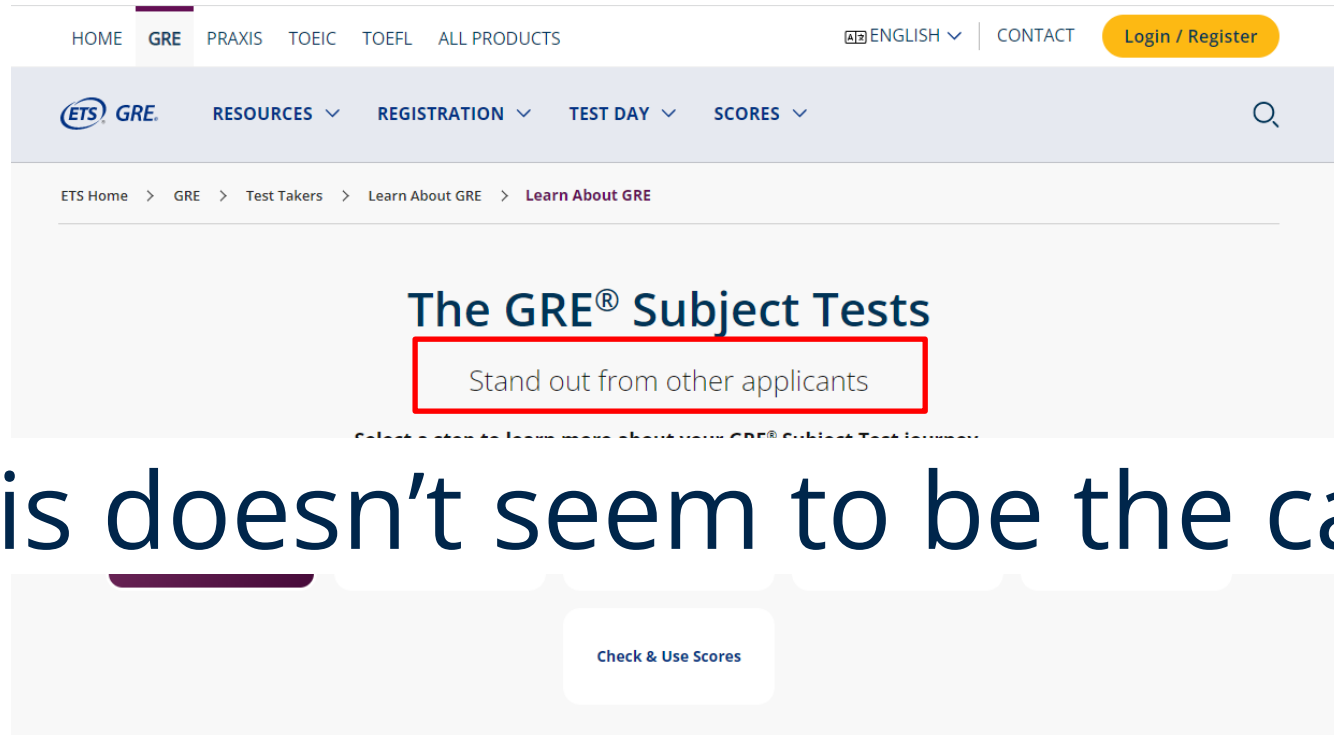
Stand out from other applicants

Select a step to learn more about your GRE<sup>®</sup> Subject Test journey.

