Beth Holloway, Director
WIEP

P.K. Imbrie, Director
College-wide Honors

Teri Reed-Rhoads,
Assistant Dean

WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

You Can't Graduate Them If You Don't Admit Them: Using Modeling Techniques to Inform Admissions Policy

Beth Holloway, P.K. Imbrie, and Teri Reed-Rhoads
Purdue University – West Lafayette

September 14, 2012

WEPAN 2012-2013 Webinar Series

- **Host: Diane Matt,** Executive Director, WEPAN, Women in Engineering ProActive Network
- **Moderator: Jenna Carpenter, Associate Dean, Administrative & Strategic Initiatives,** Louisiana Tech University
- **Presenters: Beth Holloway, P.K. Imbrie, and Teri Reed-Rhoads,** Purdue University – West Lafayette

WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

Housekeeping Information

- **The webinar will use Voice Over Internet. If the sound quality is not good, a teleconference line is available:**
  - **Phone: +1 (914) 339-0021**
  - **Access Code: 516-111-282**
  - **Audio Pin: Check your screen once you dial in**
- **Stay with us if we are temporarily disconnected.**
- **Download PowerPoint at www.wepan.org > Webinars**
- **Recorded webinar link will be posted at www.wepan.org > Webinars**
- **Survey following the webinar—please respond!**

WEPAN

Asking Questions and Discussion

- **Participant microphones are muted for webinar quality.**
- **Questions and discussion are hosted at: www.wepanknowledgecenter.org > Log In or Register > My Professional Interest Groups > Gender Bias in Admissions Forum**
- **Presenters will stay on the webinar for 30 minutes for expanded discussion!**

About WEPAN www.wepan.org

- **WEPAN's Core Purpose: To propel higher education to increase the number and advance the prominence of diverse communities of women in engineering.**
- **WEPAN's Core Values:**

  Knowledge, Collaboration, Inclusion and Leadership
- **700 members from 200 engineering schools, corporations, government and non-profits**
- **Support WEPAN's work by becoming a member and making a donation at www.wepan.org**

WEPAN

WEPAN Knowledge Center

http://wepanknowledgecenter.org

Goal: Increase the number, scope and effectiveness of initiatives to advance women in engineering.

- **Catalogued and fully cited resources-1,300+**

  Research, reports, data and statistics, agenda papers, bibliographies, best practices,
- **Online Professional Community**

  Network, collaborate, identify experts, share information

WEPAN

Who's on the Call Today

- **We have 240+ registered participants!**
- **Thank you to ASEE's WIED, ERM, FYP, NAPE Stem Equity Pipeline, NGCP, and many others for helping us spread the word!**
- **Links to the PowerPoint and recorded webinar will be posted at: www. wepan.org >> Webinars**

WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

Beth Holloway, Director
WIEP

P.K. Imbrie, Director
College-wide Honors

Teri Reed-Rhoads,
Assistant Dean

WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

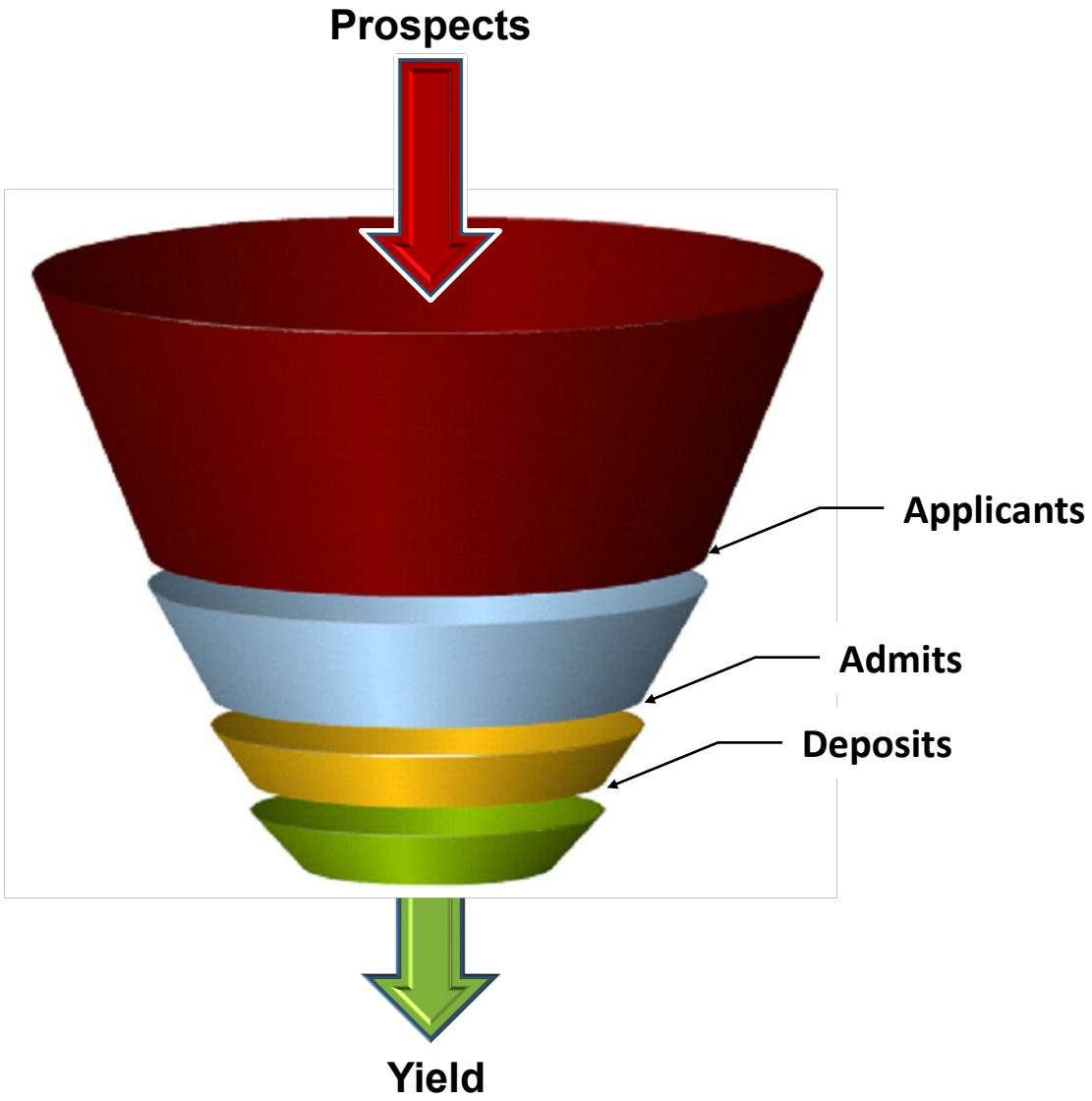
You Can't Graduate Them If You Don't Admit Them: Using Modeling Techniques to Inform Admissions Policy

