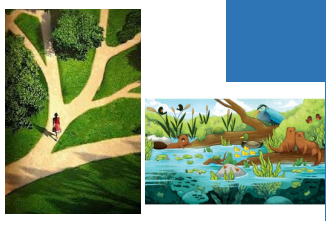
ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

William Elgin Wickenden Award

Beyond Pipeline and Pathways: Ecosystem Metrics

Susan Lord, Matthew Ohland,
Richard Layton and Michelle Camacho

National Science Foundation
WHERE DISCOVERIES BEGIN



MIDFIELD

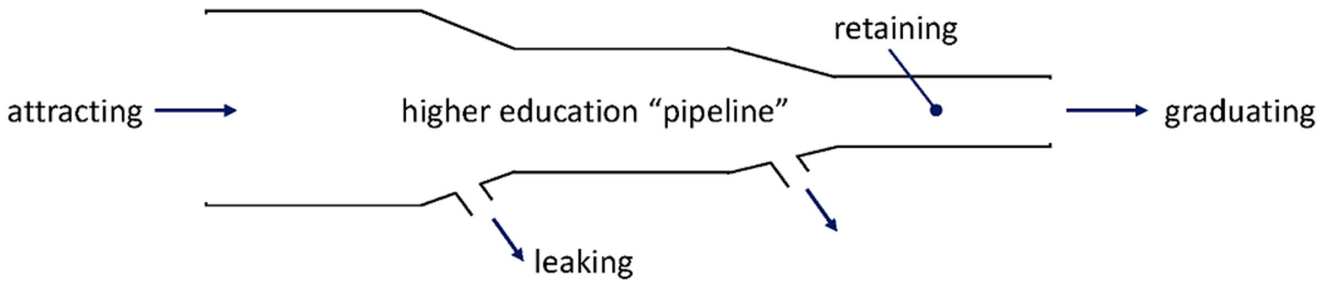
Multiple-Institution Database For Investigating Engineering Longitudinal Development

- 11 public universities (most Southeast USA).
- 1/9 of USA engineering graduates
- > 1 million unique students over 20 years
- Permits intersectional analysis: disaggregation by race/ethnicity and gender
- Longitudinal-can calculate graduation rate

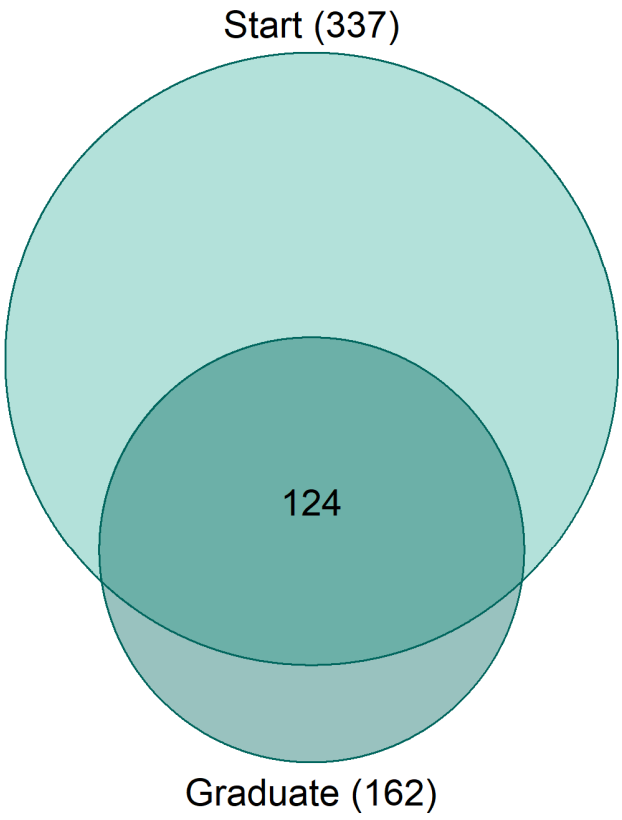
Variation by Engineering discipline

- Electrical (EE) & Mechanical Engineering (ME): highest # students but lowest % women
- Other engineering disciplines: higher % women but smaller # students
- Aggregating all engineering disciplines produces skewed view.
- Engineering Disciplines have their own cultures

