Get the slides: https://bit.ly/young_ou_2023

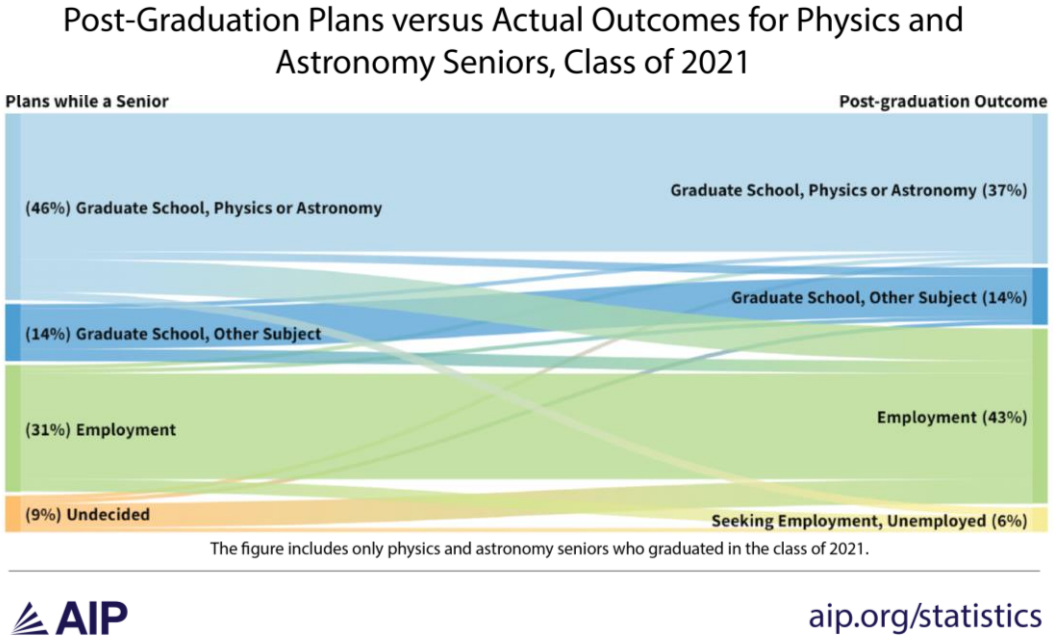
Toward a More Equitable and Effective Physics Graduate Admissions Process

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

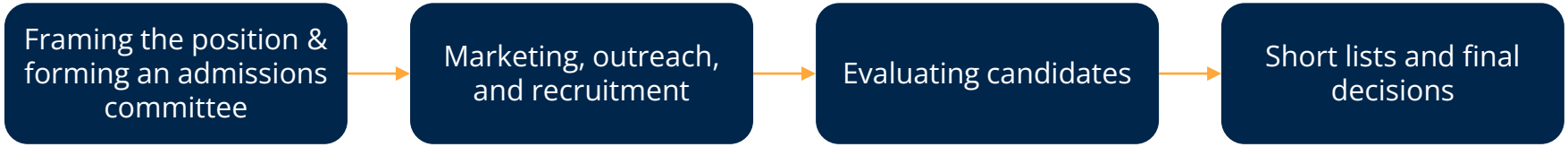
Research supported by the Michigan State University College of Natural Sciences, Lappan-Phillips Foundation, and the University of Michigan's Center for Academic Innovation.

ACADEMIC INNOVATION
UNIVERSITY OF MICHIGAN

Graduate school is a popular choice for physics majors

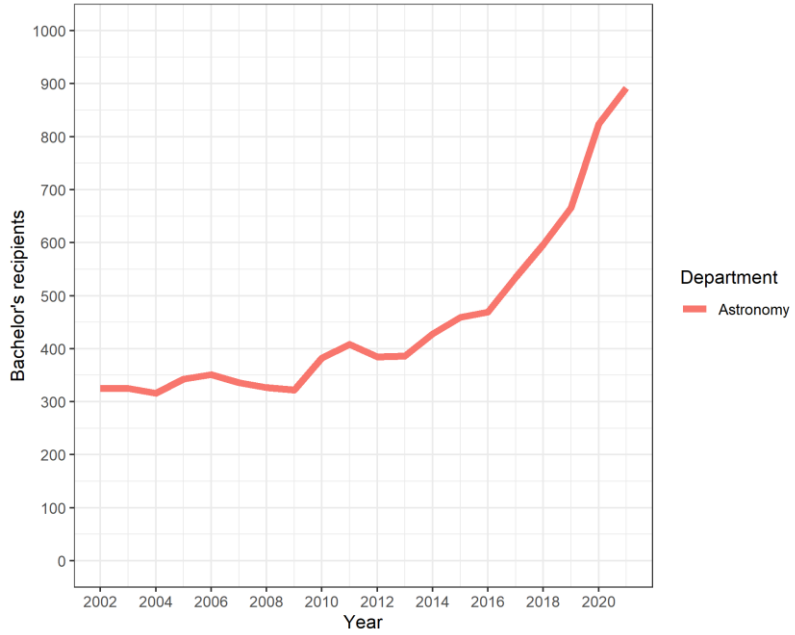


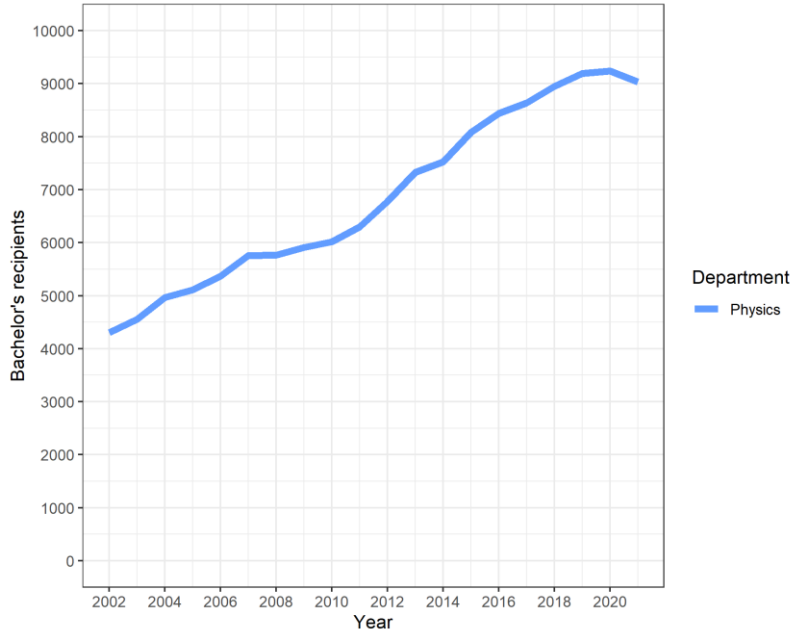
The Graduate Admissions Process



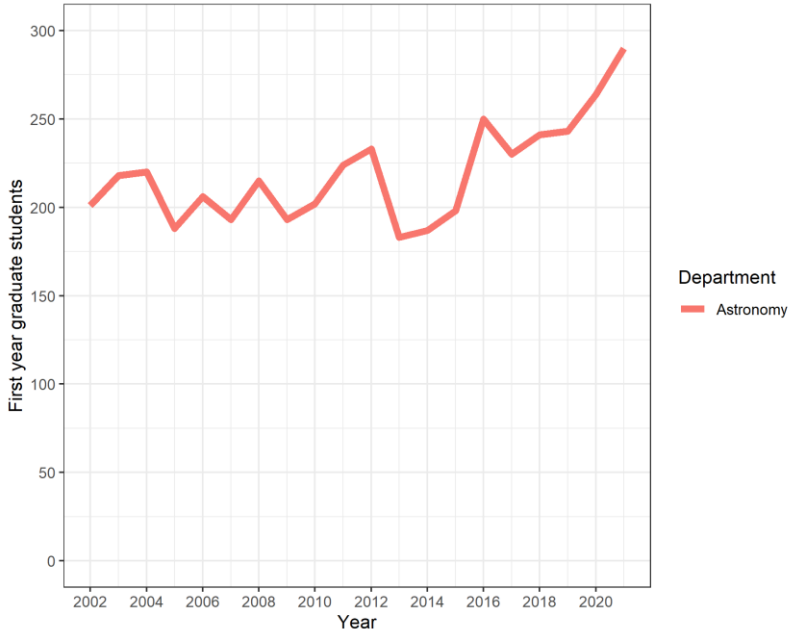
Adapted from O'Meara et al. 2020

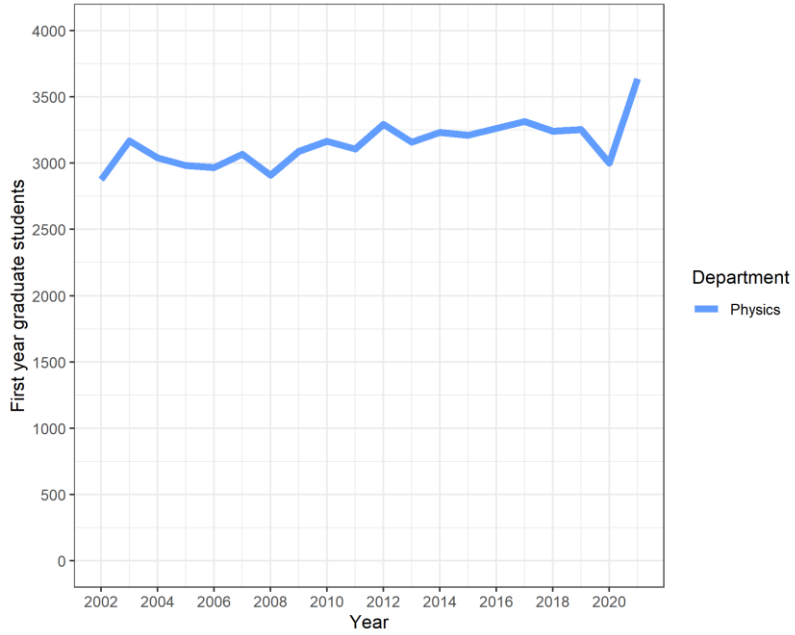
Larger context: Number of Astronomy and Physics undergraduate degrees awarded are increasing.