**Learn About GRE** Testing Information Where to Test Schedule Your Test Prepare for a Test

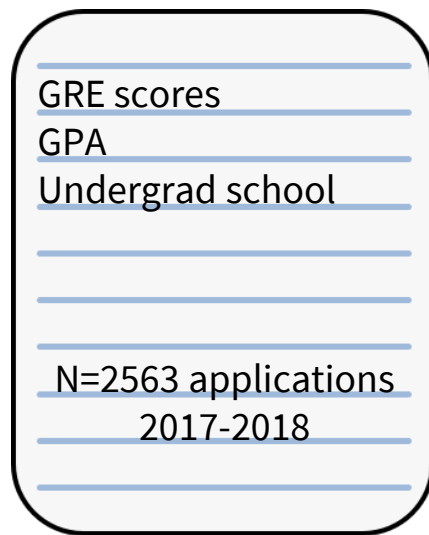
Check & Use Scores





This doesn't seem to be the case

# Data

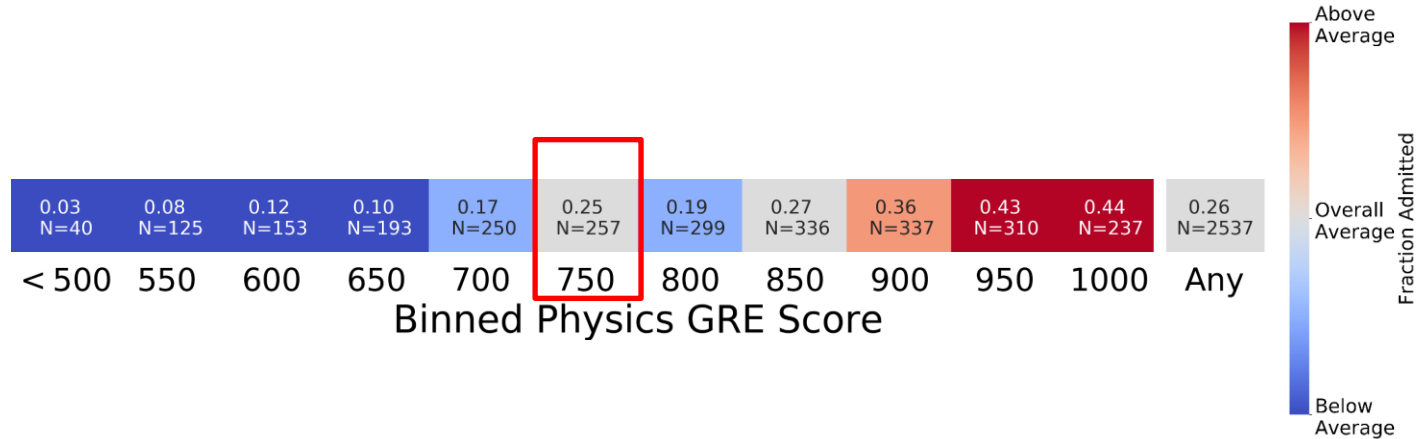


4 Big Ten Universities

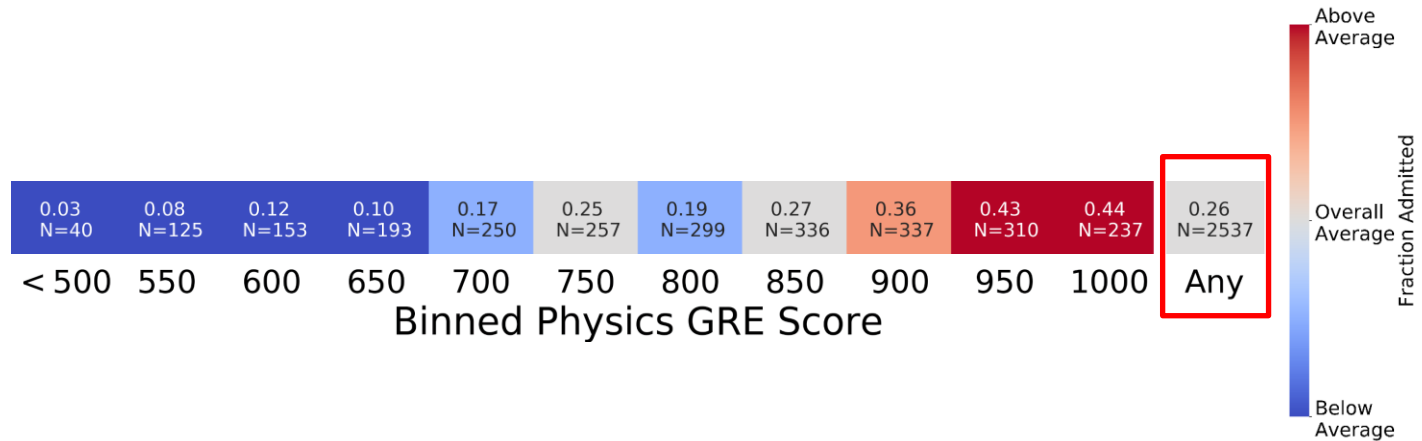


1 private Midwest University

# Having a higher pGRE score helps...



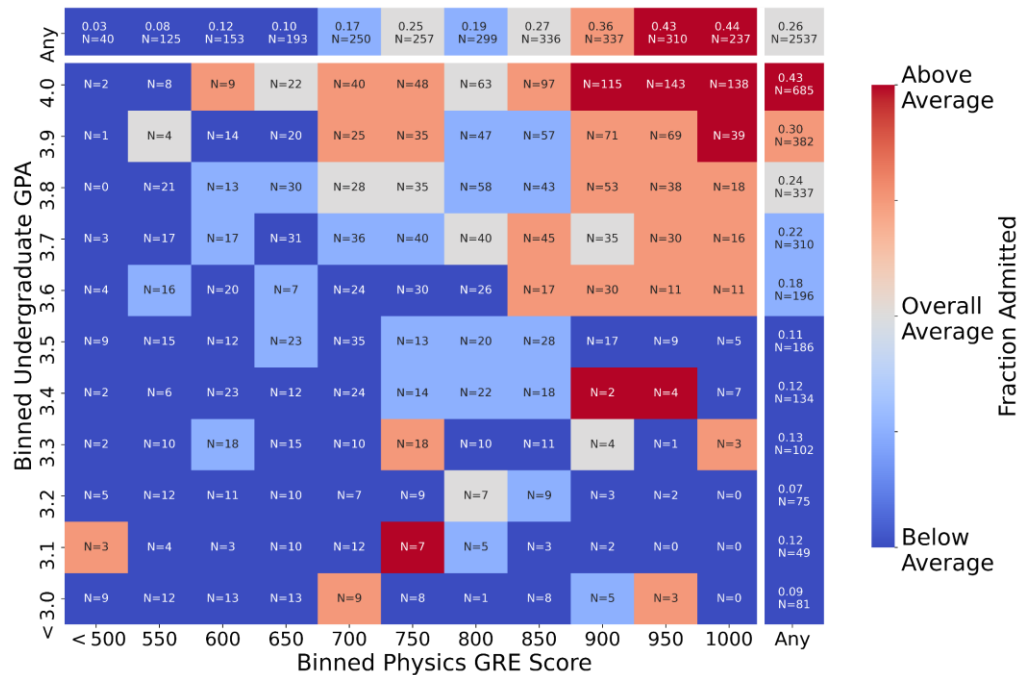
# Having a higher pGRE score helps...