Pipeline



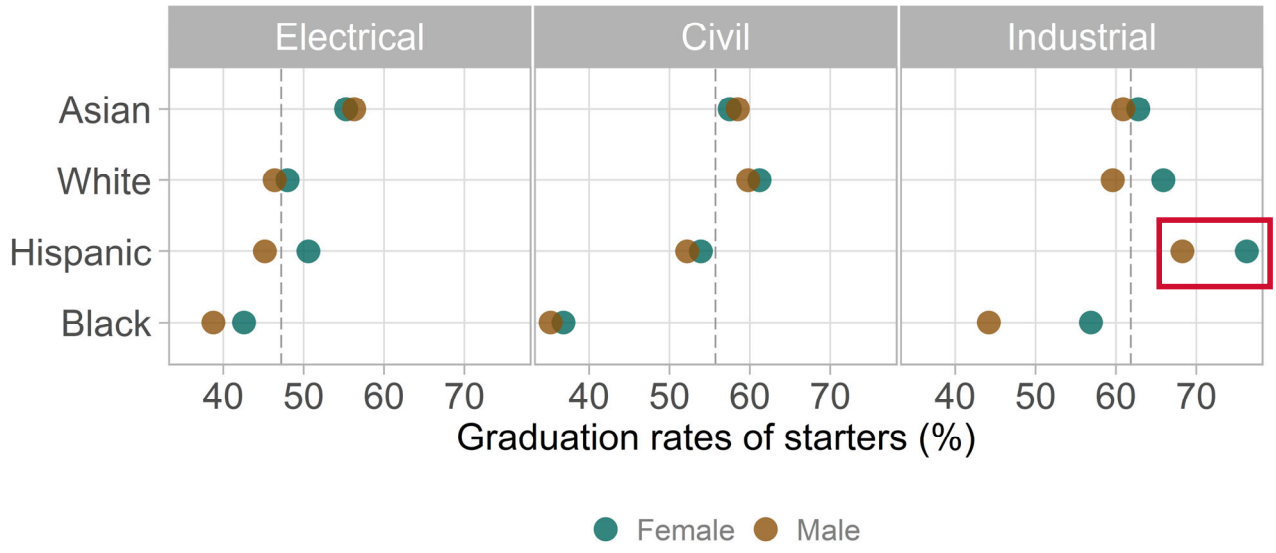
Pipeline Metric: Graduation Rate



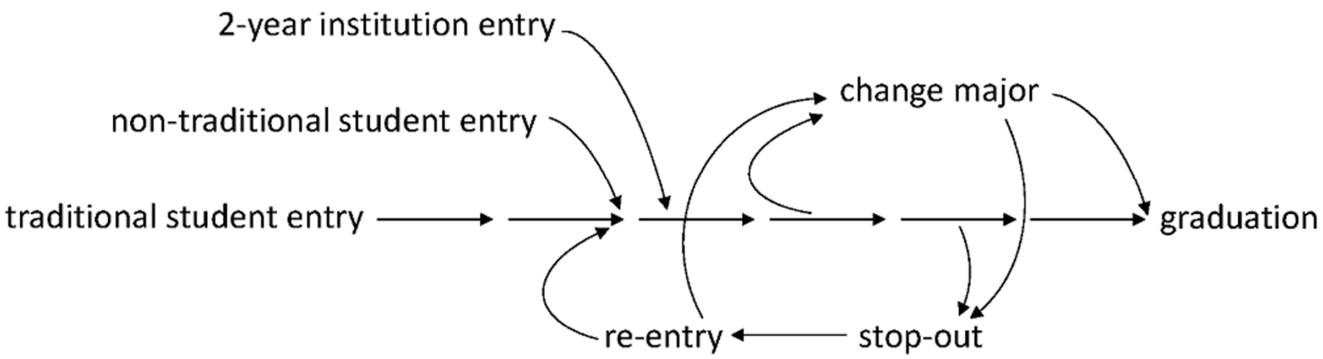
Black Female students in CE
337 start in CE

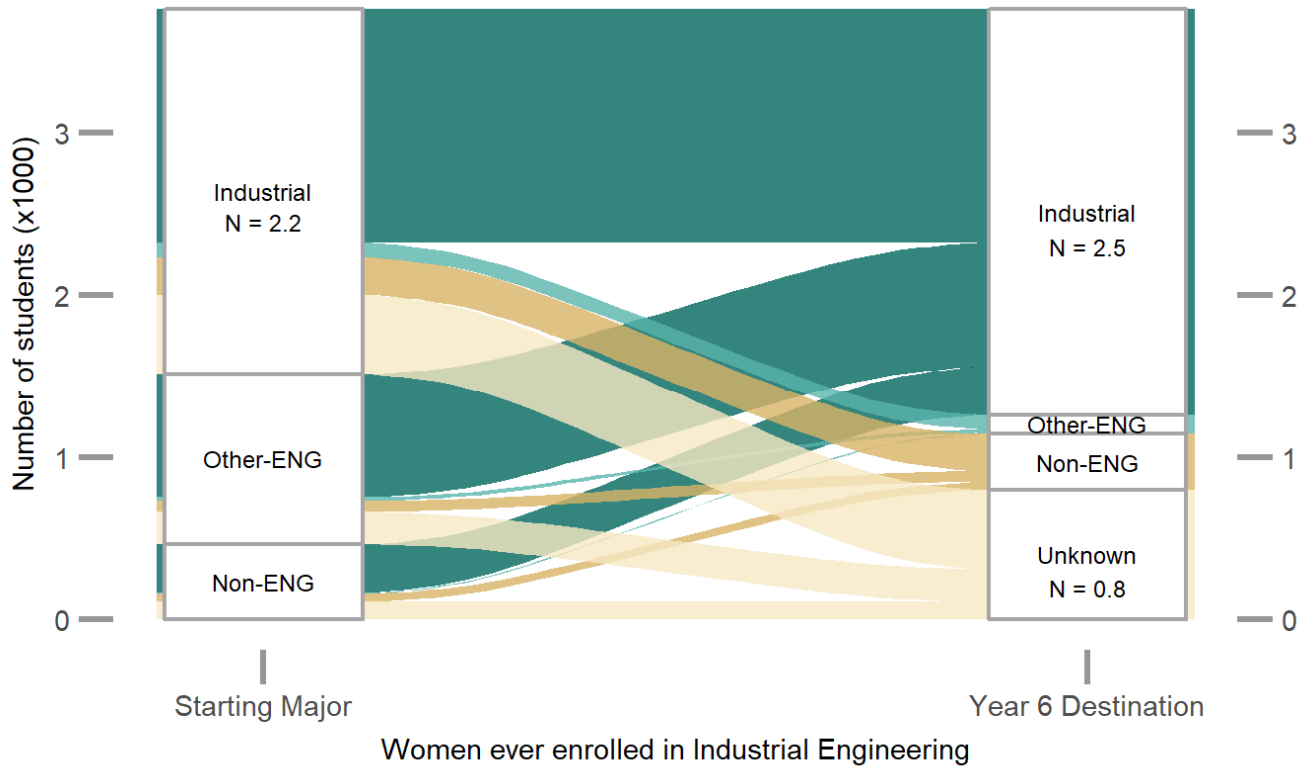
Of those, 124 graduate in CE
Graduation rate = 124 / 337 = 37%