Beth Holloway, P.K. Imbrie, and Teri Reed-Rhoads

Purdue University – West Lafayette

September 14, 2012

Recruiting and Admission Funnel



WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

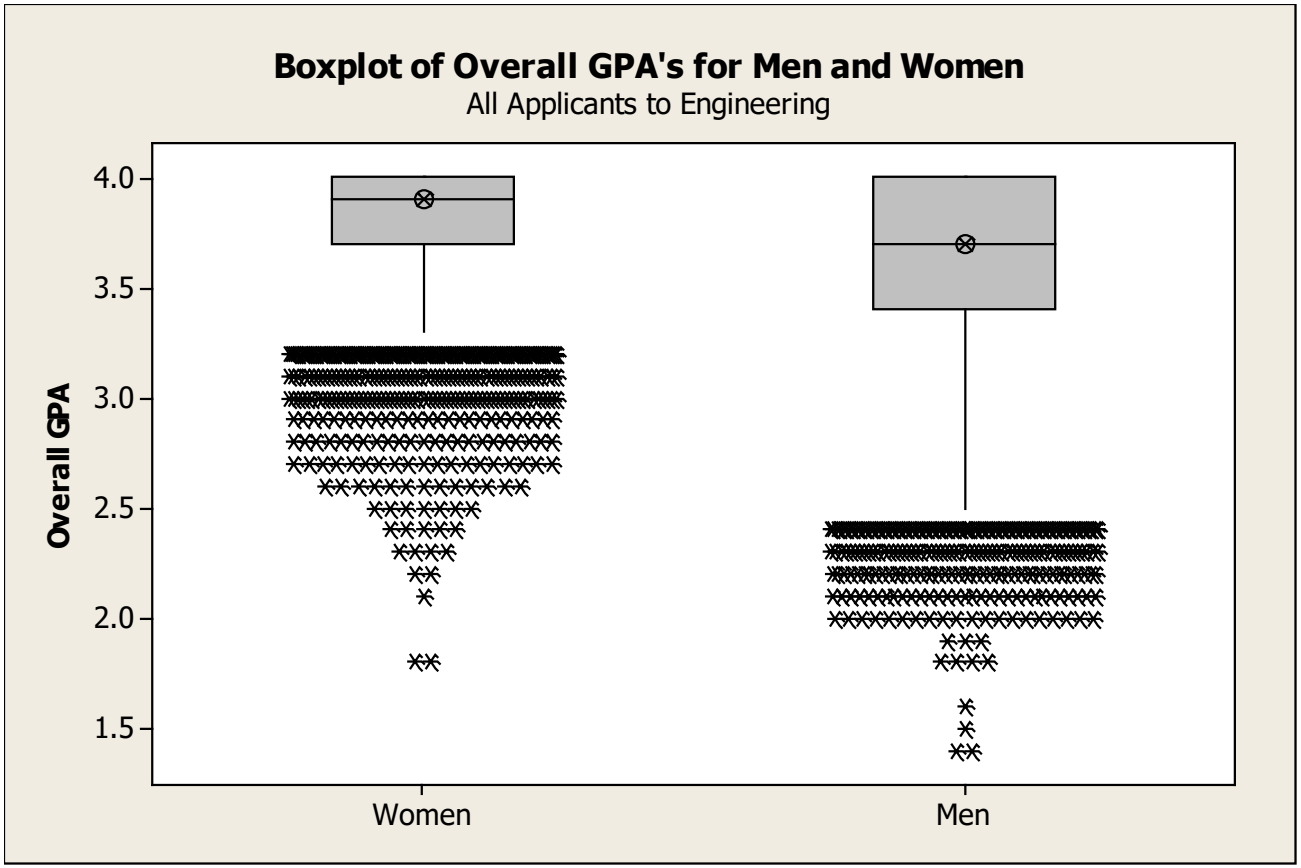
Motivation

- Purdue's College of Engineering (COE) has been working to increase the representation of women in its first-year class for many years.
- From 2006 - 2010, we have seen a 46% increase in the number of applications received from women, but only a 24% increase in the number of women admitted.
- At the same time, casual analysis seems to indicate that admitted women have higher metrics, on average, than admitted men.

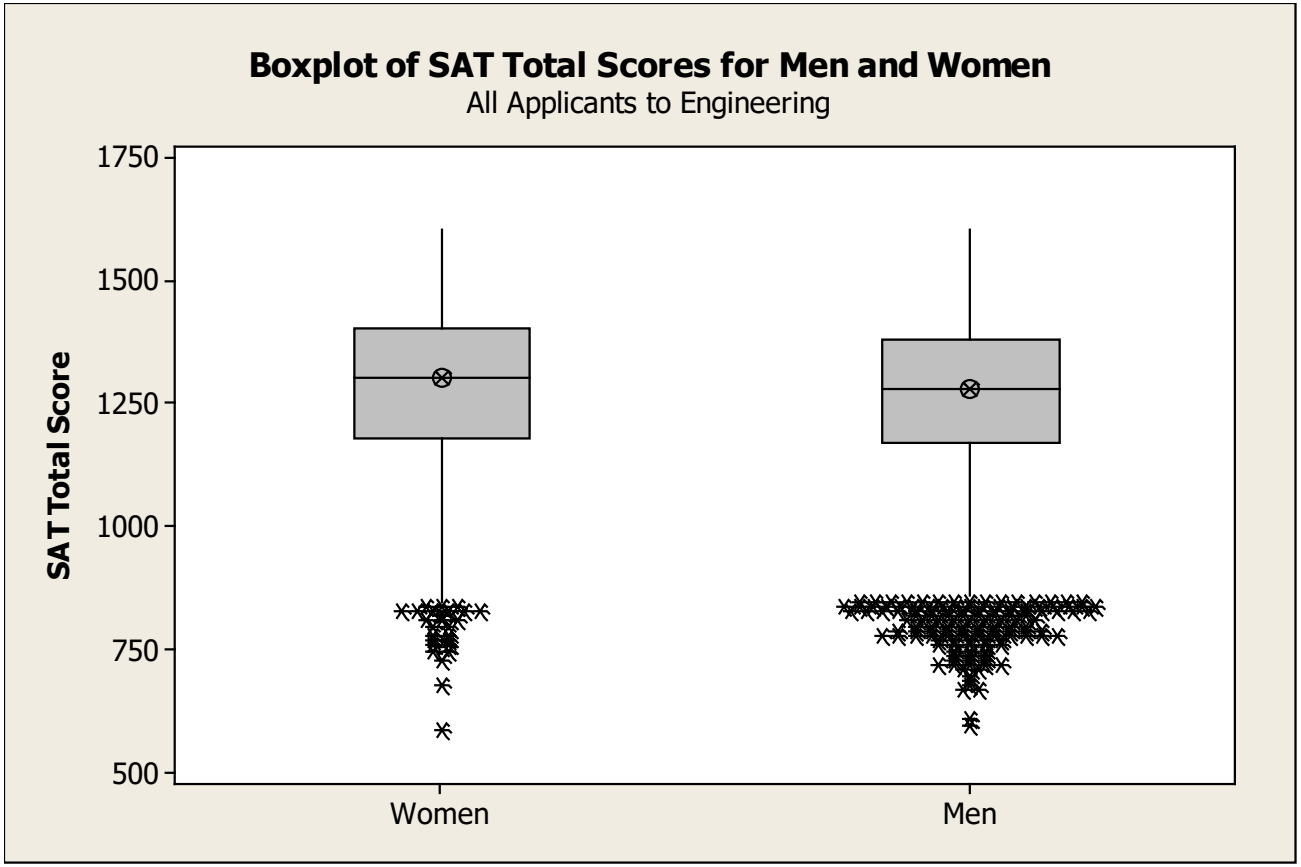
Analysis of Metric Medians for Applicant Pool

All Applicants		Total		
		Women	Men	p-value
Overall GPA	Median	**3.9**	3.7	0.0000
	N	*4457*	*17441*	
Core GPA	Median	**3.74**	3.48	0.0000
	N	*4603*	*18113*	
Class Rank	Median	**93**	86	0.0000
	N	*3029*	*11346*	
SAT Verbal	Median	**620**	600	0.0000
	N	*4611*	*18148*	
SAT Math	Median	670	**680**	0.0000
	N	*4611*	*18148*	
SAT Total	Median	**1300**	1280	0.0000
	N	*4611*	*18148*	