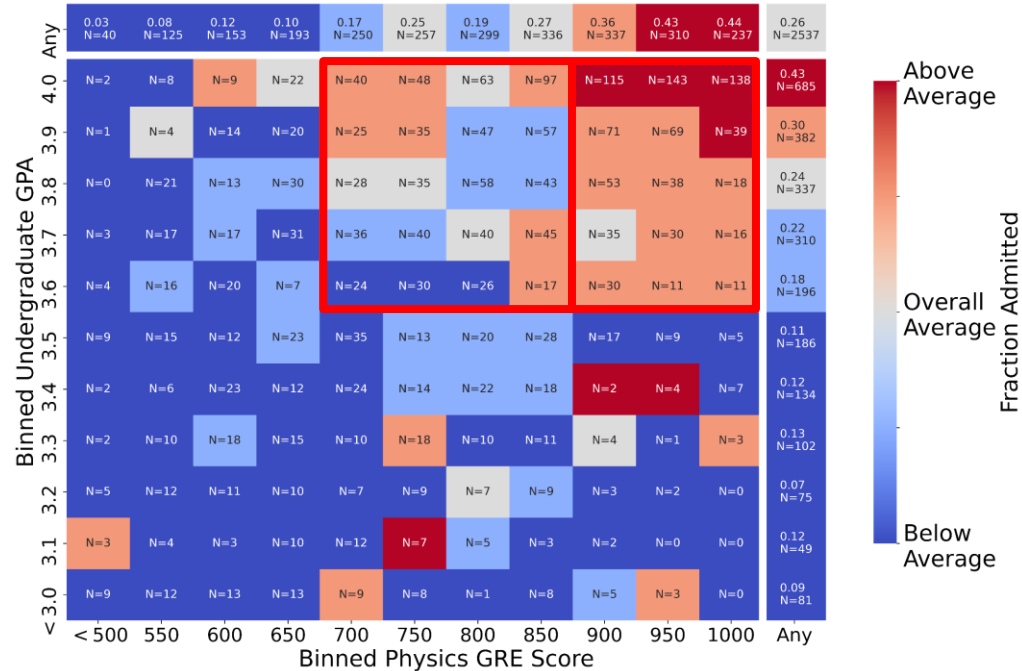


**Q: Who needs to stand out?**  
**A: Applicants with a low GPA.**

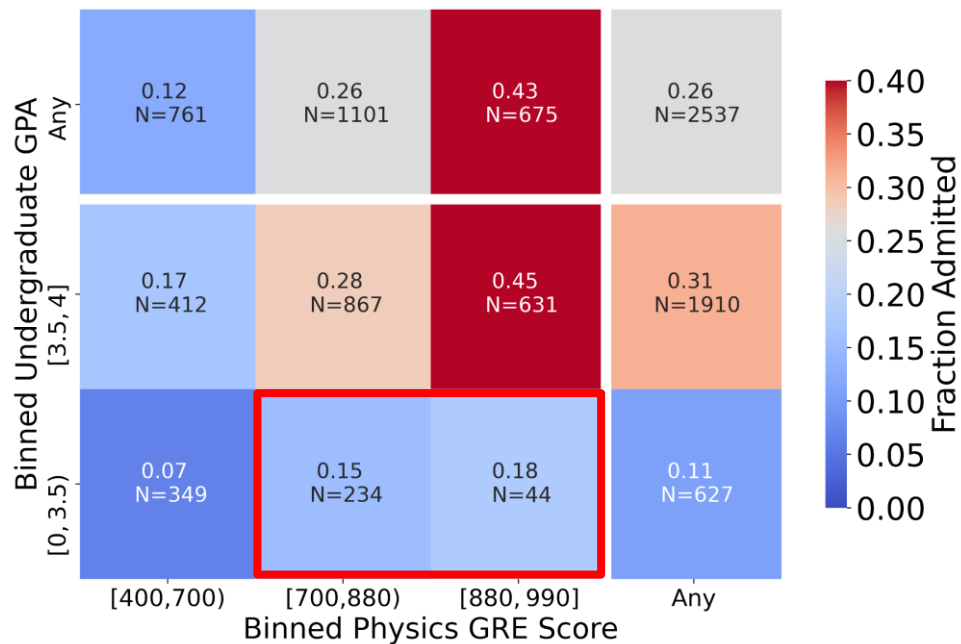
# but doesn't help an applicant with a low GPA "stand out."