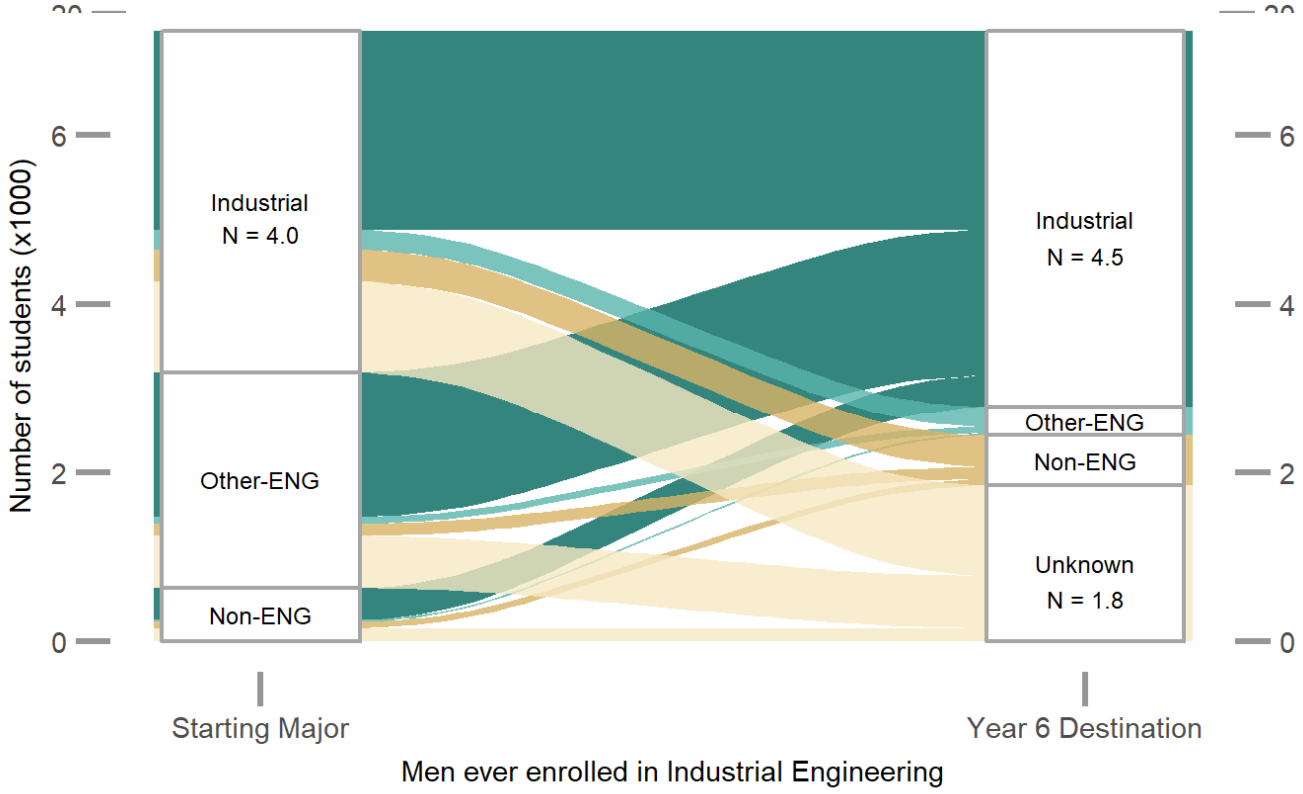
Engineering Discipline Matters



Pathways


2-year institution entry
non-traditional student entry
traditional student entry
change major
graduation
re-entry
stop-out


Number of students (x1000)
3
2
1
0
Industrial
N = 2.2
Other-ENG
Non-ENG
Industrial
N = 2.5
Other-ENG
Non-ENG
Unknown
N = 0.8
Starting Major
Year 6 Destination
Women ever enrolled in Industrial Engineering