Boxplot of Overall GPA -Applicants



Boxplot of SAT Total Scores - Applicants

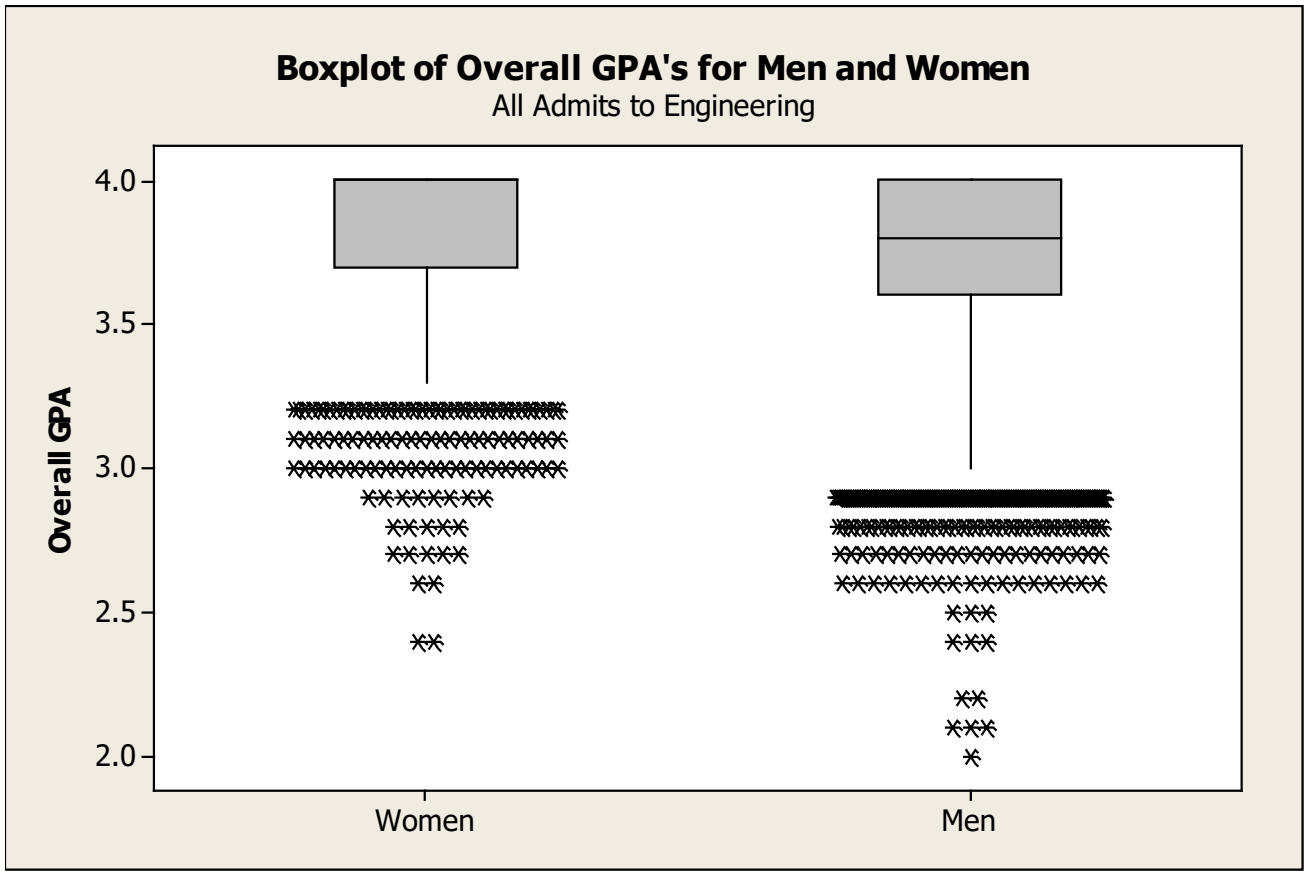


Analysis of Metric Medians for Admits to Engineering

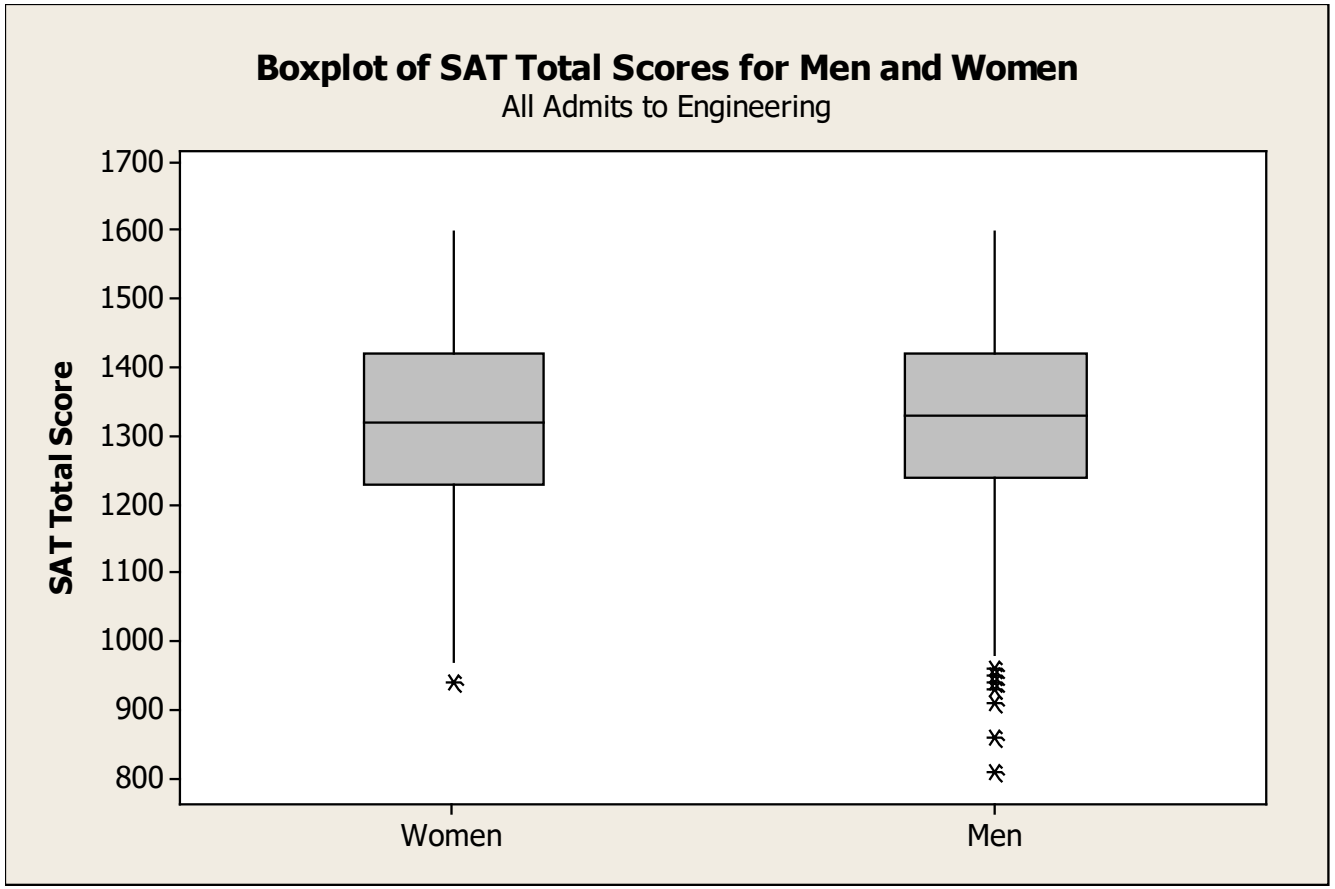
All Admits to Engineering		Total		
		Women	Men	p-value
Overall GPA	Median	**4.0**	3.8	0.0000
	N	*3829*	*12790*	
Core GPA	Median	**3.80**	3.60	0.0000
	N	*3935*	*13201*	
Class Rank	Median	**94**	90	0.0000
	N	*2558*	*7963*	
SAT Verbal	Median	**630**	620	0.0000
	N	*3911*	*13127*	
SAT Math	Median	680	**700**	0.0000
	N	*3911*	*13127*	
SAT Total	Median	1320	1330	0.0100
	N	*3911*	*13127*	

WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

Boxplot of Overall GPA - Admits



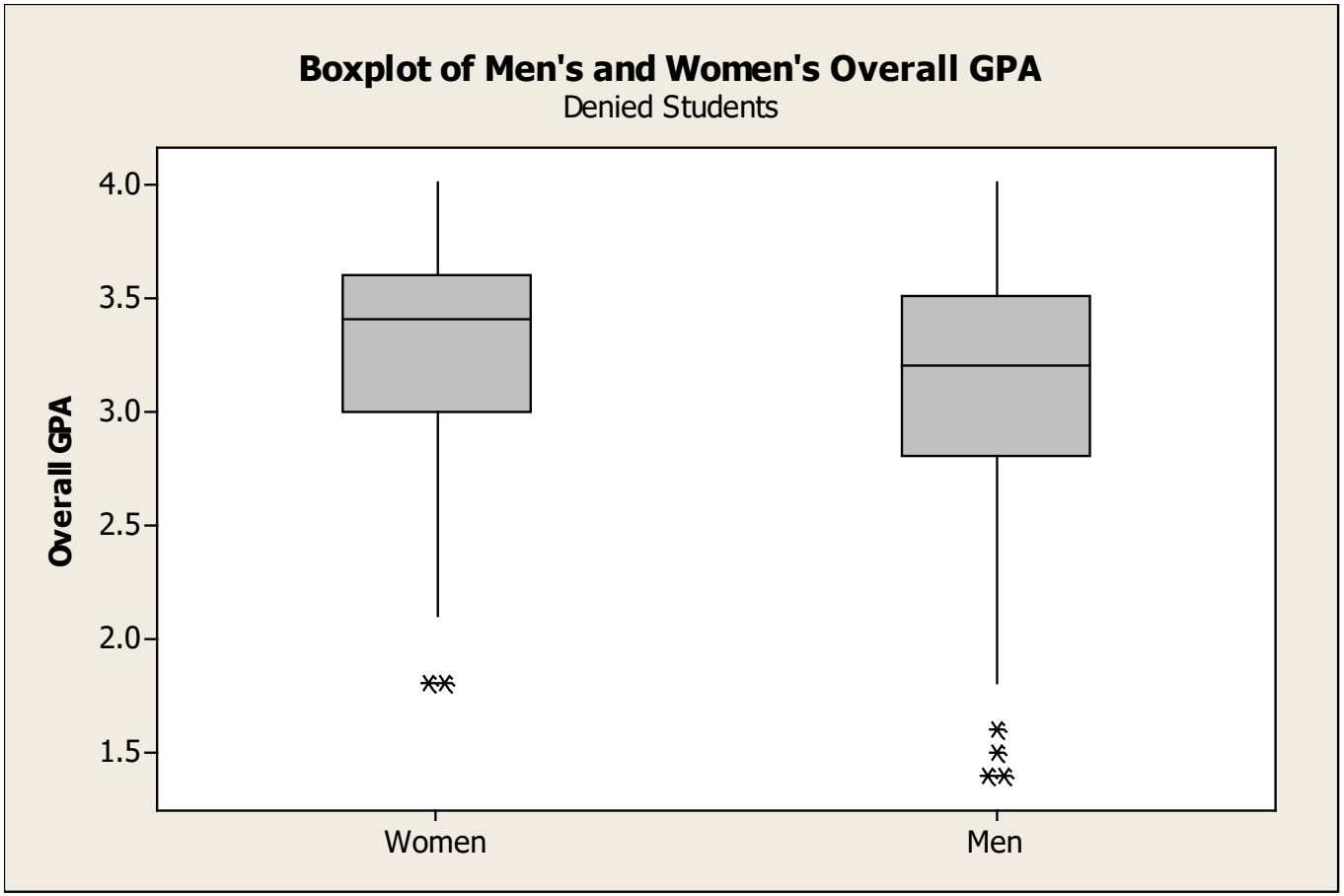
Boxplot of SAT Total Scores - Admits



Analysis of Metric Medians for Denied Students

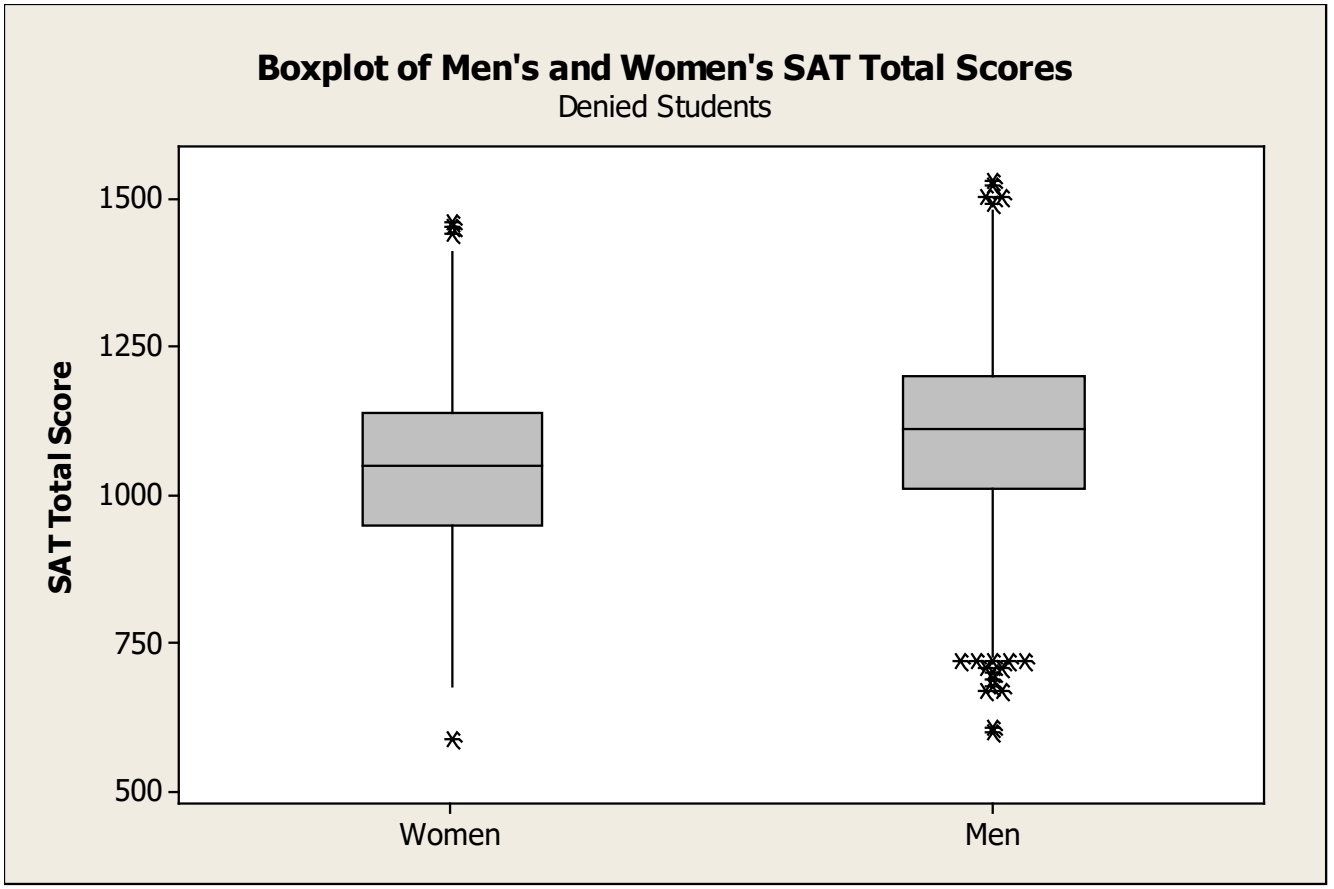
All Denies		Total		
		Women	Men	p-value
Overall GPA	Median	**3.4**	3.2	0.0000
	N	*241*	*2071*	
Core GPA	Median	**3.06**	2.91	0.0000
	N	*255*	*2202*	
Class Rank	Median	**75**	66	0.0000
	N	*171*	*1485*	
SAT Verbal	Median	490	**510**	0.0002
	N	*277*	*2324*	
SAT Math	Median	550	**590**	0.0000
	N	*277*	*2324*	
SAT Total	Median	1050	**1110**	0.0000
	N	*277*	*2324*	

Boxplot of Overall GPA - Denied



WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

Boxplot of SAT Total Scores - Denied



Discussion

- An unbiased process would result in no statistical differences in the metrics of the admitted populations.
- SAT/ACT are intended to be a predictor of first year college grades, not academic achievement.
- Research shows that high school metrics are a better predictor of first year college grades than SAT (correlation coefficient of 0.42 vs. 0.36) Adding the two together gives a correlation coefficient of 0.52.
- 37 studies have shown a consistent gender bias in standardized tests. One study showed a 35 point bias in favor of males on the SAT math section.

Possible Conclusions

- Only the highest ability women are encouraged and/or self-select to apply to the College of Engineering, and men with a much wider range of academic ability are encouraged and/or self-select to do so.
- Women are held to a higher standard than men with regard to their high school performance.
- The admissions counselors put more weight on test scores than high school performance in the admissions process.

Bias at Work?

- According to Sevo & Chubin, “In situations where we evaluate the professional competence of men and women, and where there is much room for interpretation, men will have significant advantage due to unconscious assumptions. Our schema for males is a better fit for professional success, and especially for high-intensity scientific and engineering careers.”

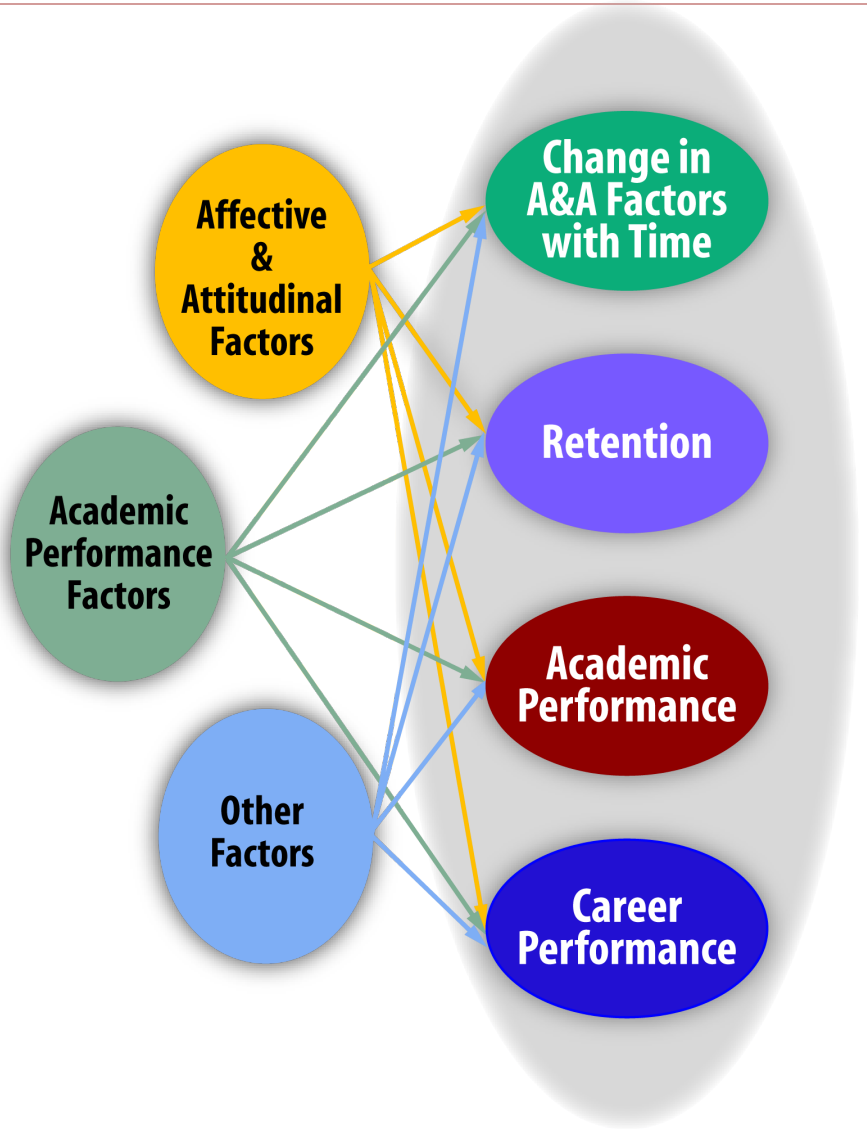
Bias at Work?