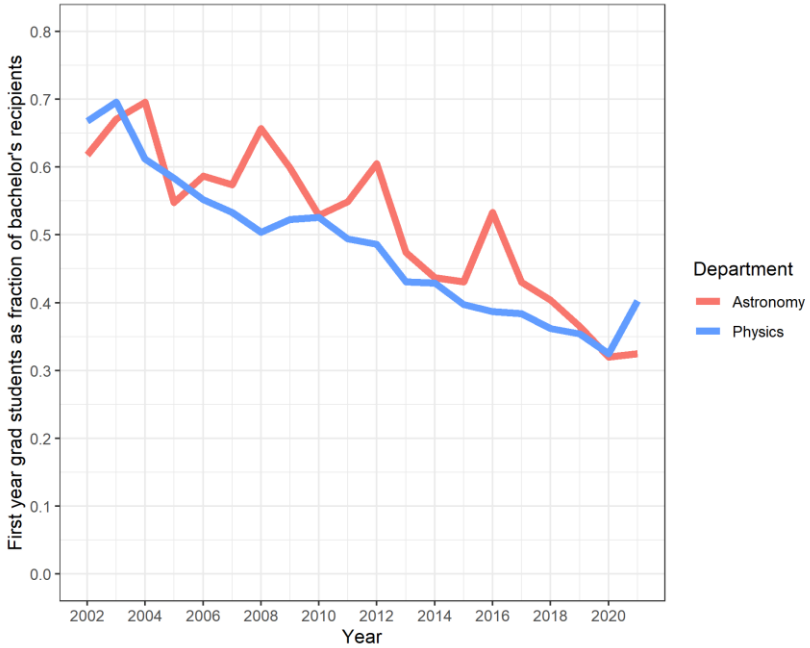


Larger context: Spots in graduate programs have seen slower growth.

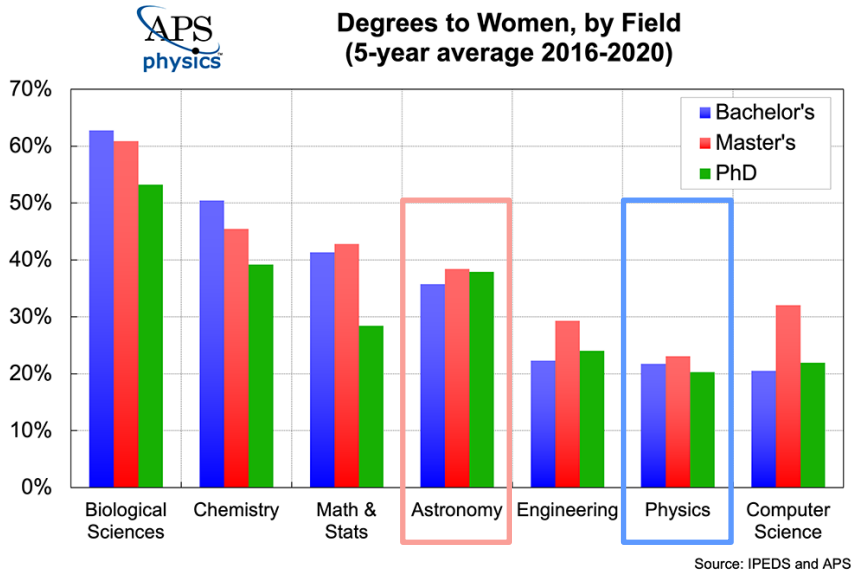


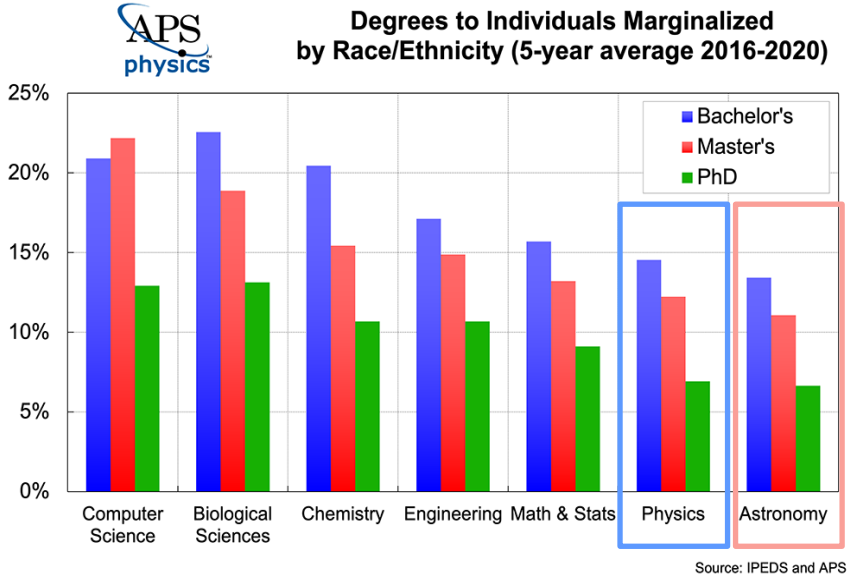


Larger context: The number of available spots per bachelor's graduate is decreasing.



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





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

The typical admissions package

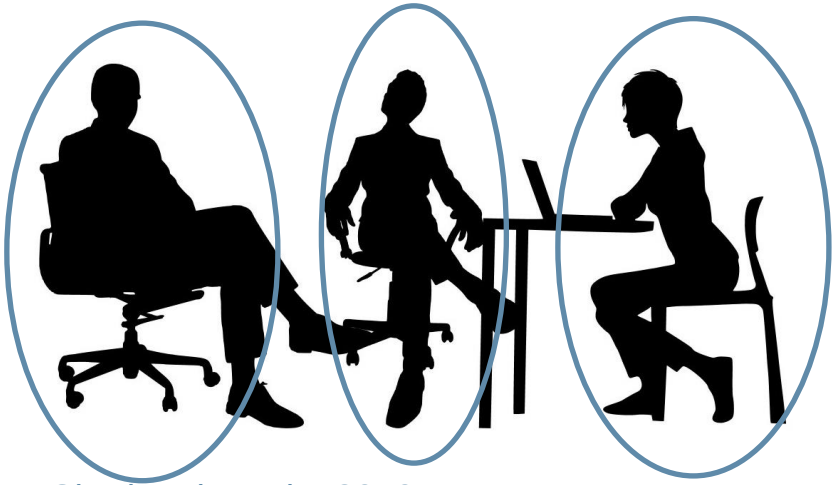
GRE scores
GPA
Personal statement
Research statement
Letters of recommendation

The typical admissions package

GRE scores
GPA
Personal statement
Research statement
Letters of recommendation

The typical admissions package

GRE scores
GPA
Personal statement
Research statement
Letters of recommendation



Chari and Potvin, 2019
Potvin et al. 2017

The typical admissions package

GRE scores
GPA
Personal statement
Research statement
Letters of recommendation

Chari and Potvin, 2019
Potvin et al. 2017

Posselt, 2016

The typical admissions package

GRE scores
GPA
Personal statement
Research statement
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

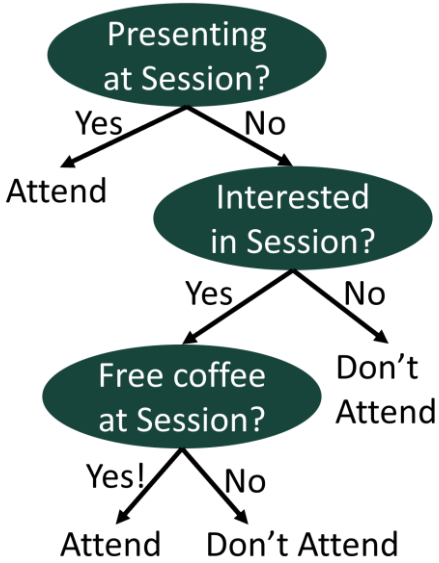
GRE scores
GPA
Undergrad school

N=512 domestic applications

Michigan State University
2014-2017

Machine Learning

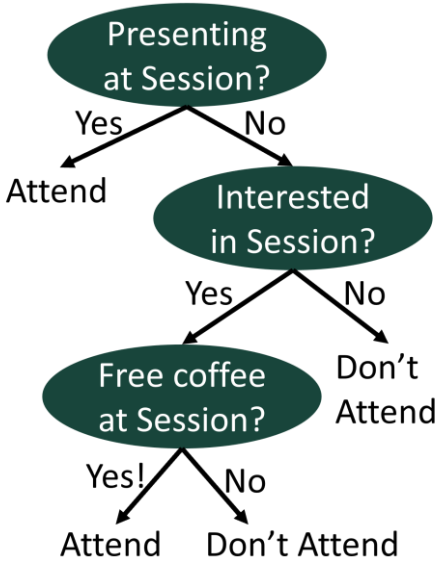
Hypothetical Example: Do you attend an 8am conference session?