Research Question

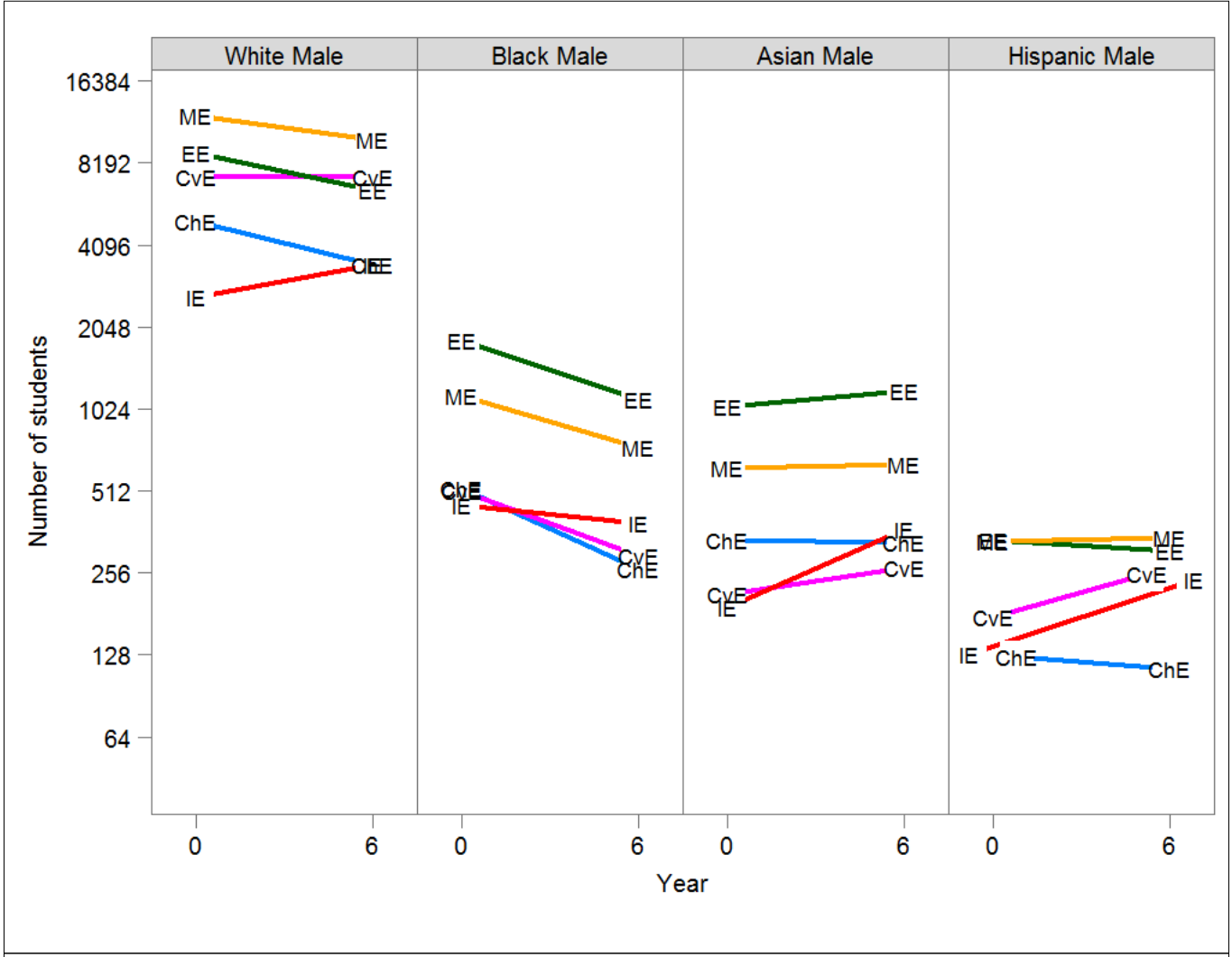
"How do the trajectories of engineering students in different engineering disciplines vary by race/ethnicity and gender?"