# but doesn't help an applicant with a low GPA "stand out."

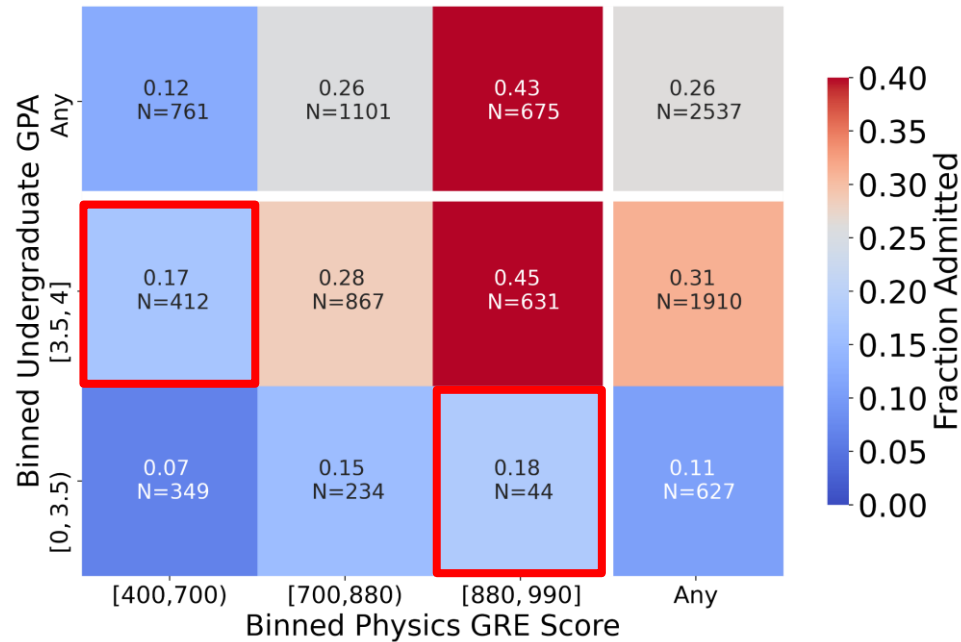


# Having a high physics GRE score isn't much better than having an average score.





# Having a high GPA is just as good as a high physics GRE score.





# Who else might need to stand out?

Limited evidence of the physics GRE helping those applicants stand out either



# Takeaway

In theory, the physics GRE could help applicants stand out.

# Takeaway

In theory, the physics GRE could help applicants stand out.

In practice, it does not.

# What would it look like to rethink graduate admissions and make it more equitable?

# Rubric-based holistic review

Kent and McCarthy 2016

Posselt 2016

Miller & Posselt 2020

# Rubric-based holistic review



[Flickr](#), CC-BY-2.0

|                            |                                     |
|----------------------------|-------------------------------------|
| Academic Preparation (25%) | Physics Coursework                  |
|                            | Math Coursework                     |
|                            | Other Coursework                    |
|                            | Academic honors and/or recognitions |

|                                  |                         |
|----------------------------------|-------------------------|
| Non-Cognitive Competencies (25%) | Achievement Orientation |
|                                  | Conscientiousness       |
|                                  | Initiative              |
|                                  | Persistence             |

|                |                  |
|----------------|------------------|
| Research (25%) | variety/duration |
|                | quality of work  |
|                | technical skills |
|                | dispositions     |

|                        |           |
|------------------------|-----------|
| Fit with program (15%) | research  |
|                        | faculty   |
|                        | community |
|                        | diversity |

|                  |             |
|------------------|-------------|
| GRE Scores (10%) | General GRE |
|                  | Physics GRE |



|                            |                                     |
|----------------------------|-------------------------------------|
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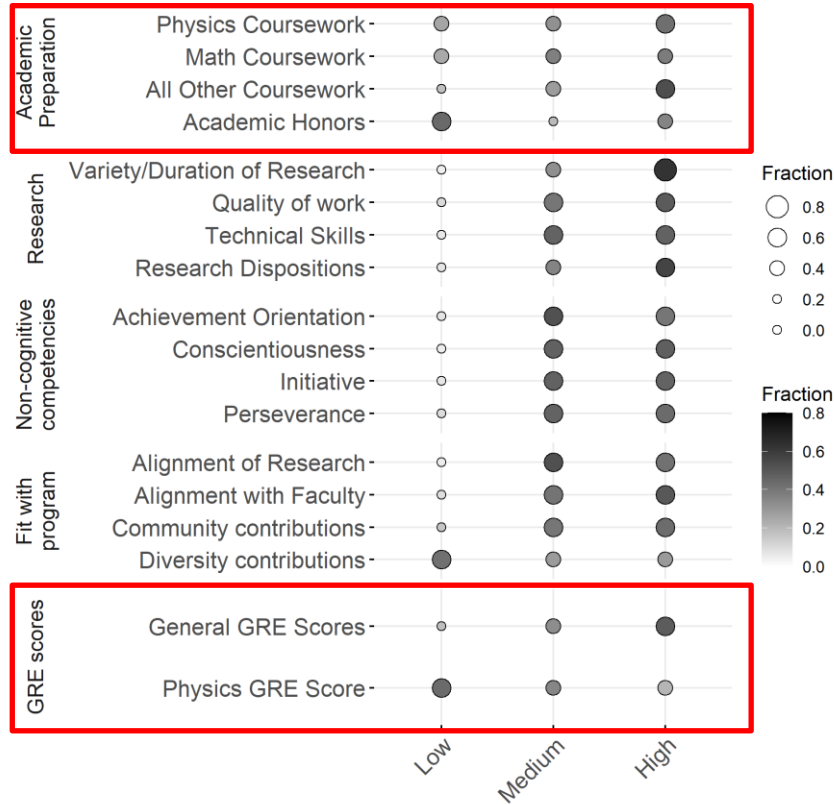
|                                  |                             |
|----------------------------------|-----------------------------|
| Non-Cognitive Competencies (20%) | Personality and Orientation |
|                                  | Conscientiousness           |
|                                  | Initiative                  |
|                                  | Persistence                 |

|                        |           |
|------------------------|-----------|
| Fit with program (15%) | research  |
|                        | faculty   |
|                        | community |
|                        | diversity |