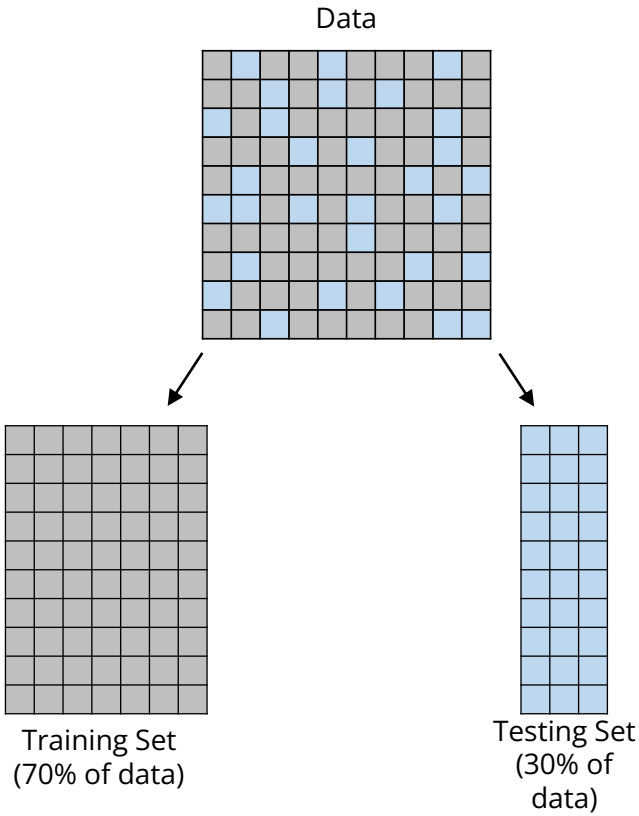


Breiman 2001 Strobl et al. 2007 Janitza et al. 2013

Machine Learning

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

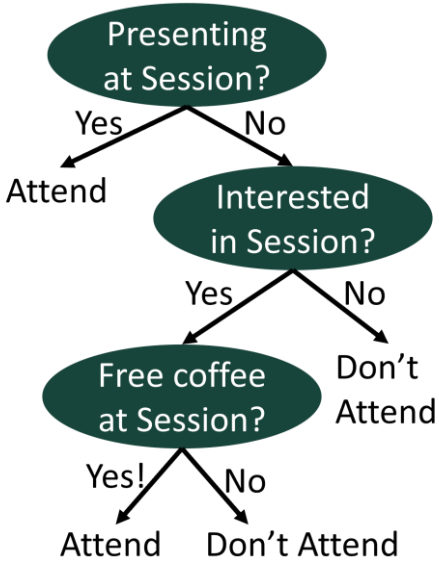


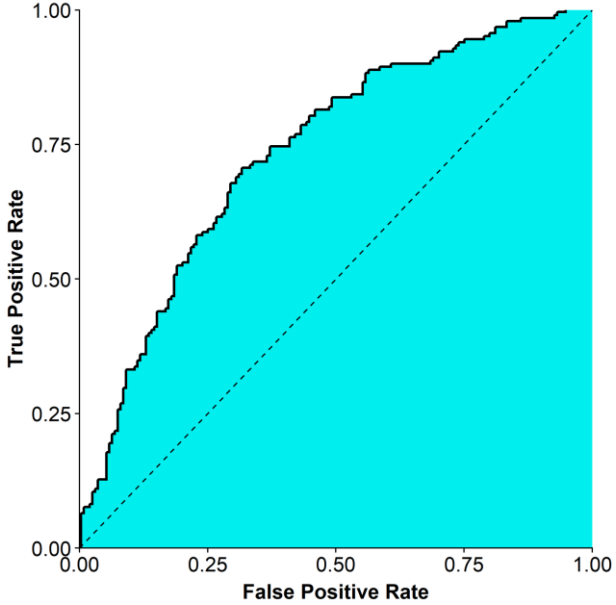


Breiman 2001 Strobl et al. 2007 Janitza et al. 2013

Machine Learning

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

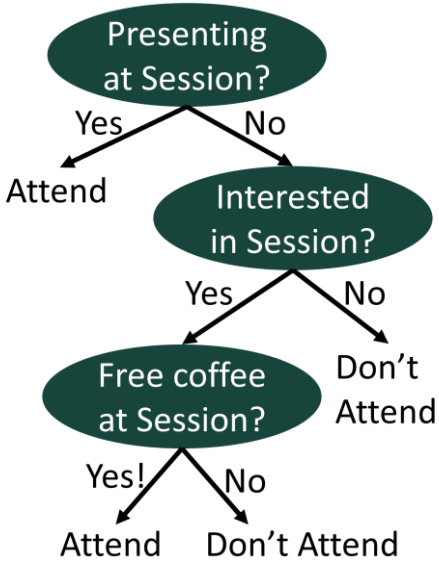


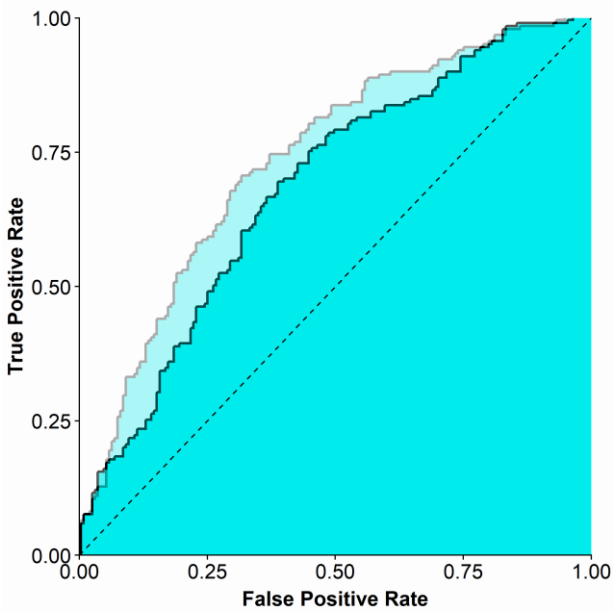


Breiman 2001 Strobl et al. 2007 Janitza et al. 2013

Machine Learning

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

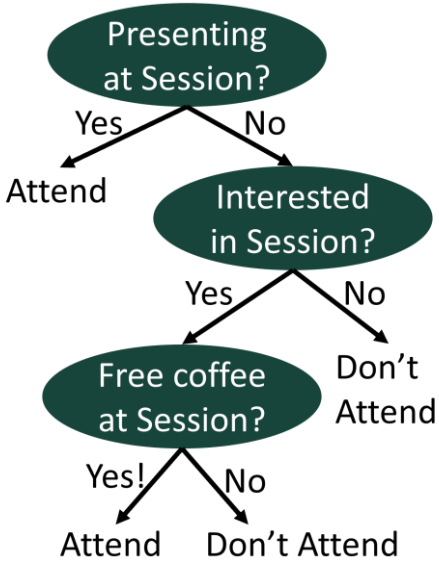


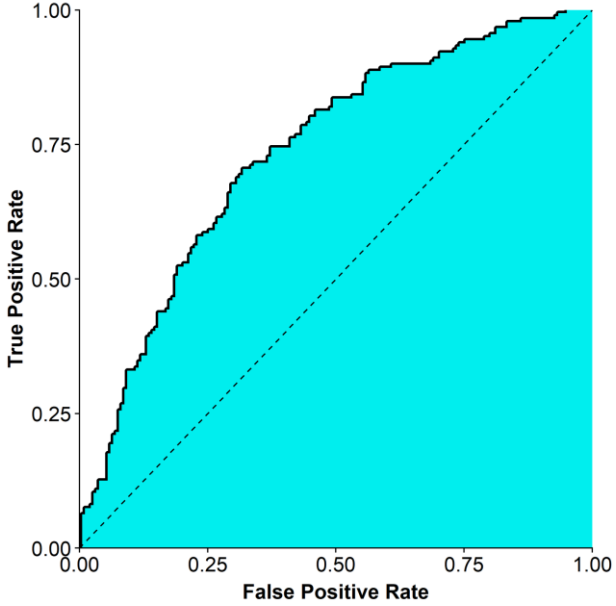


Breiman 2001 Strobl et al. 2007 Janitza et al. 2013

Machine Learning

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



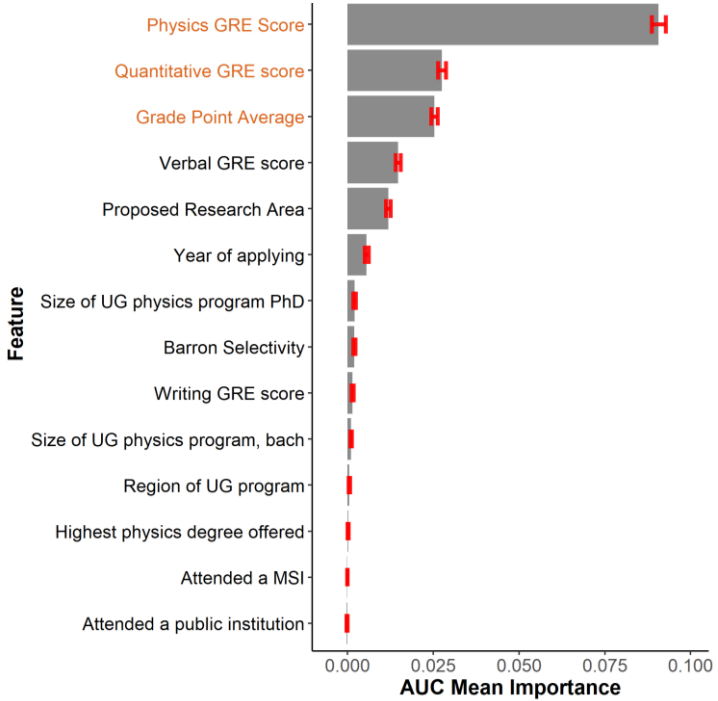