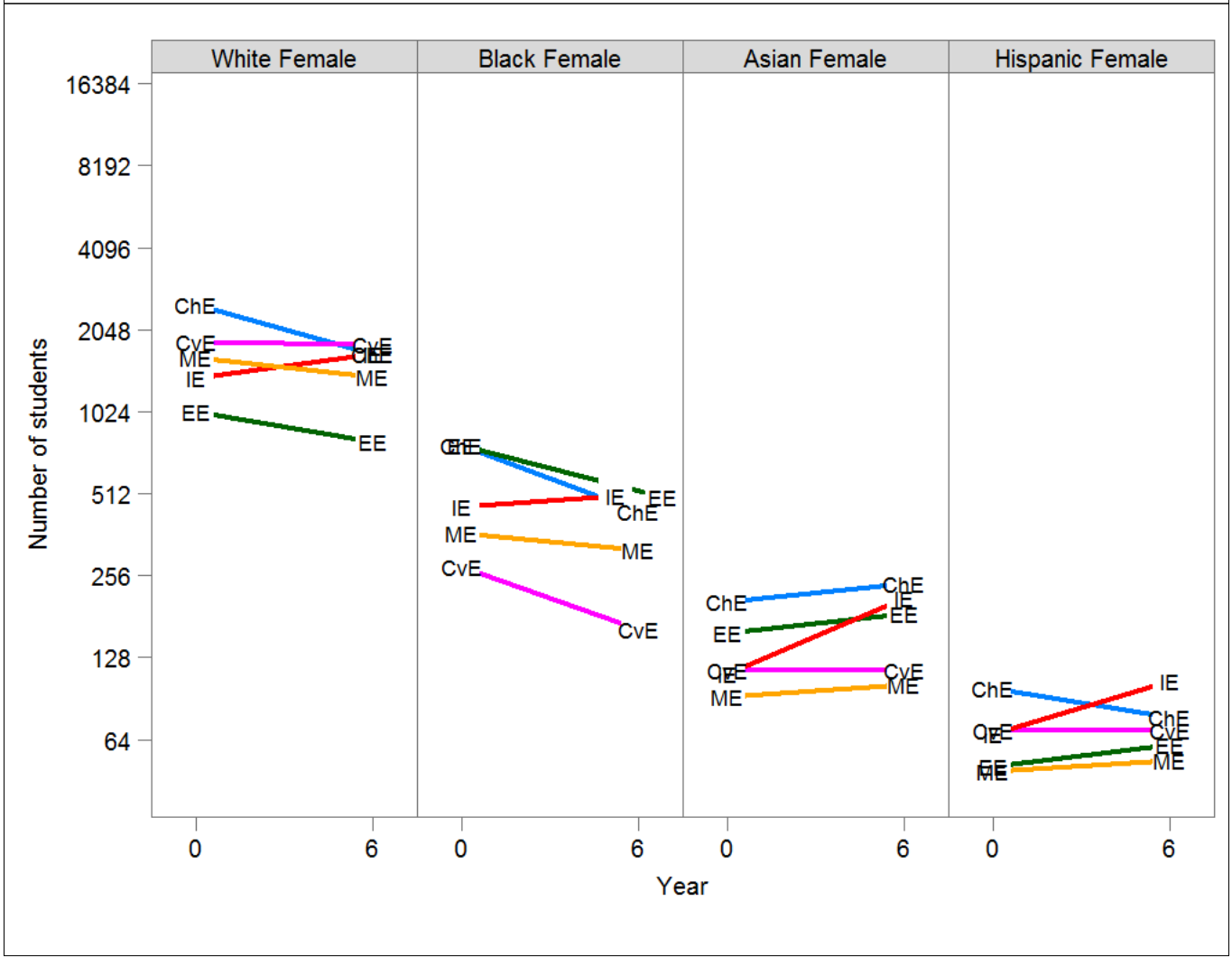
Research Method

- Focuses on largest engineering disciplines: Chemical (ChE), Civil (CVE), Electrical (EE), Industrial (IE), & Mechanical (ME)
- Trajectories measured at matriculation & 6-year graduation for students who
  - Matriculate directly into engineering discipline (FTIC)
  - Matriculate into a first-year engineering (FYE) program (FTIC)
  - Migrate into engineering (FTIC)
  - Choose engineering as Transfer students
- Race/ethnicity self-reported by students including Asian, Black, Hispanic, and White

Trajectories

- All engineering disciplines lose about half of their starters.
- When transfer students and others who switch into the majors included, there is variation by race/ethnicity, gender, and engineering discipline.


White Male
Black Male
Asian Male
Hispanic Male
Number of students
16384
8192
4096
2048
1024
512
256
128
64
0
6
Year
ME
EE
CvE
ChE
IE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Year
ChE
CvE
ME
IE
EE

Most popular engineering disciplines vary by gender and race/ethnicity

For male engineering students

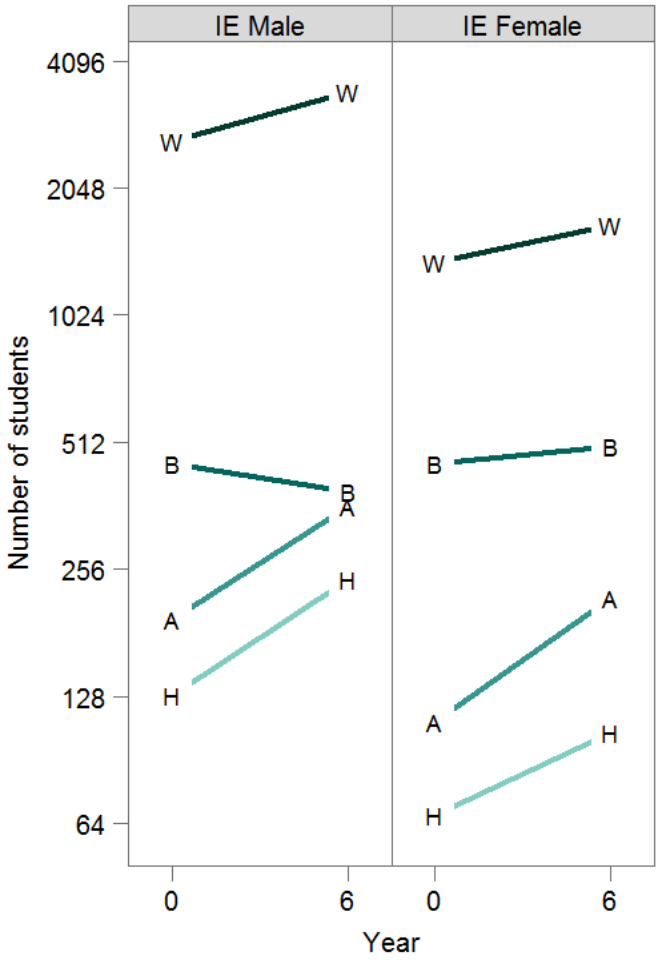
- Top 2 choices at *start* and graduation: ME and EE
- Whites prefer ME; Blacks & Asians prefer EE; Latinos choose ME and EE at about same #