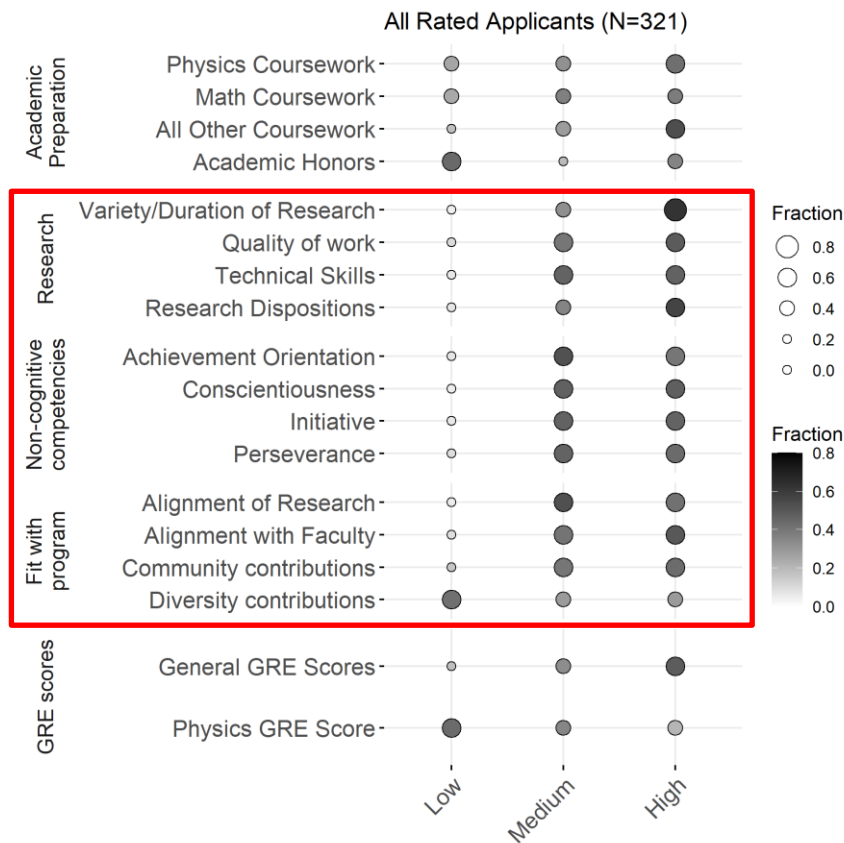
|                  |             |
|------------------|-------------|
| GRE Scores (10%) | General GRE |
|                  | Physics GRE |

3 years  
321 Rated Domestic Applicants

All Rated Applicants (N=321)



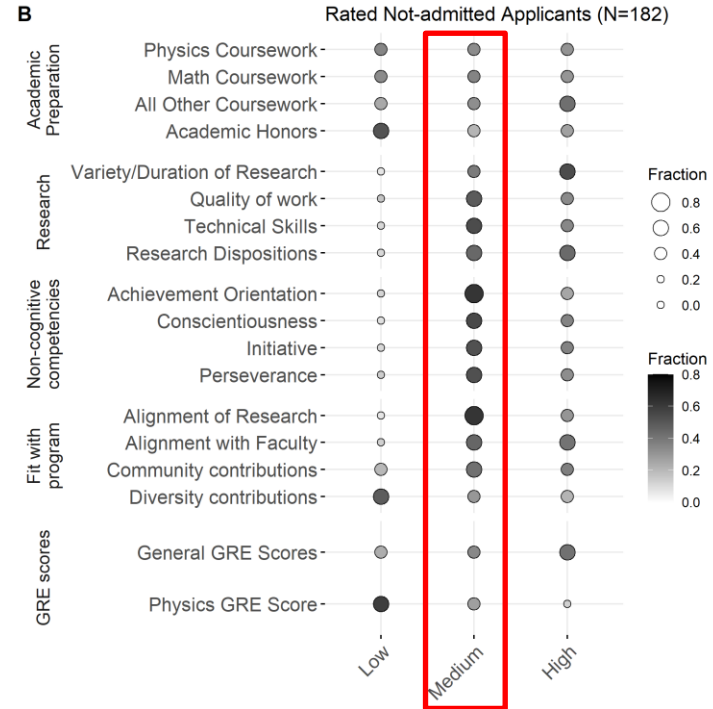
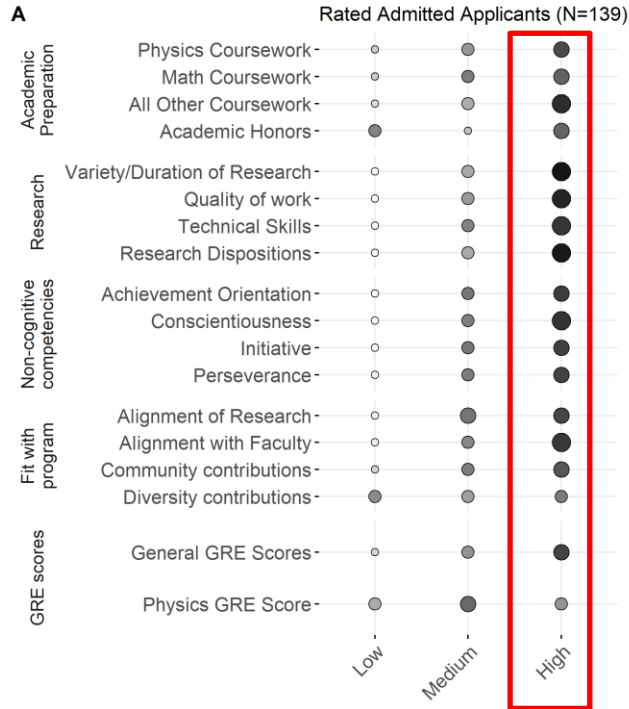
Applicants spread between the rubric levels



Applicants concentrated in the “medium” and “high” categories

Admitted applicants tend to score “high”...