- If a policy or tradition of an institution is to require a certain level of achievement on a test that is known to disadvantage a certain group, institutional bias exists.

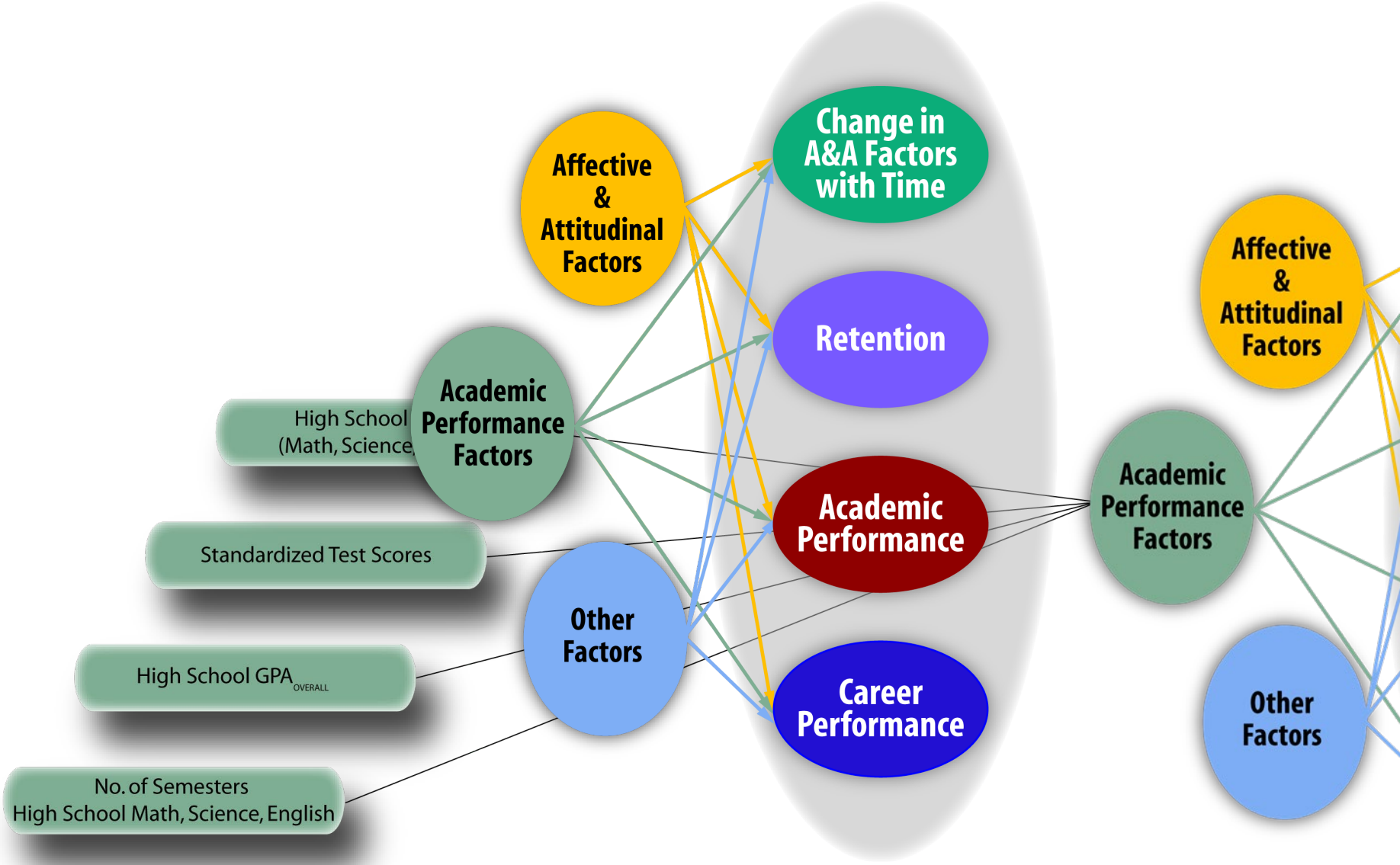
Bottom Line

You can’t graduate a student you don’t admit…

Modeling Student Success

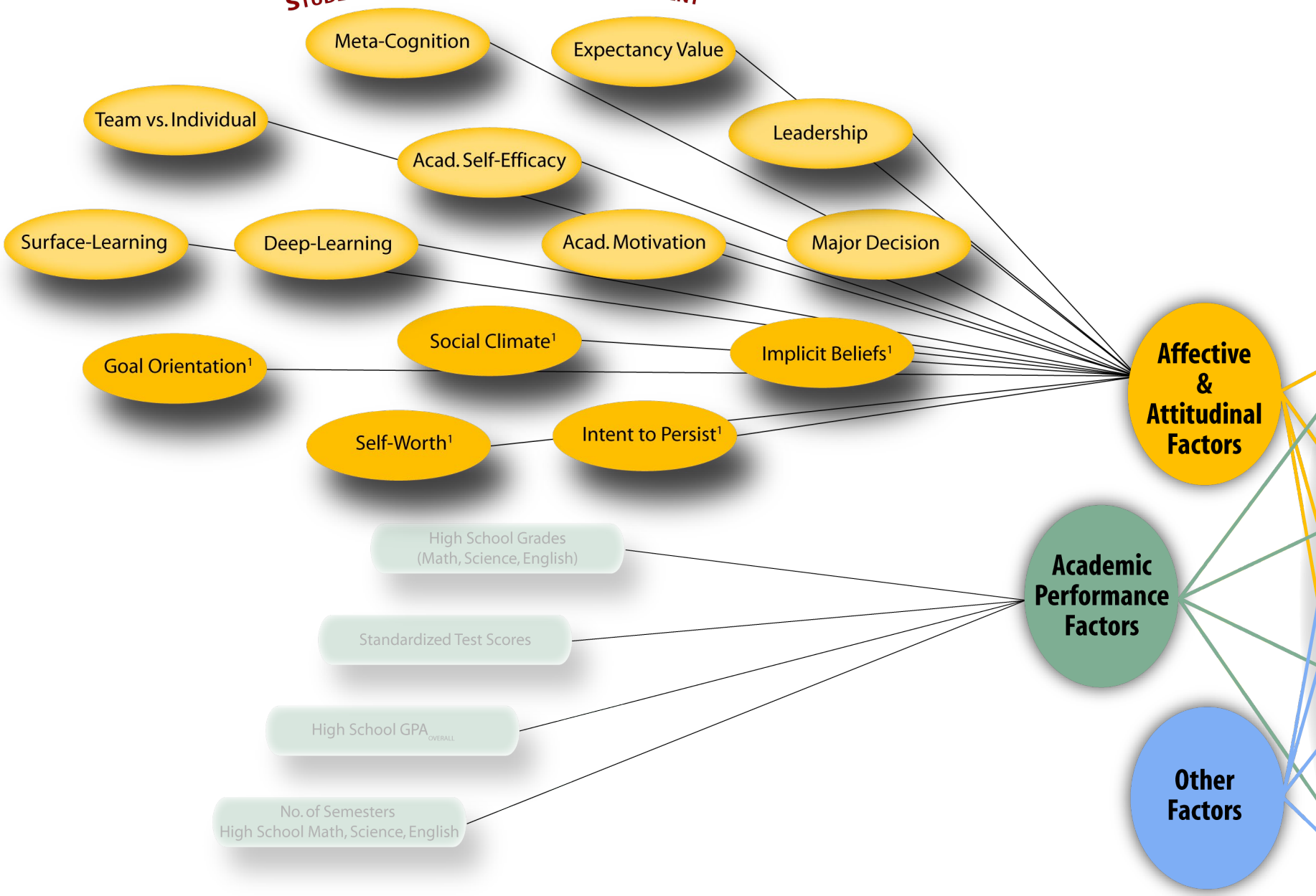


WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

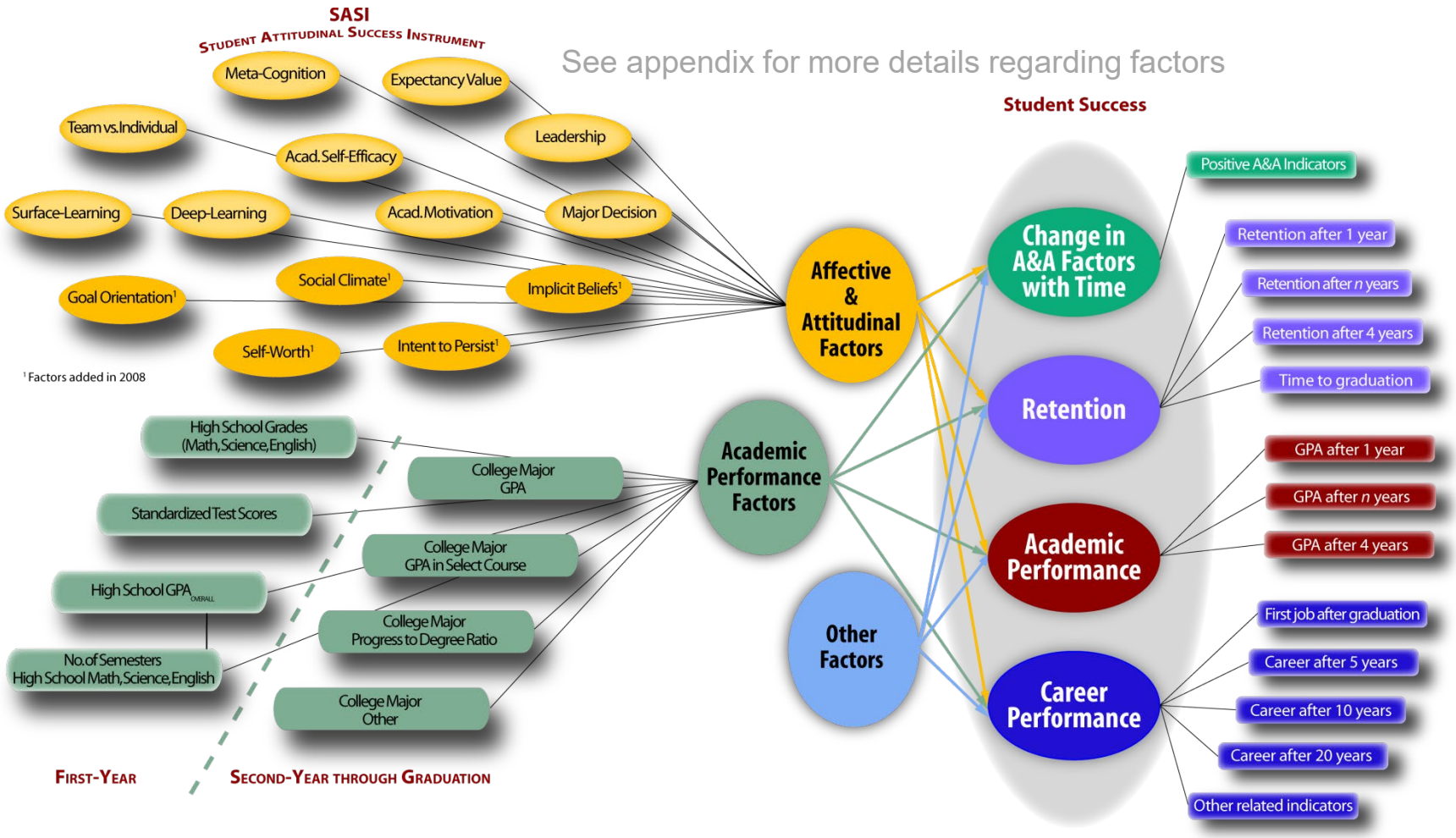

Affective & Attitudinal Factors
Change in A&A Factors with Time
Retention
Academic Performance Factors
High School (Math, Science,
Standardized Test Scores
Academic Performance
Other Factors
High School GPA OVERALL
Career Performance
No. of Semesters High School Math, Science, English
Academic Performance Factors
Affective & Attitudinal Factors
Other Factors

SASI