For female engineering students

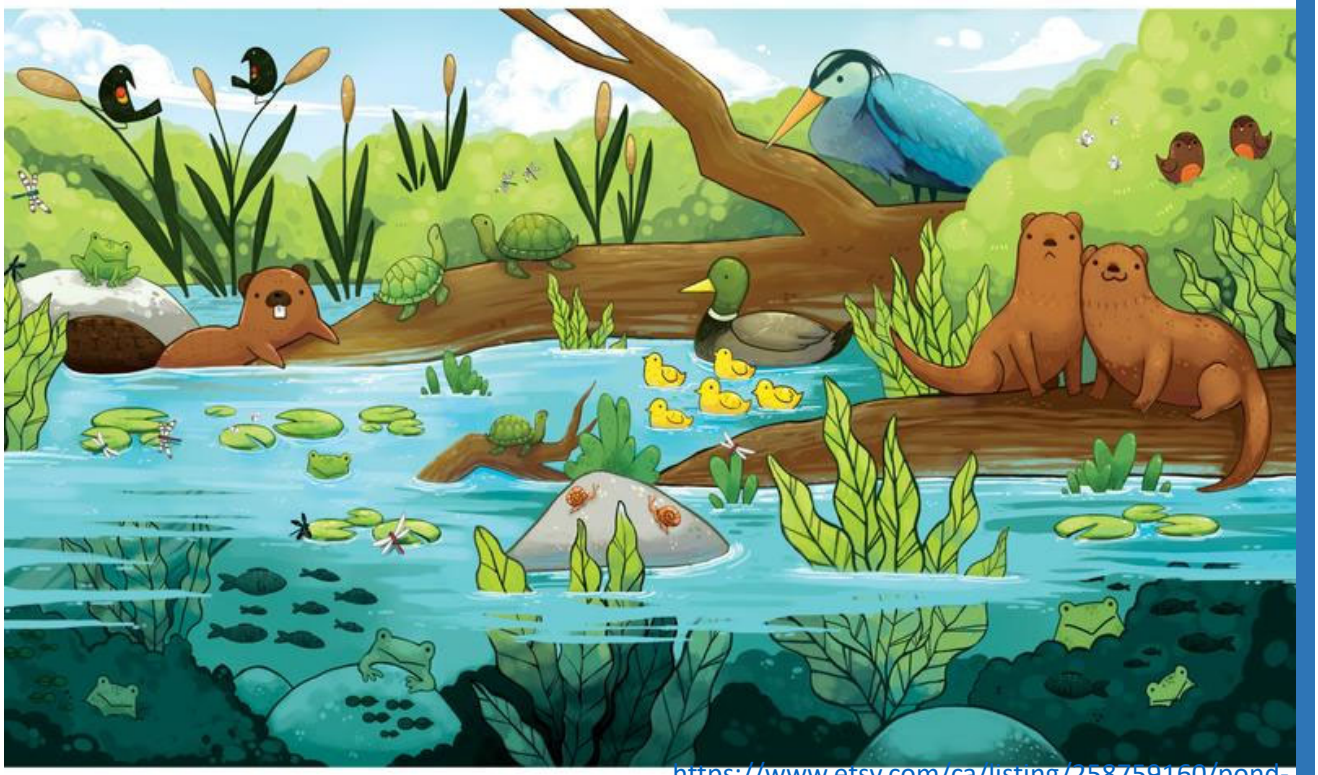
- ChE more popular than ME
- Latinas prefer ChE & IE at *start*; flip to IE & ChE by graduation
- Whites top 2: ChE and Civil at *start* and graduation
- Black and Asian top choices at *start* ChE and EE
- Graduation top choices: EE & IE for Black and ChE & IE for Asian

Industrial Engineering is different!

- Growth for all populations (except Black men) between matriculation and graduation
- IE attracts men and women from all races/ethnicities.
- Lessons to be learned?

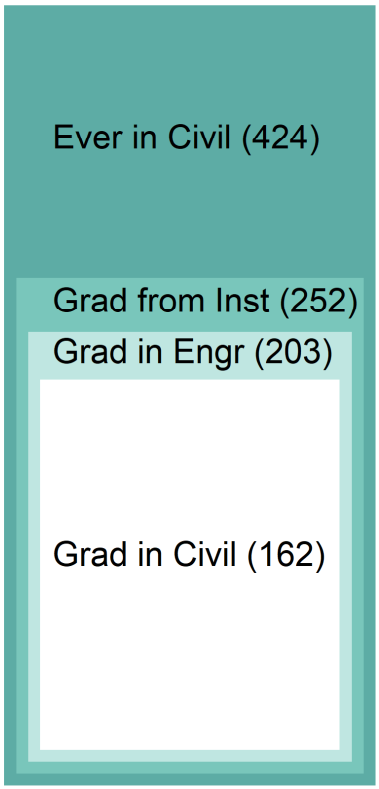


Ecosystem



https://www.etsy.com/ca/listing/258759160/pond-and-river-ecosystem-print-childrens