Breiman 2001 Strobl et al. 2007 Janitza et al. 2013

Test scores & GPA are most predictive of admission

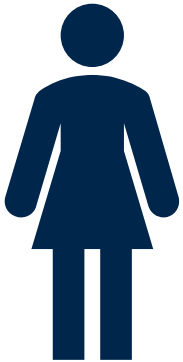
All Variables
Average Testing Accuracy:
75.6% ± 0.6%
Null accuracy: 52.7%

Average Testing
Area Under the Curve (AUC):
0.756 ± 0.006



Why the Physics GRE is inequitable

Cost



Score discrepancies

Limited predictive ability

Miller et al. 2019, Owens et al. 2020

Store | Contact Us | Search for...

ETS GRE

For Test Takers | For Institutions

ETS Home > GRE Home > Subject Tests > About the Tests

ETS Account

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

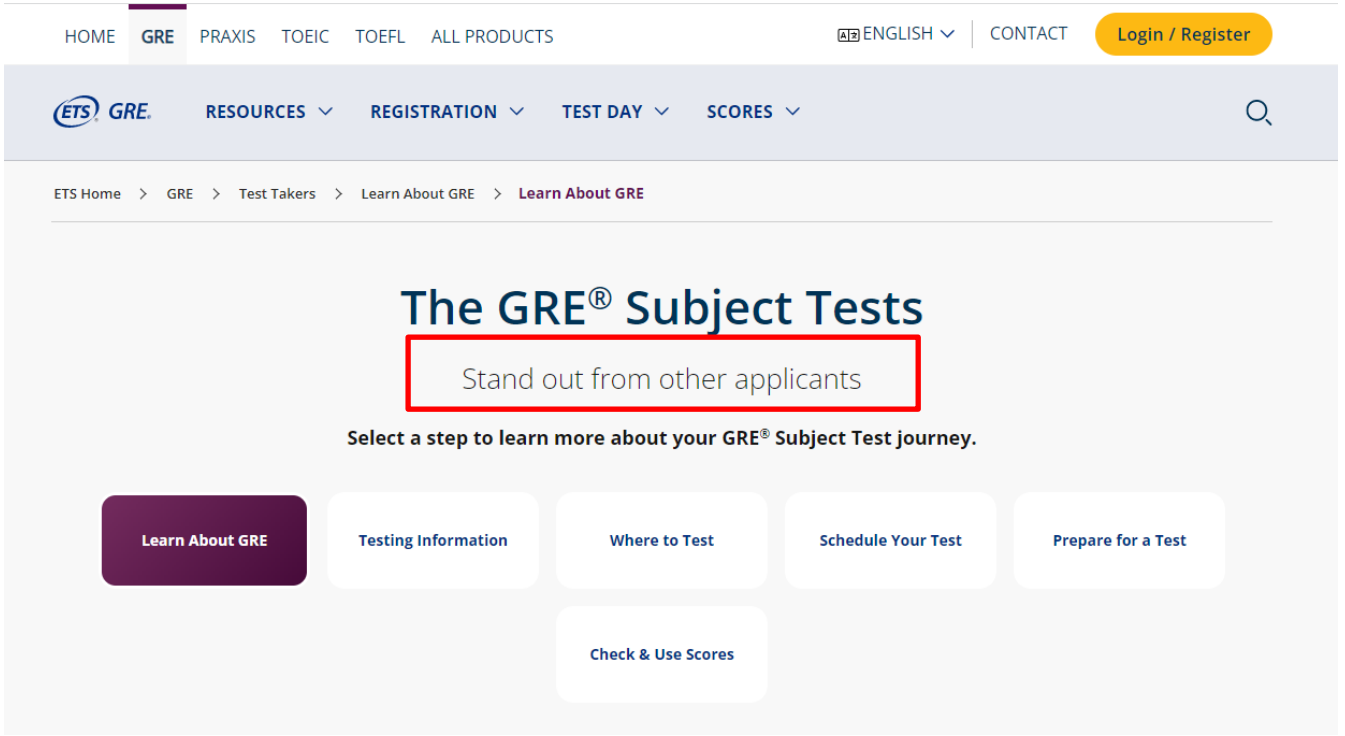
Send Only Your Best Scores

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

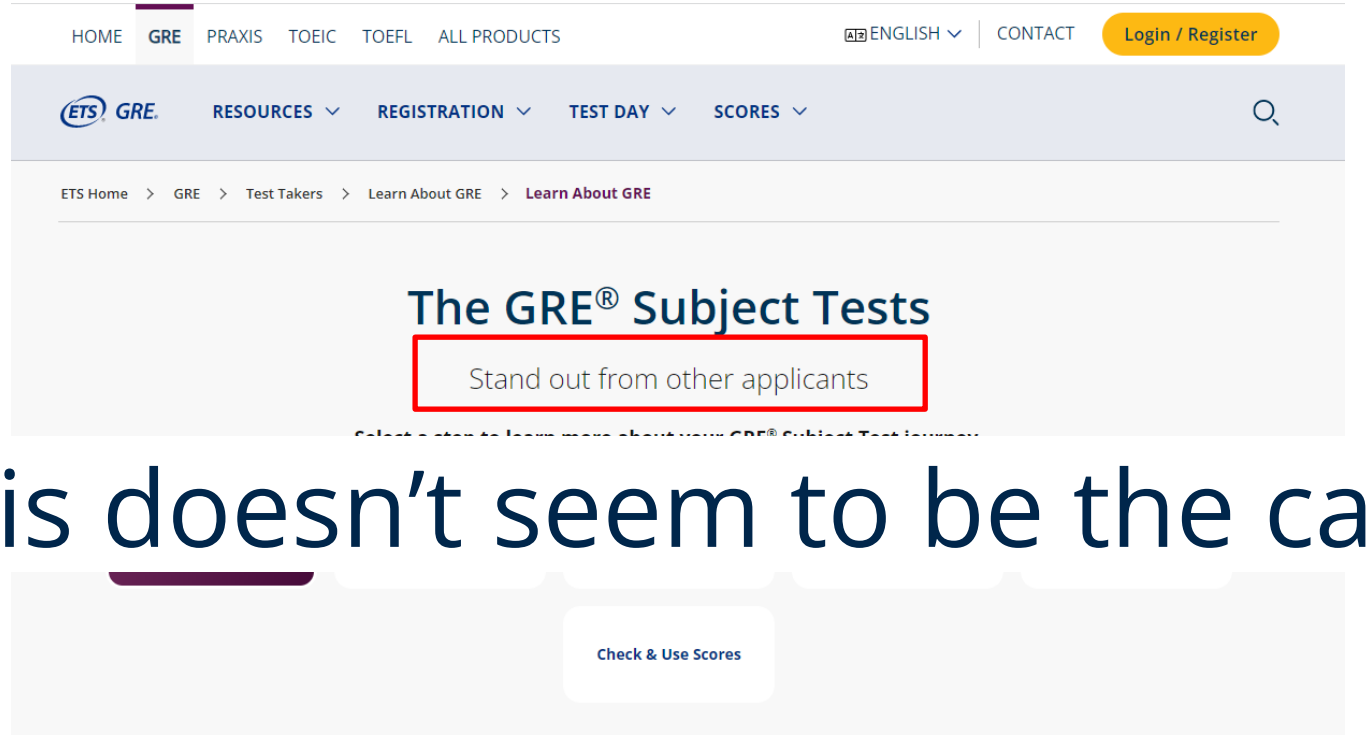
Official Test Prep from ETS

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.