Student Attitudinal Success Instrument

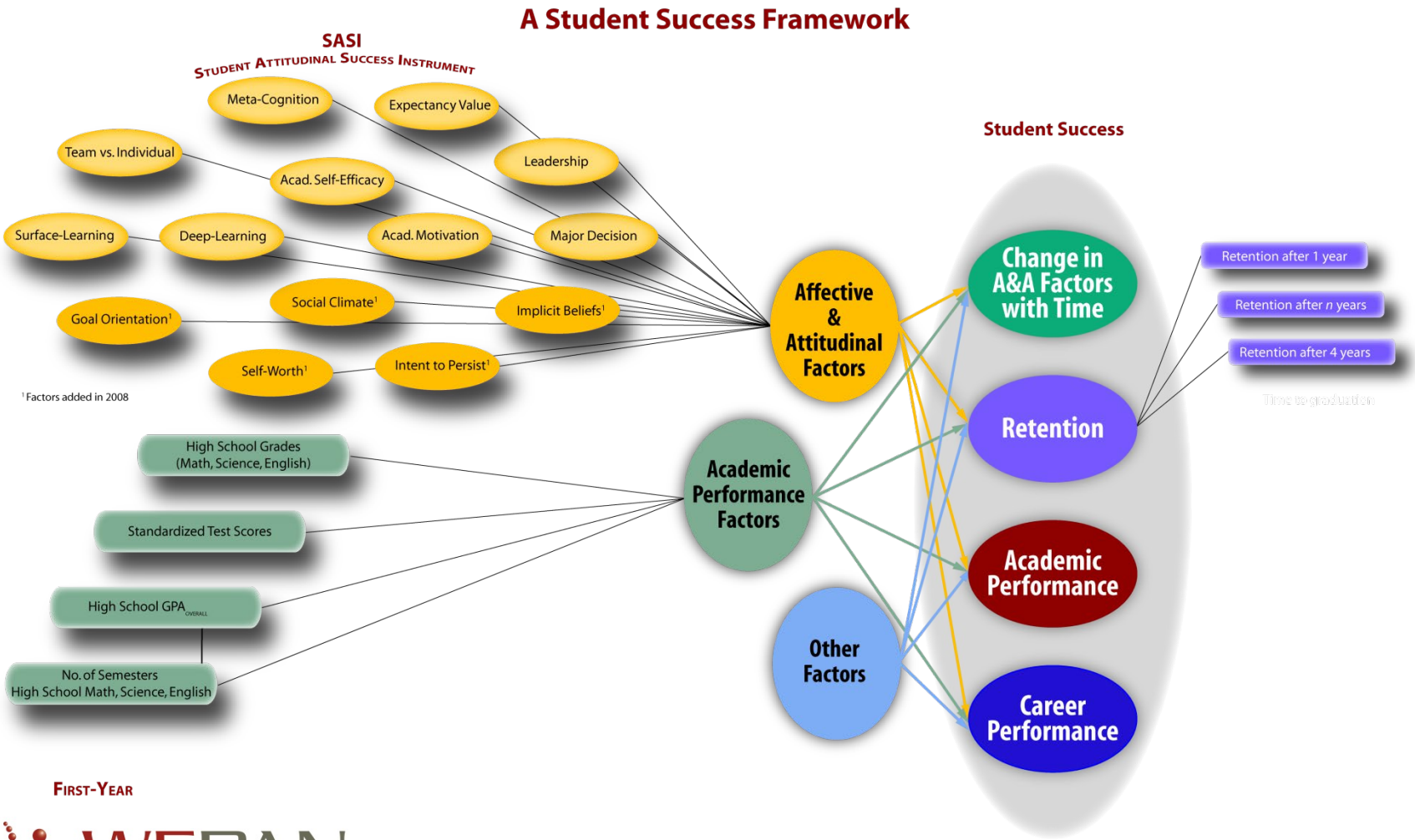


Model of Student Success



Imbrie, Lin & Malyscheff 2008, Reid 2009

Model of Student Success – for this Investigation



WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

Participants

- Incoming engineering students completing each component of the instrument

Cohort	Population	Female	Male
2004 cohort	N = 1615	*N* = 312 (19.3%)	*N* = 1303 (80.6%)
2005 cohort	N = 1781	*N* = 276 (15.5%)	*N* = 1505 (84.5%)
2006 cohort	N = 1779	*N* = 297 (16.7%)	*N* = 1482 (83.3%)
2007 cohort	N = 1711	*N* = 348 (20.3%)	*N* = 1363 (79.7%)

- If examined in aggregate, the incoming population was approximately 83% male, 17% female and based on the following race/ethnicity: 77% white/Caucasian, 9% Asian / Pacific Islander, 3% African American and 3% Hispanic.

WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

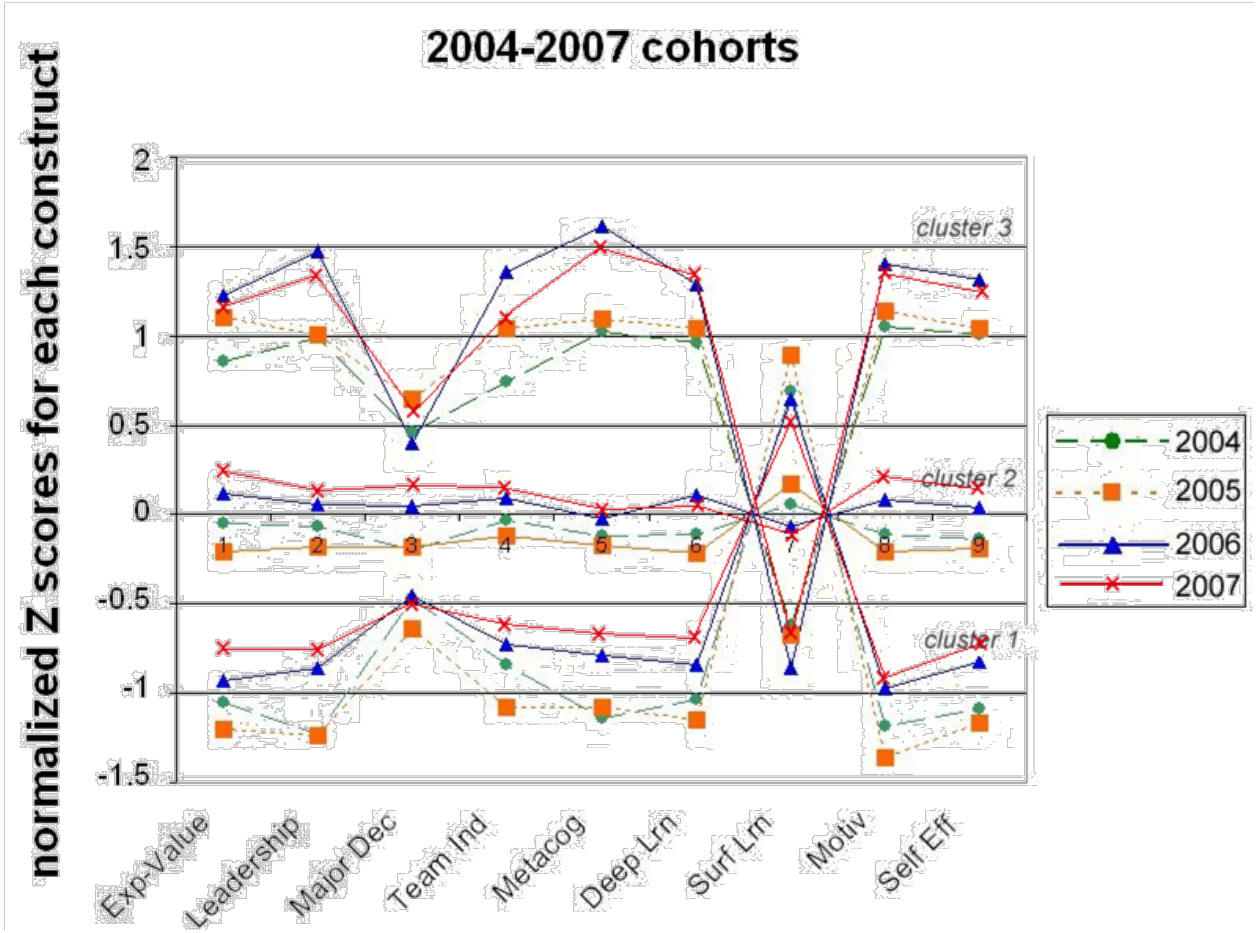
The researchers wish to acknowledge the support provided by a grant from the National Science Foundation, Division of Engineering Education and Centers (Award No. 0416113)

Model Fit

- Psychometric properties
  - Cronbach's coefficient alpha values for all constructs and subfactors > 0.80
    - Spearman-Brown formula used to extrapolate subfactors to 10 items
    - Exceptions:
      - Self-worth construct (0.69, 2007 cohort)
      - Team vs. Individual / Individual orientation subfactor (0.74, 2006 cohort)
- Exploratory Factor Analysis (EFA)
  - Subfactor structure verified or defined for each construct.
- Confirmatory Factor Analysis (CFA)
  - Subfactor structure verified for each construct; and
  - Fit indices in all cases showed excellent fit*
    - GFI>0.90, CFI>0.95
- Normative taxonomy
  - 3 clusters indicated for each cohort (2004 – 2007)
  - 2004 – 2007 cohorts
    - Visual inspection; and
    - Values of Cattell's between cluster similarity coefficient again show three distinctly different clusters.

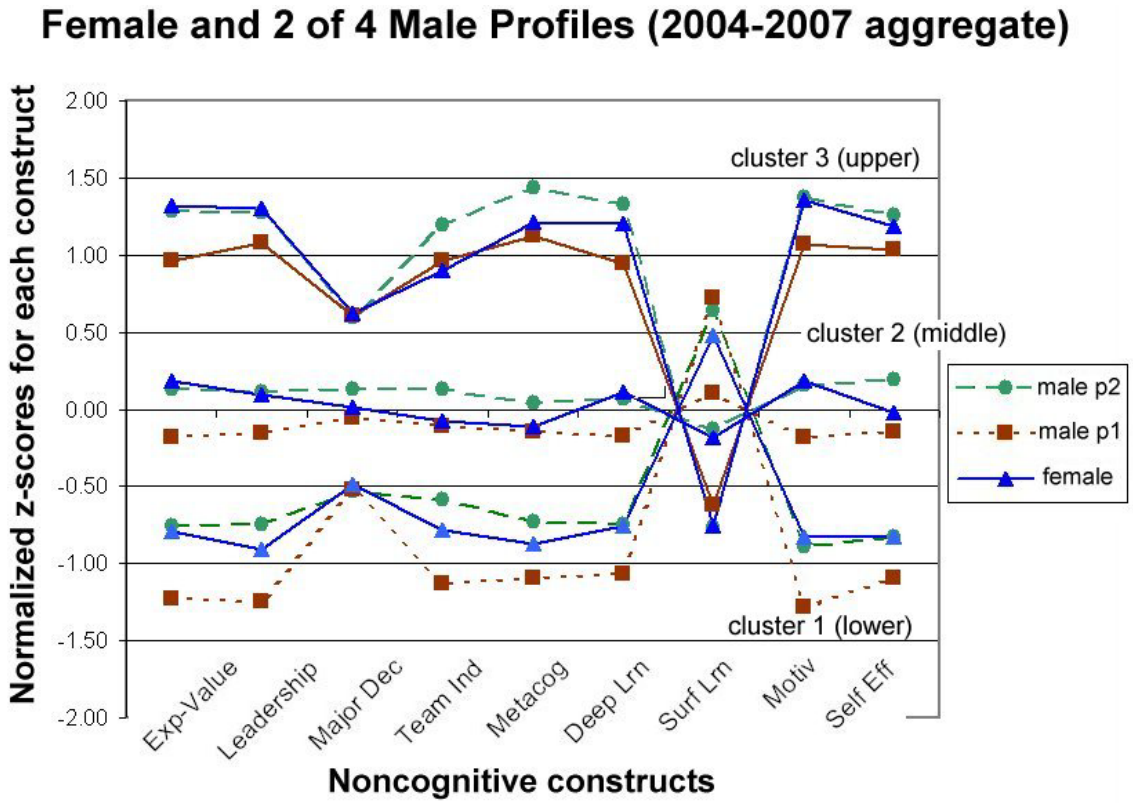
*RMSEA < 0.05 for excellent fit, <0.08 for acceptable fit

Cluster analysis results



WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

Normative taxonomy: female vs. male



	n (female)	*n* (male p1)	*n* (male p2)
Cluster 1 (lower)	570 (32%)	611 (35%)	401 (25%)
Cluster 2 (middle)	892 (50%)	840 (47%)	804 (50%)
Cluster 3 (upper)	317 (18%)	326 (18%)	400 (25%)