Stickiness



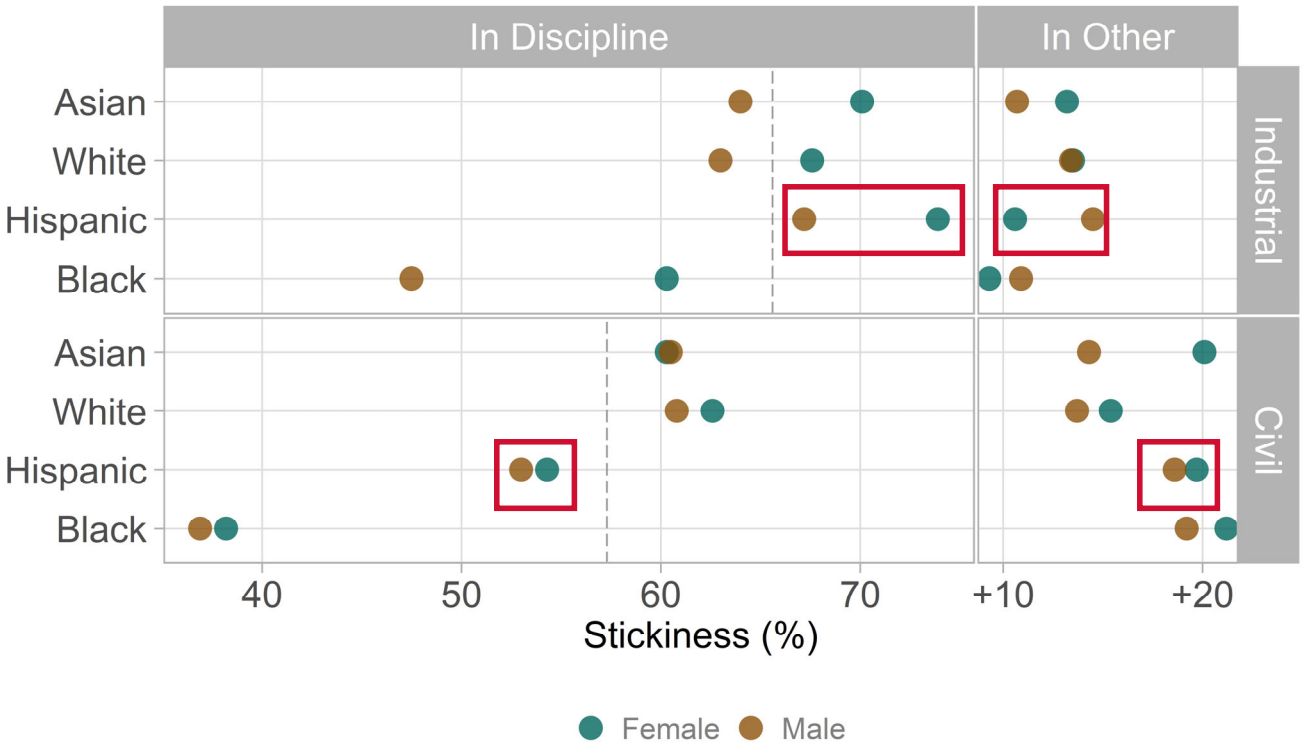
Black Female students in CE
424 ever enrolled in CE

Of those, 252 graduated from the Institution
Institutional stickiness = 252 / 424 = 59%

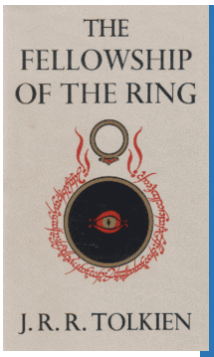
Of those, 203 graduated in an Engr discipline
Engineering stickiness = 203 / 424 = 48%