https://www.ets.org/gre/subject/about Langin 2019



https://www.ets.org/gre/subject/about Langin 2019



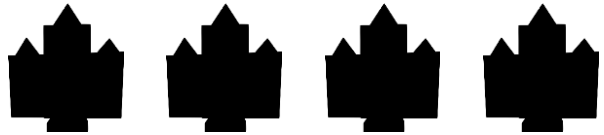
This doesn't seem to be the case

Young and Caballero 2021

Data

GRE scores
GPA
Undergrad school

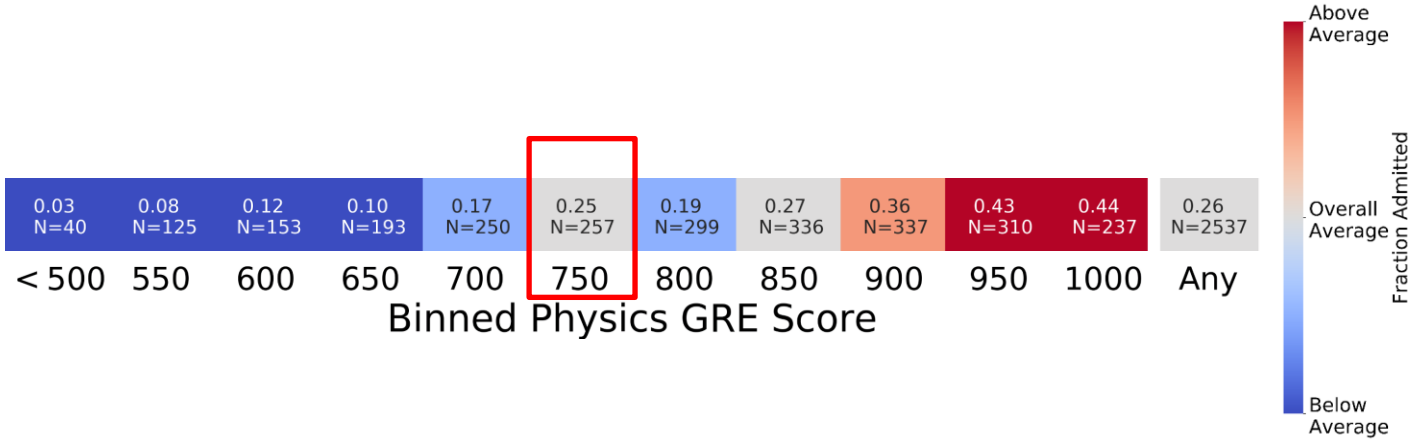
N=2563 applications
2017-2018



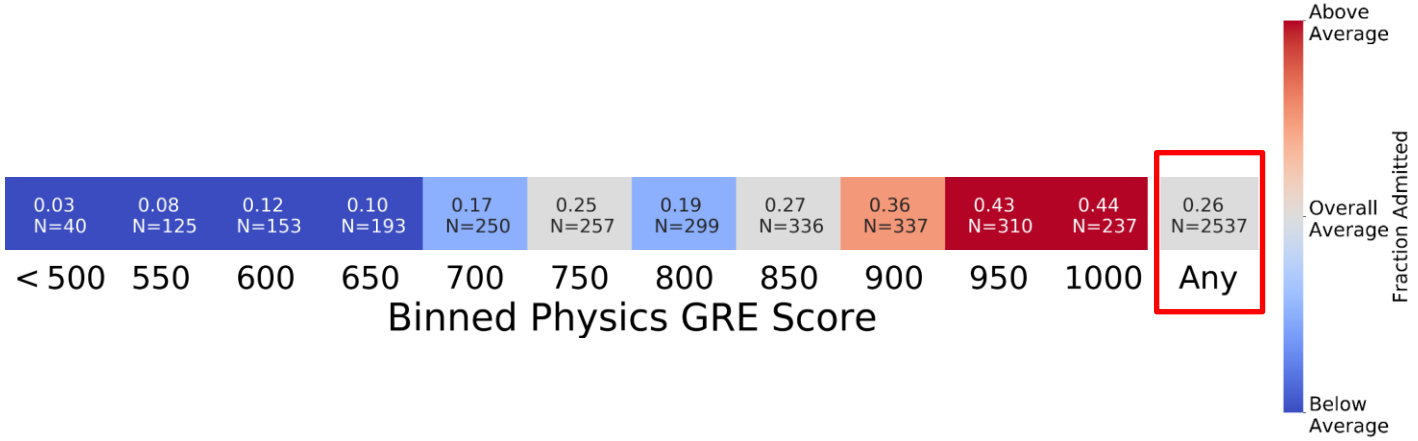
4 Big Ten Universities

1 private Midwest University

Having a higher pGRE score helps…

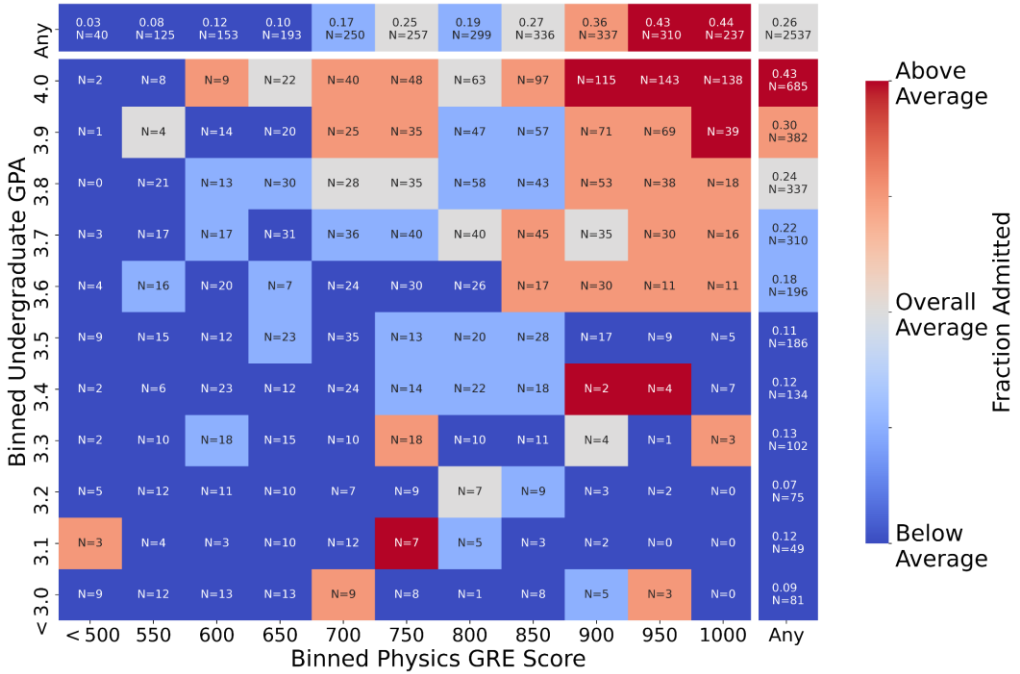


Having a higher pGRE score helps…

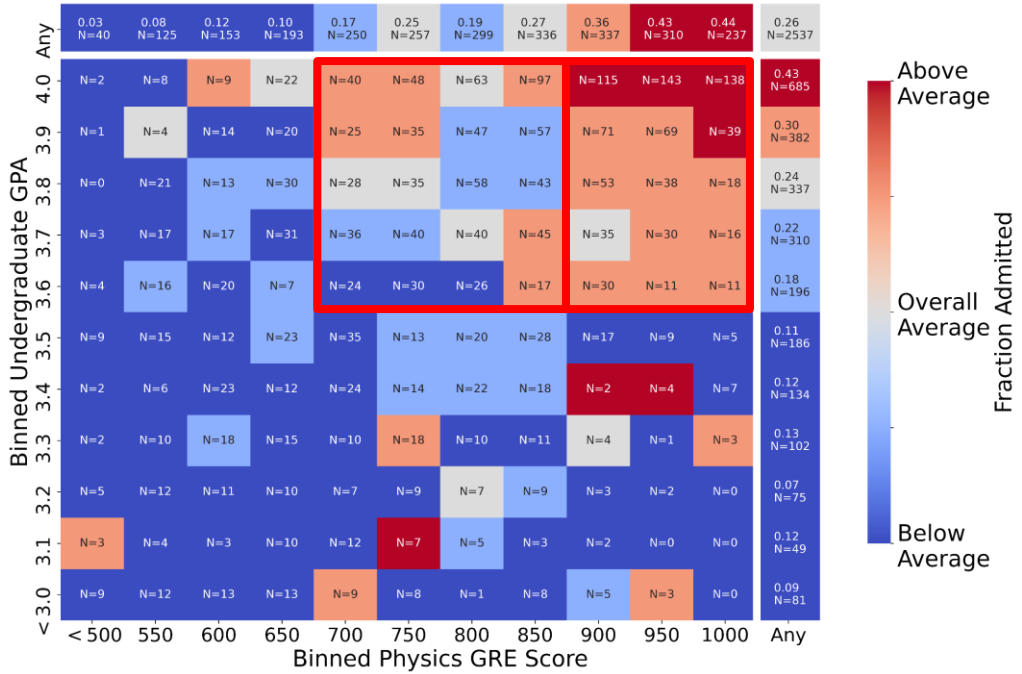


Q: Who needs to stand out?
A: Applicants with a low GPA.