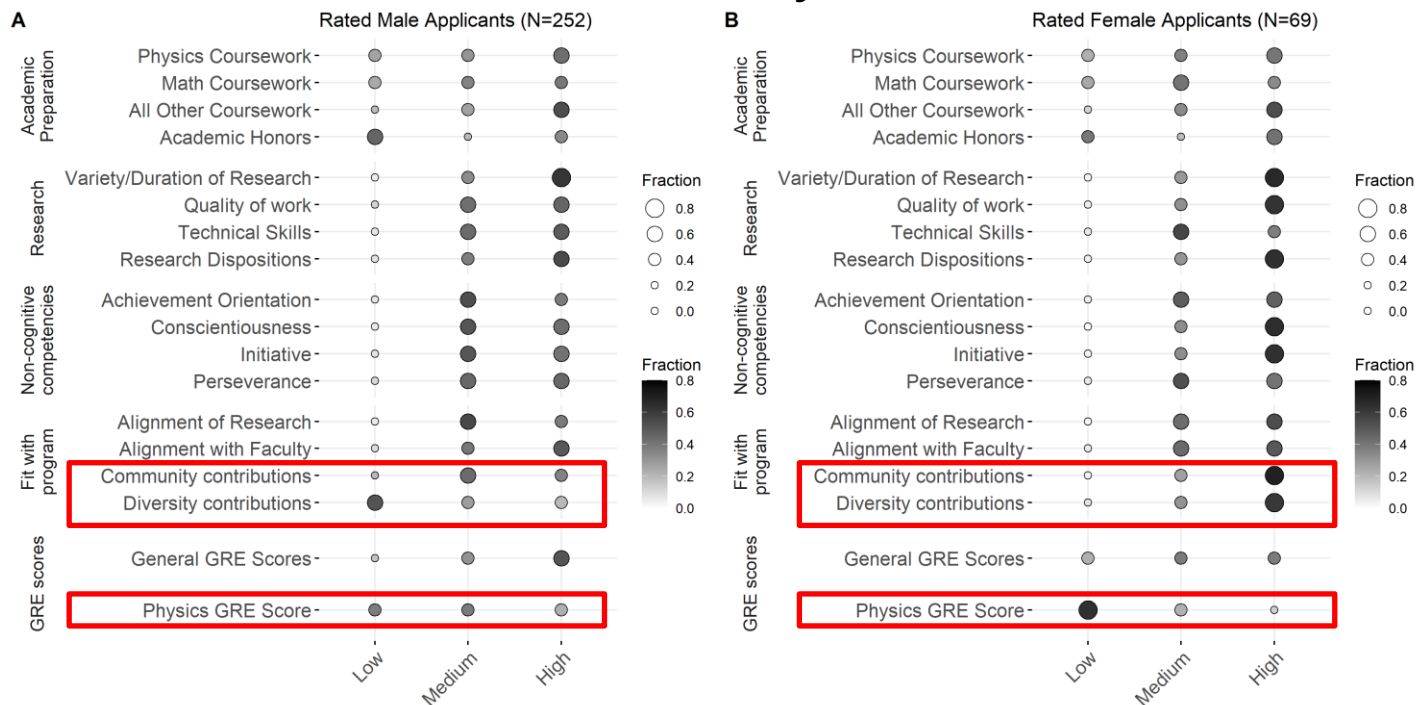
Rejected applicants tend to score “medium”

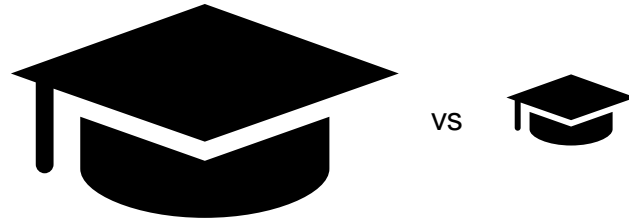




**What about equity???**

The only differences in ratings between males & females were on physics GRE scores and service/diversity work.





**Test scores are the only consistent difference**

# Takeaway

**Rubric-based holistic review seems promising for achieving equity in graduate admissions.**





**But is really a different process?**

# The data



Applicant data before rubric  
(2014-2017)



Applicant data after rubric  
(2018-2020)



Rubric data after rubric  
(2018-2020)

# The data



Applicant data before rubric  
(2014-2017)



Applicant data after rubric  
(2018-2020)



Rubric data after rubric  
(2018-2020)

### Pre-rubric

Average Testing

Accuracy:

$75.6\% \pm 0.6\%$

Null accuracy: 52.7%

Average Testing

Area Under the

Curve (AUC):

$0.756 \pm 0.006$

# The post-rubric model doesn't fit the data well.

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## Post-rubric

Average Testing

Accuracy:

$71.4\% \pm 0.6\%$

Null accuracy: 66.0%

Average Testing

Area Under the

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$0.626 \pm 0.006$

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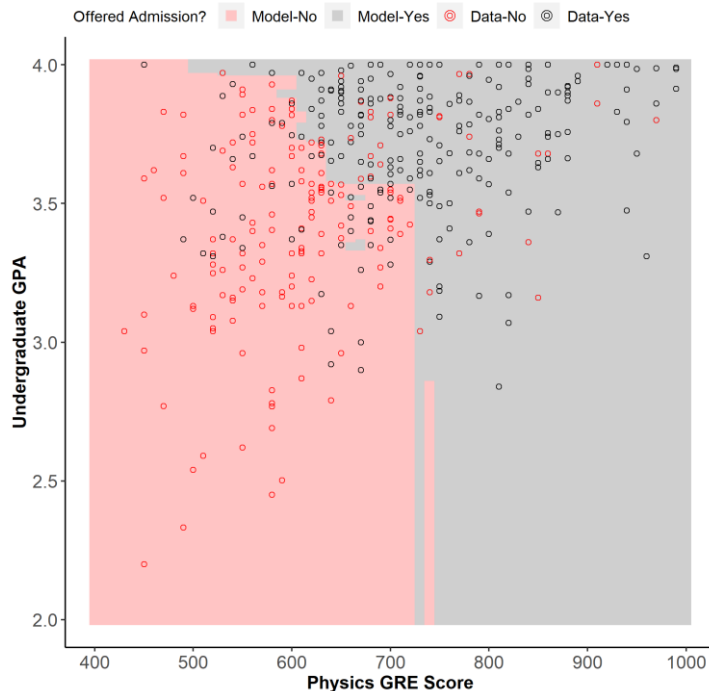
Area Under the