Of those, 162 graduated in CE
Major stickiness = 162 / 424 = 38%

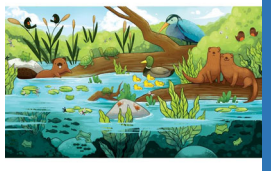
Stickiness



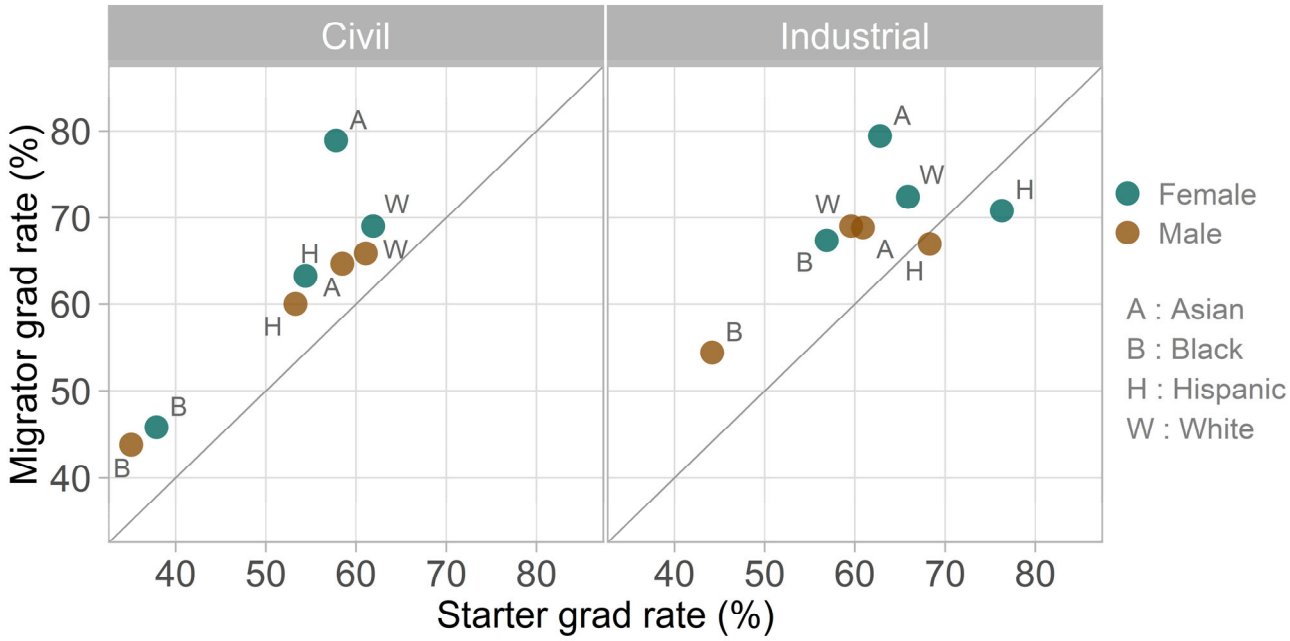
Migrators

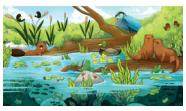


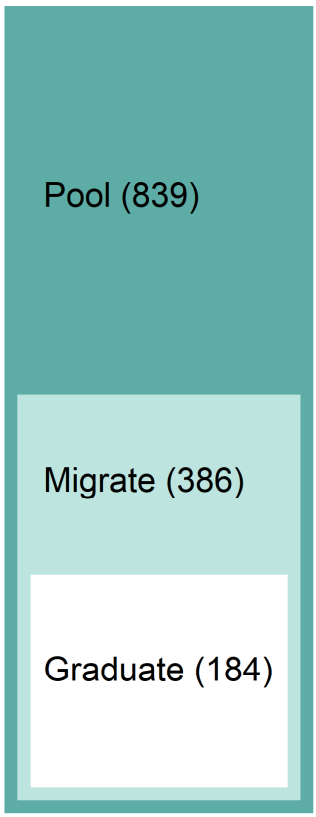
- "Not all those who wander are lost."
- How successful are undergraduate students who migrate into engineering?
- Adopting an ecosystem mindset, we developed metrics to uncover successes of students who migrate among the top five engineering disciplines.



Migrators are successful!







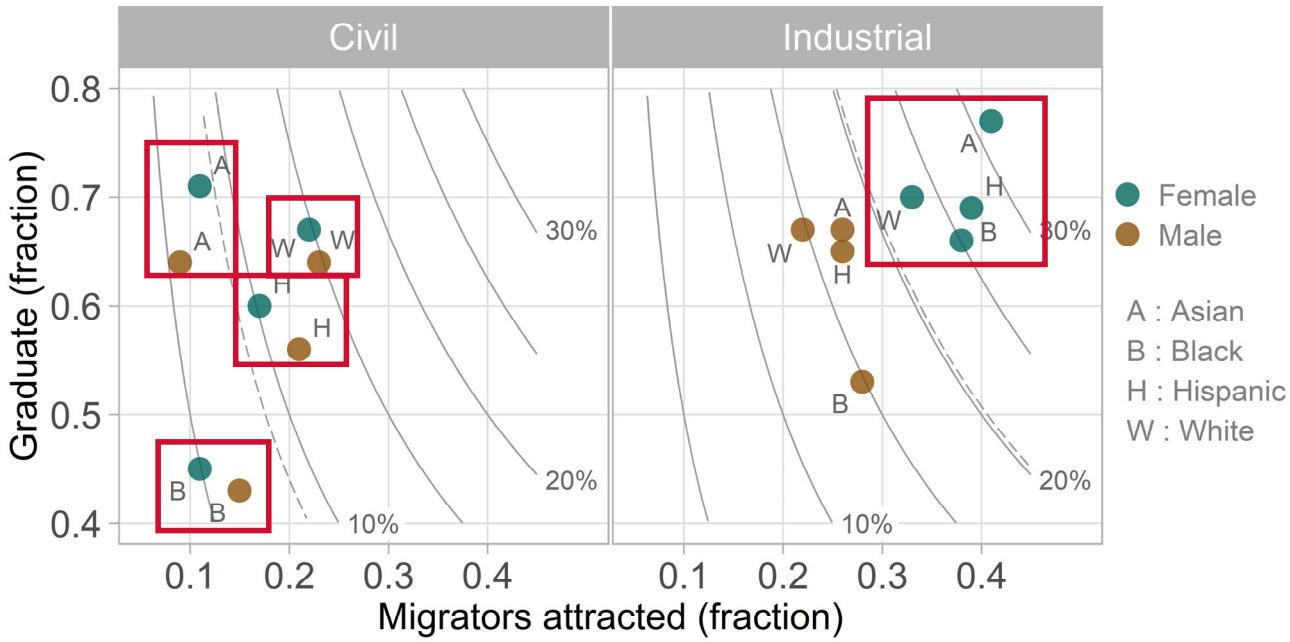
Black Male students in EE
839 potential migrators to EE

Of those, 386 migrated to EE
Fraction of migrators attracted = 386 / 839 = 0.460

Of those, 184 graduated in EE
Fraction attracted that graduate = 184 / 386 = 0.477

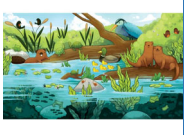
Migration yield is computed in one of two ways:
Product of the two fractions: 0.460 x 0.477 = 22%
Ratio of graduates to pool: 184 / 839 = 22%

Migration Yield



Summary/Conclusion

- Metaphors influence metrics
- Nuances of engineering education ecosystem
- Migrators have stories of success
- Consider more effective metrics and data displays
- Use an ecosystem mindset to offer new insights

S. M. Lord, M. W. Ohland, R. A. Layton, & M. M. Camacho, "Beyond Pipeline and Pathways: Ecosystem Metrics," *Journal of Engineering Education*, **108**(1), 32-56, 2019.

https://onlinelibrary.wiley.com/doi/abs/10.1002/jee.20250