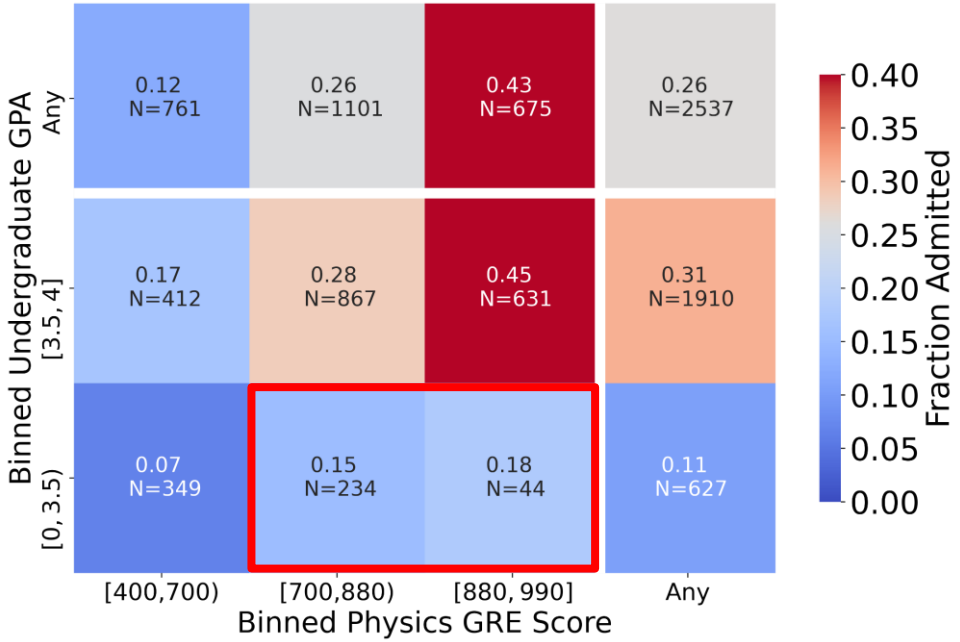
but doesn’t help an applicant with a low GPA “stand out.”



but doesn’t help an applicant with a low GPA “stand out.”

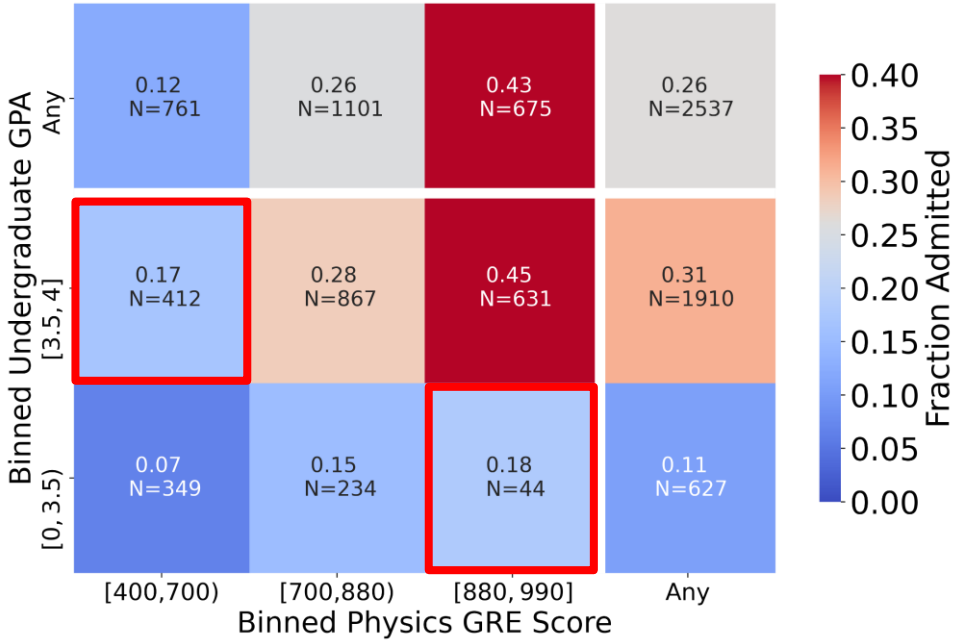


Having a high physics GRE score isn't much better than having an average score.



Miller et al. 2019

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



Miller et al. 2019

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?

Young et al. 2022

Rubric-based holistic review

Kent and McCarthy 2016 Posselt 2016 Miller & Posselt 2020

Rubric-based holistic review

Flickr, CC-BY-2.0

Miller 2015 Barceló et al 2021 Woo et al 2020

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

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

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

https://igenetwork.org/

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

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

Non-Cognitive Competencies (30%)	Achievement Orientation
	Conscientiousness
	Initiative
	Perserverence

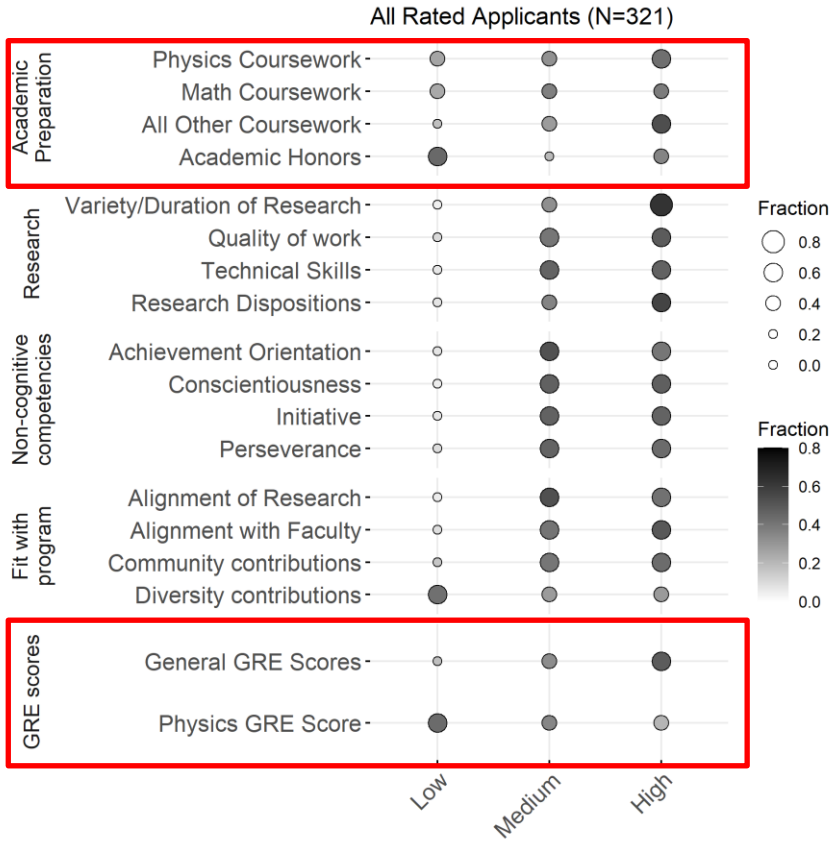
Fit with program (15%)	research
	faculty
	community
	diversity