Curve (AUC):

$0.626 \pm 0.006$

## Suggests the process changed

# Some applicants seem to go against the trend

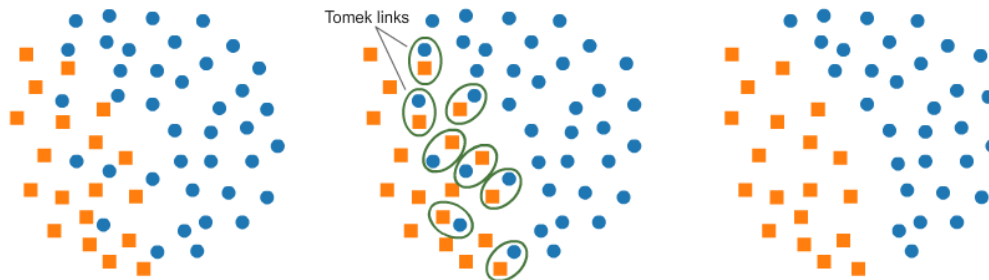


# Tomek Links

For two instances, P1 and P2, if

1. The closest instance to P1 is P2
2. The closest instance to P2 is P1
3. P1 and P2 are of different outcome groups

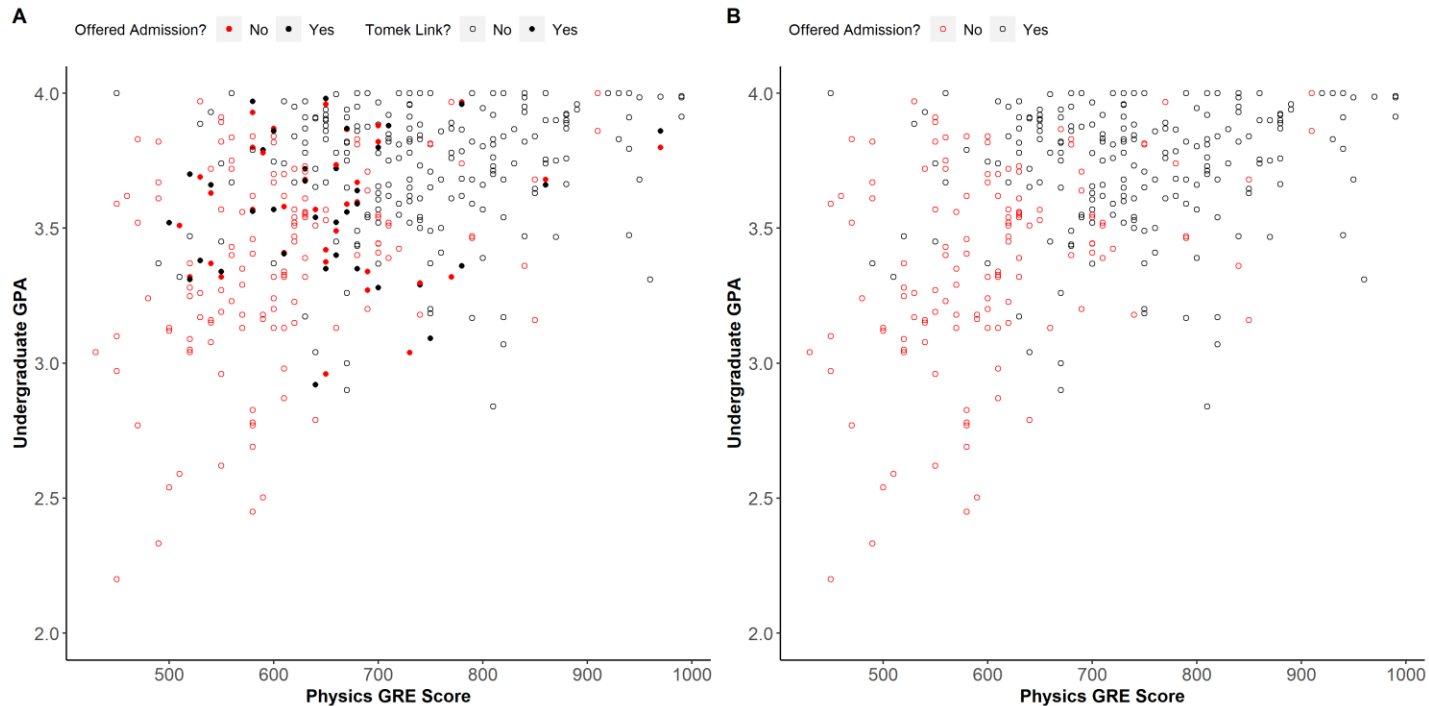
Then P1 and P2 are Tomek Links



source: <https://mlwhiz.com/blog/2020/01/28/imbal/>



# Tomek Links in Practice



## Slight improvement, but models of the data after the implementation of the rubric still aren't great

|                  | Applications<br>before rubric | Applications<br>after rubric | Rubric scores     |
|------------------|-------------------------------|------------------------------|-------------------|
| Cases Dropped    | 11%-14%                       | 15%-18%                      | 12%-17%           |
| Testing AUC      | 0.809 $\pm$ 0.009             | 0.670 $\pm$ 0.015            | 0.704 $\pm$ 0.014 |
| Testing Accuracy | 0.806 $\pm$ 0.009             | 0.775 $\pm$ 0.012            | 0.717 $\pm$ 0.012 |
| Null Accuracy    | 0.539 $\pm$ 0.006             | 0.699 $\pm$ 0.009            | 0.575 $\pm$ 0.010 |