GRE Scores (10%)	General GRE
	Physics GRE

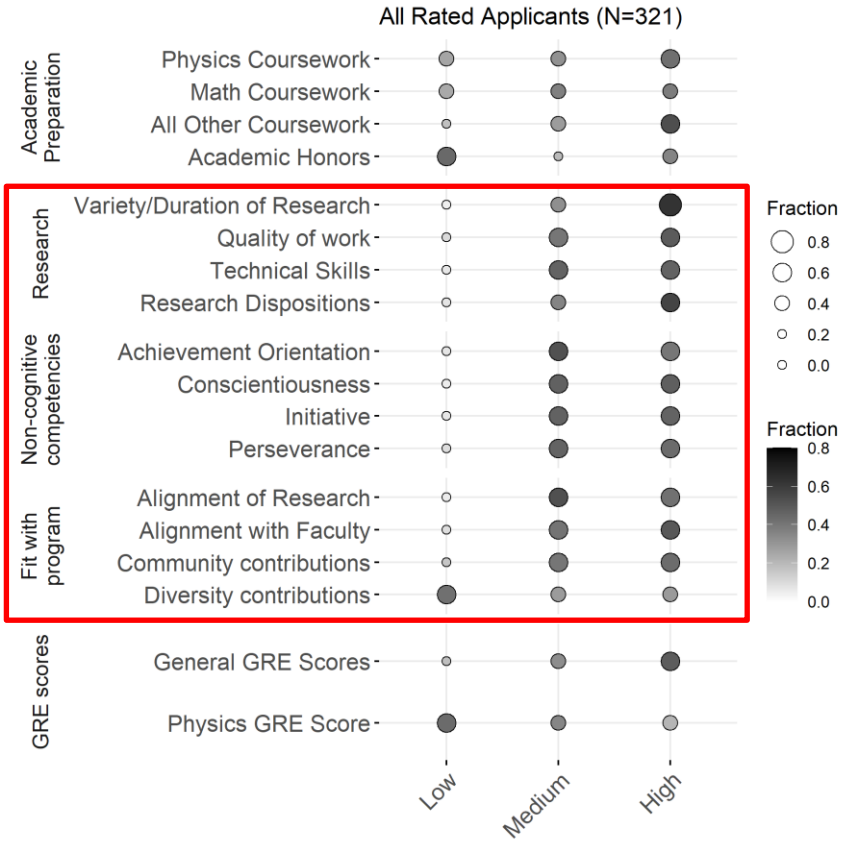
3 years

321 Rated Domestic Applicants

https://igenetwork.org/



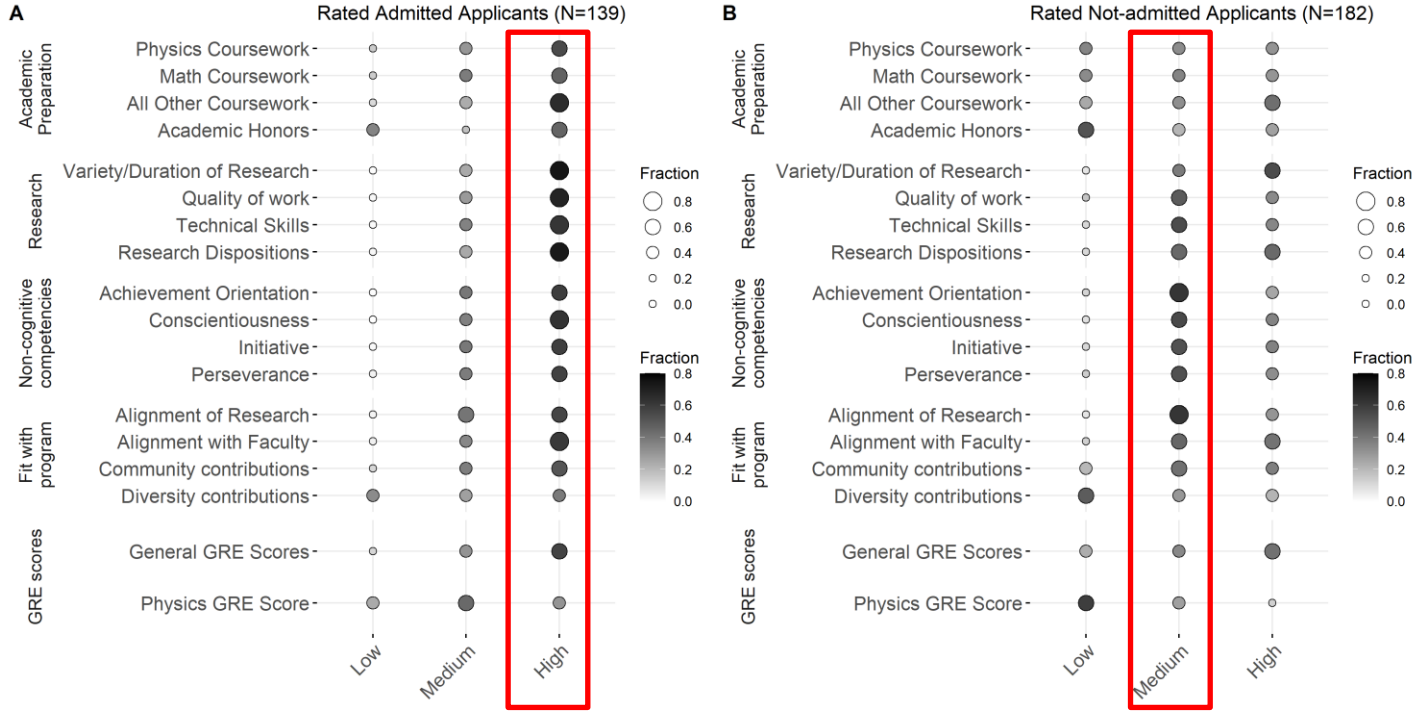
Applicants spread between the rubric levels



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

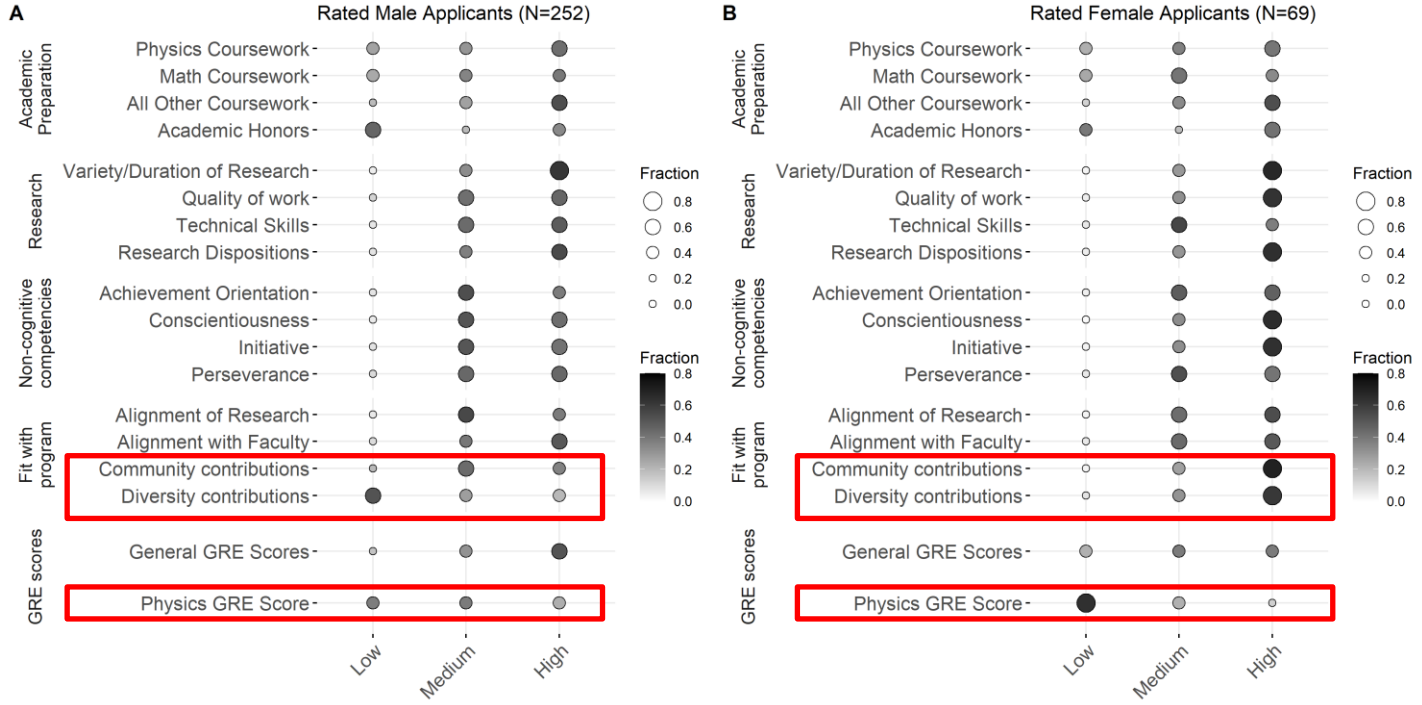
Admitted applicants tend to score “high”…

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.



Miller et al. 2019, Guarino & Borden 2017

Test scores are the only consistent difference

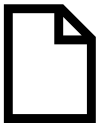
Mikkelsen, Young, Caballero 2021

Takeaway

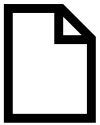
Rubric-based holistic review seems promising for achieving equity in graduate admissions.

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% ± 0.6%
Null accuracy: 52.7%

Average Testing Area Under the Curve (AUC):
0.756 ± 0.006

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

Pre-rubric
Average Testing Accuracy:
75.6% ± 0.6%
Null accuracy: 52.7%

Average Testing Area Under the Curve (AUC):
0.756 ± 0.006

Post-rubric
Average Testing Accuracy:
71.4% ± 0.6%
Null accuracy: 66.0%

Average Testing Area Under the Curve (AUC):
0.626 ± 0.006

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

Pre-rubric
Average Testing Accuracy:
75.6% ± 0.6%
Null accuracy: 52.7%

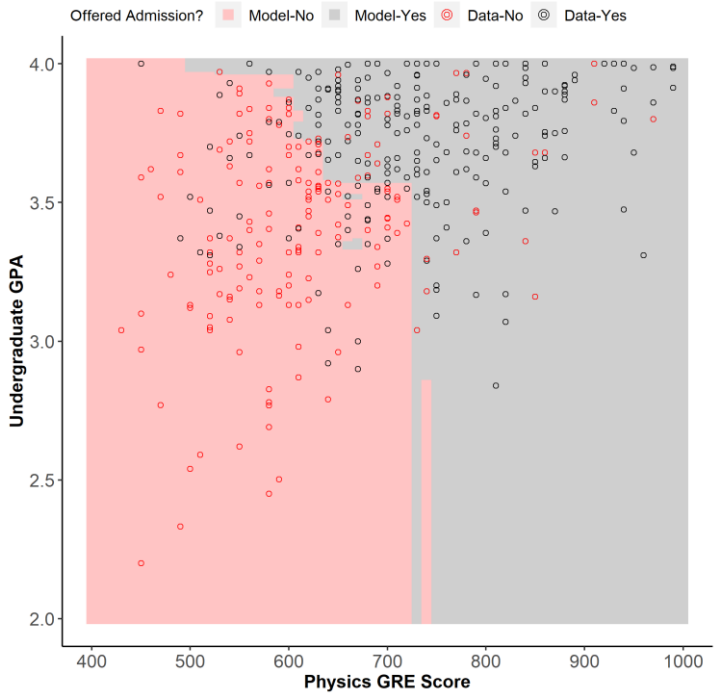
Average Testing Area Under the Curve (AUC):
0.756 ± 0.006

Post-rubric
Average Testing Accuracy:
71.4% ± 0.6%
Null accuracy: 66.0%

Average Testing Area Under the Curve (AUC):
0.626 ± 0.006

Suggests the process changed

Some applicants seem to go against the trend

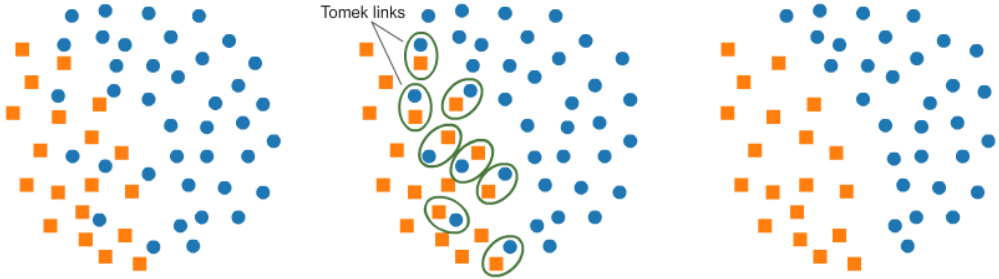


Tomek Links

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

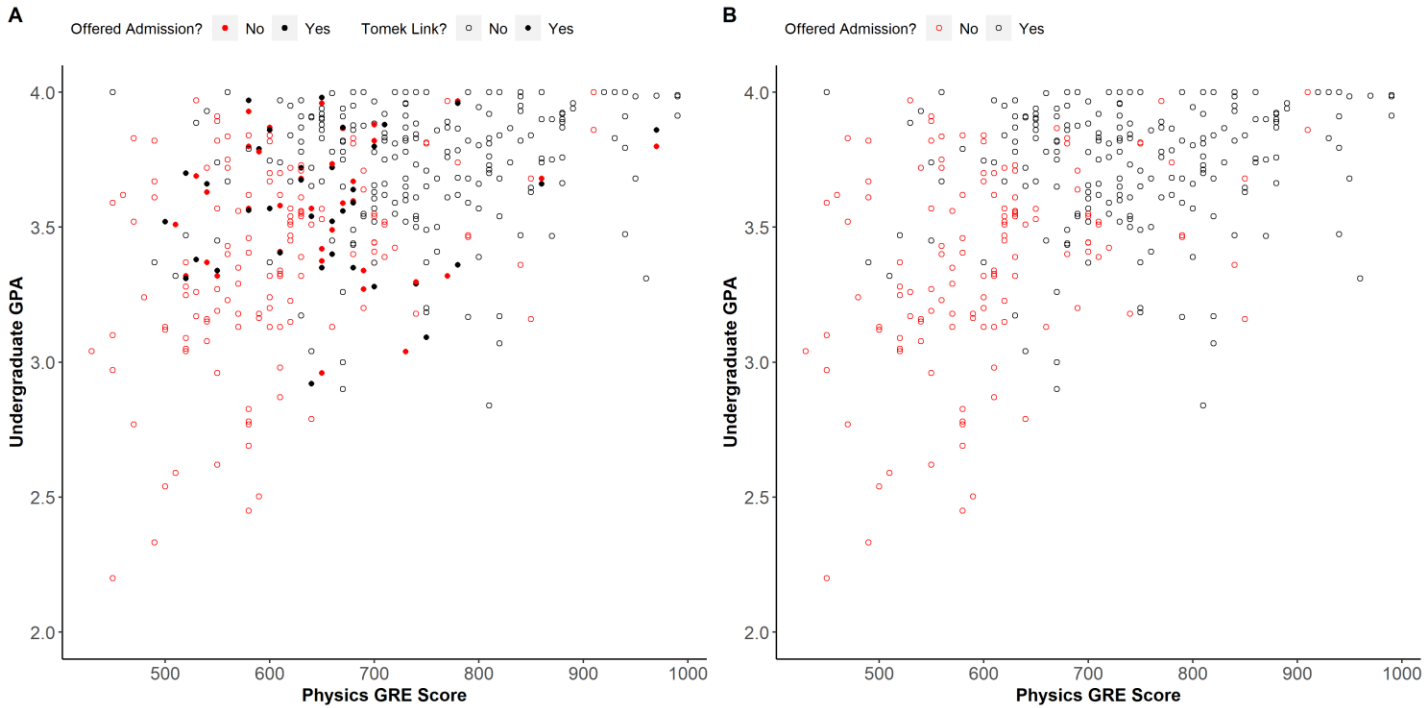
Then P1 and P2 are Tomek Links



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

Tomek (1976) Hoens and Chawla (2013)

Tomek Links in Practice



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

	Applications before rubric	Applications after rubric	Rubric scores
Cases Dropped	11%-14%	15%-18%	12%-17%
Testing AUC	0.809 ± 0.009	0.670 ± 0.015	0.704 ± 0.014
Testing Accuracy	0.806 ± 0.009	0.775 ± 0.012	0.717 ± 0.012
Null Accuracy	0.539 ± 0.006	0.699 ± 0.009	0.575 ± 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.

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.

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

Owens et al 2020

Recommendations

- Discontinue the use of the physics GRE
- 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)

Recommendations

- Discontinue the use of the physics GRE
- Rethink the admissions process in terms of what applicants are evaluated on, how they are evaluated, and who is doing the evaluating
- Engage in self-study and report on what is and is not working

Scherr et al 2017, Rudolph et al 2020

Recommendations

- Discontinue the use of the physics GRE
- Rethink the admissions process in terms of what applicants are evaluated on, how they are evaluated, and who is doing the evaluating
- Engage in self-study and report on what is and is not working

Questions?

ntyoung@umich.edu

Slides:

bit.ly/young_ou_2023

Scherr et al 2017, Rudolph et al 2020

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.
- Miller, Casey W., Benjamin M. Zwickl, Julie R. Posselt, Rachel T. Silvestrini, and Theodore Hodapp. “Typical Physics Ph.D. Admissions Criteria Limit Access to Underrepresented Groups but Fail to Predict Doctoral Completion.” *Science Advances* 5, no. 1 (January 1, 2019): eaat7550. https://doi.org/10.1126/sciadv.aat7550.
- 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.
- 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.
- Potvin, Geoff, Deepa Chari, and Theodore Hodapp. “Investigating Approaches to Diversity in a National Survey of Physics Doctoral Degree Programs: The Graduate Admissions Landscape.” *Physical Review Physics Education Research* 13, no. 2 (December 29, 2017): 020142. https://doi.org/10.1103/PhysRevPhysEducRes.13.020142.
- 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.
- Young, Nicholas T., and Marcos D. Caballero. “Physics Graduate Record Exam Does Not Help Applicants ``stand out”.” *Physical Review Physics Education Research* 17, no. 1 (June 23, 2021): 010144. https://doi.org/10.1103/PhysRevPhysEducRes.17.010144.
- 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.