**The evidence suggests that rubric-based holistic admissions is a change from the traditional admissions process...**



**The evidence suggests that rubric-based holistic admissions is a change from the traditional admissions process...**

**but there's still some work to do to be confident in that conclusion.**

# Takeaways

- The traditional graduate admissions process in physics is test score and GPA heavy.

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# Takeaways

- The traditional graduate admissions process in physics is test score and GPA heavy.
- In practice, the physics GRE does not help applicants stand out.
- Rubric-based holistic review seems promising for achieving equity in graduate admissions.

# Recommendations

- Discontinue the use of the physics GRE



# Recommendations

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- Rethink the admissions process in terms of what applicants are evaluated on, how they are evaluated, and who is doing the evaluating

View the Michigan State Rubric:

Rubric-based holistic review: A promising route to equitable graduate admissions in physics (Young et al 2022)

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Questions?

[ntyoung@umich.edu](mailto:ntyoung@umich.edu)

Slides:

[bit.ly/young\\_ou\\_2023](https://bit.ly/young_ou_2023)

# Recommended reading

- Barthelemy, Ramón, MacKenzie Lenz, Alexis Knaub, Jordan Gerton, and Pearl Sandick. "Graduate Program Reform in One Department of Physics and Astronomy: From Tragedy to More Progressive Policies and an Evolving Culture." *Physical Review Physics Education Research* 19, no. 1 (January 9, 2023): 010102. <https://doi.org/10.1103/PhysRevPhysEducRes.19.010102>.
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- Miller, Casey, and Julie Posselt. "Equitable Admissions in the Time of COVID-19." *Physics* 13 (December 17, 2020). [https://physics.aps.org/articles/v13/199?utm\\_campaign=weekly&utm\\_medium=email&utm\\_source=emailalert](https://physics.aps.org/articles/v13/199?utm_campaign=weekly&utm_medium=email&utm_source=emailalert).
- Owens, Lindsay M., Benjamin M. Zwickl, Scott V. Franklin, and Casey W. Miller. "Misaligned Visions for Improving Graduate Diversity: Student Characteristics vs. Systemic/Cultural Factors," 2018. <https://www.compadre.org/per/items/detail.cfm?ID=14834>.
- Owens, Lindsay, Benjamin M. Zwickl, Scott V. Franklin, and Casey W. Miller. "Identifying Qualities of Physics Graduate Students Valued by Faculty." In *Physics Education Research Conference Proceedings*, 2019. <https://doi.org/10.1119/perc.2019.pr.Owens>.
- Owens, Lindsay M., Benjamin M. Zwickl, Scott V. Franklin, and Casey W. Miller. "Physics GRE Requirements Create Uneven Playing Field for Graduate Applicants." In *2020 Physics Education Research Conference Proceedings*, 382–87, 2020. <https://doi.org/10.1119/perc.2020.pr.Owens>.
- Posselt, Julie R. *Inside Graduate Admissions*. Harvard University Press, 2016.

# Recommended reading

- Posselt, Julie, Theresa Hernandez, Geraldine Cochran, and Casey Miller. "Metrics First, Diversity Later? Making the Shortlist and Getting Admitted to Physics PhD Programs." *Journal of Women and Minorities in Science and Engineering* 25, no. 4 (2019). <https://doi.org/10.1615/JWomenMinorScienEng.2019027863>.
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- Scherr, Rachel E., Monica Plisch, Kara E. Gray, Geoff Potvin, and Theodore Hodapp. "Fixed and Growth Mindsets in Physics Graduate Admissions." *Physical Review Physics Education Research* 13, no. 2 (November 29, 2017): 020133. <https://doi.org/10.1103/PhysRevPhysEducRes.13.020133>.
- Rudolph, Alexander, Gibor Basri, Marcel Agüeros, Ed Bertschinger, Kim Coble, Meghan Donahue, Jackie Monkiewicz, et al. "Final Report of the 2018 AAS Task Force on Diversity and Inclusion in Astronomy Graduate Education." *Bulletin of the AAS* 51, no. 1 (01-17 2020). <https://baas.aas.org/pub/2019i0101>.
- Woo, Sang Eun, James M. LeBreton, Melissa G. Keith, and Louis Tay. "Bias, Fairness, and Validity in Graduate-School Admissions: A Psychometric Perspective." *Perspectives on Psychological Science*, June 10, 2022, 174569162110553. <https://doi.org/10.1177/17456916211055374>.
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- Young, Nicholas T., K. Tollefson, Remco G. T. Zegers, and Marcos D. Caballero. "Rubric-Based Holistic Review: A Promising Route to Equitable Graduate Admissions in Physics." *Physical Review Physics Education Research* 18, no. 2 (November 30, 2022): 020140. <https://doi.org/10.1103/PhysRevPhysEducRes.18.020140>.