WEPAN Women in Engineering ProActive Network — Transforming culture in engineering education

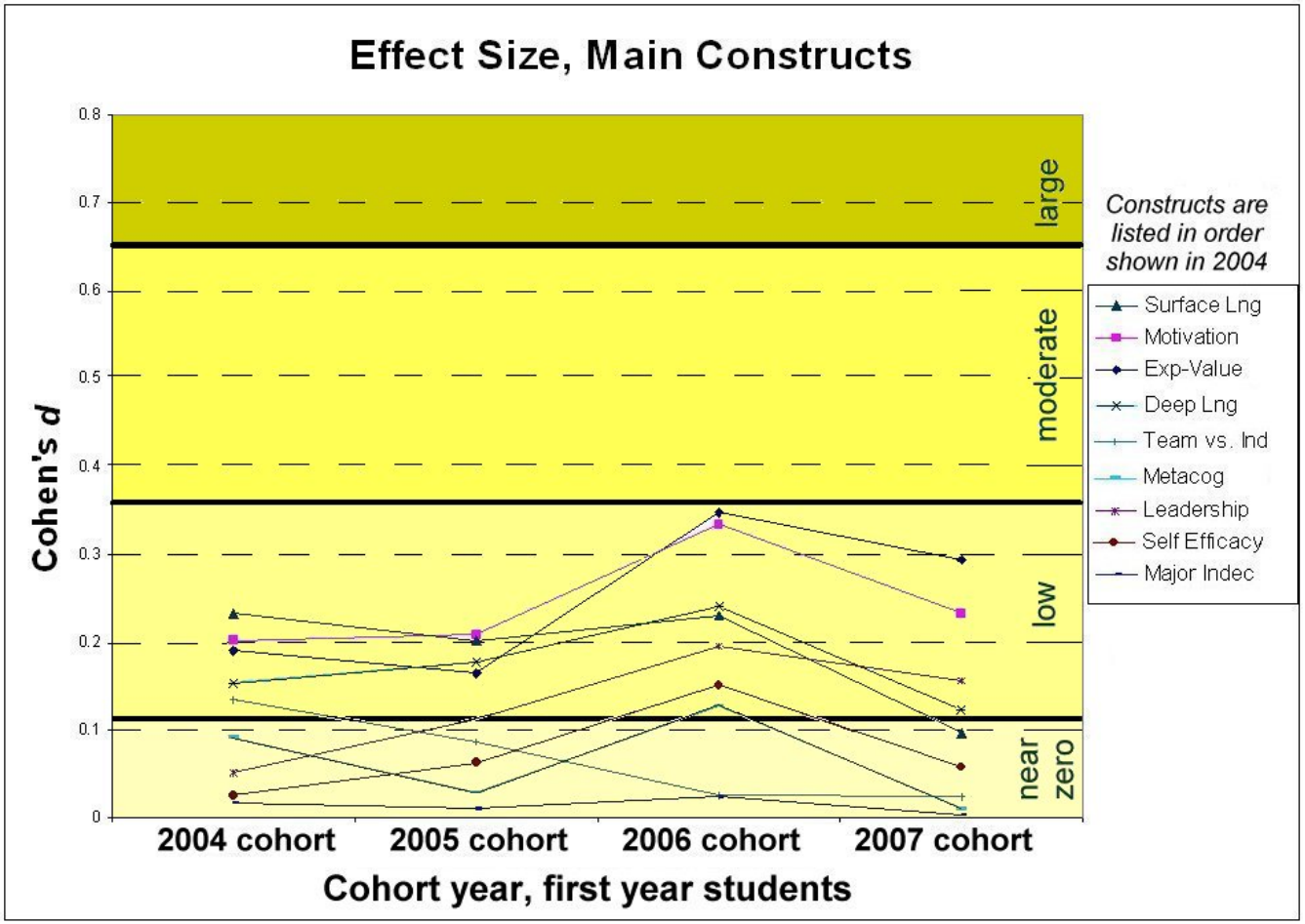
Are there differences between how females vs. males respond to SASI?

- Construct level:
  - 5 of 9 with significant differences, effect size small to near-zero

Contruct	Mean, M (N=5665)	σ, M	Mean, F (N=1234)	σ, F	M - F	Cohen's *d*	*p* (MC)
Expectancy-Value *	3.943	0.360	3.848	0.381	-0.094	-0.254	<0.0001
Motivation *	4.186	0.391	4.087	0.420	-0.098	-0.243	<0.0001
Surface Learning *	2.393	0.476	2.486	0.523	0.092	0.185	<0.0001
Deep Learning *	3.735	0.460	3.652	0.501	-0.082	-0.171	<0.0001
Leadership *	3.959	0.368	3.910	0.377	-0.048	-0.129	0.000
Self Efficacy	4.242	0.459	4.214	0.475	-0.029	-0.061	0.142
Team vs. Individual	3.931	0.381	3.947	0.399	0.016	0.041	0.092
Major Indecision	3.581	0.483	3.580	0.479	-0.001	-0.003	0.784
Metacognition	3.931	0.406	3.932	0.421	0.001	0.001	0.467

**** = Statistically significant difference, small (0.11 < d < 0.35) to near-zero (d < 0.11) effect size***

Results: Trends in Effect Size (2004 – 2007)



- N=1228 female, N=5644 male, aggregate population, 2004-2007

WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

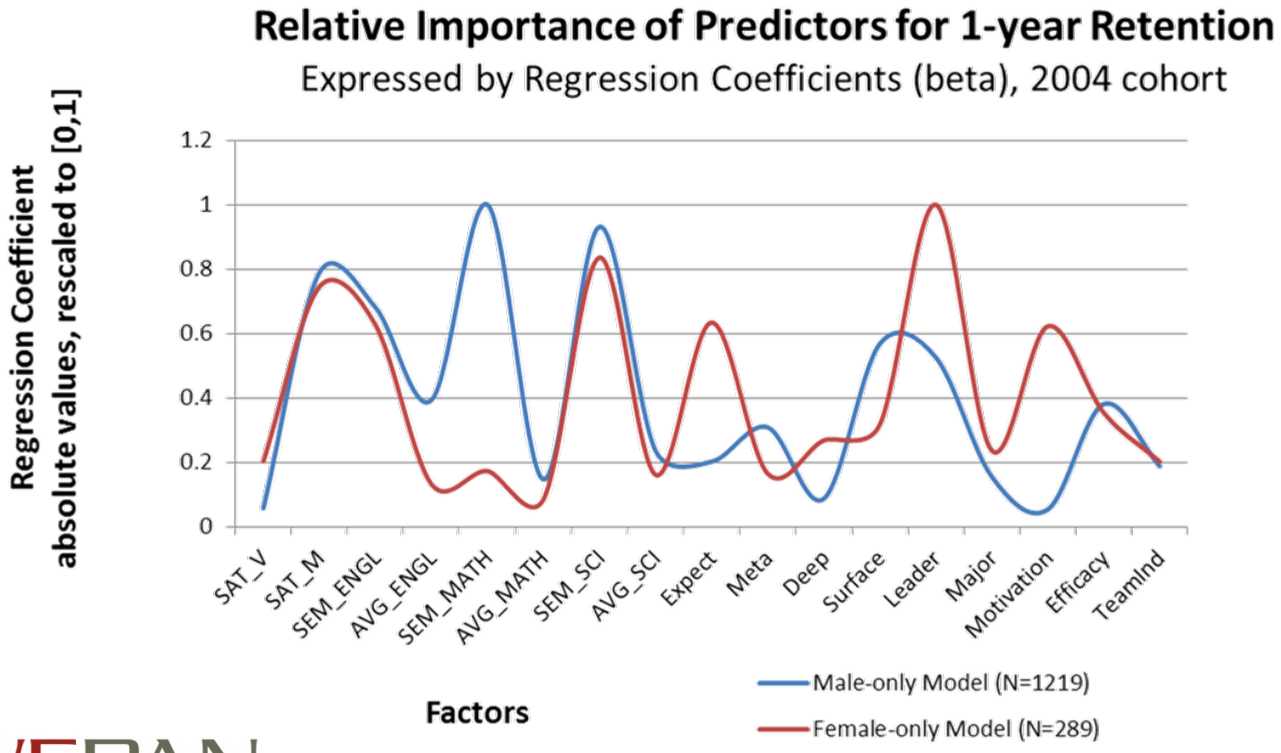
So What?!

Model results provide insight that can be used **institutionally, programmatically, and individually** to make informed decisions that will enhance undergraduate engineering education as well as provide a more personal learning experience for each of our students.

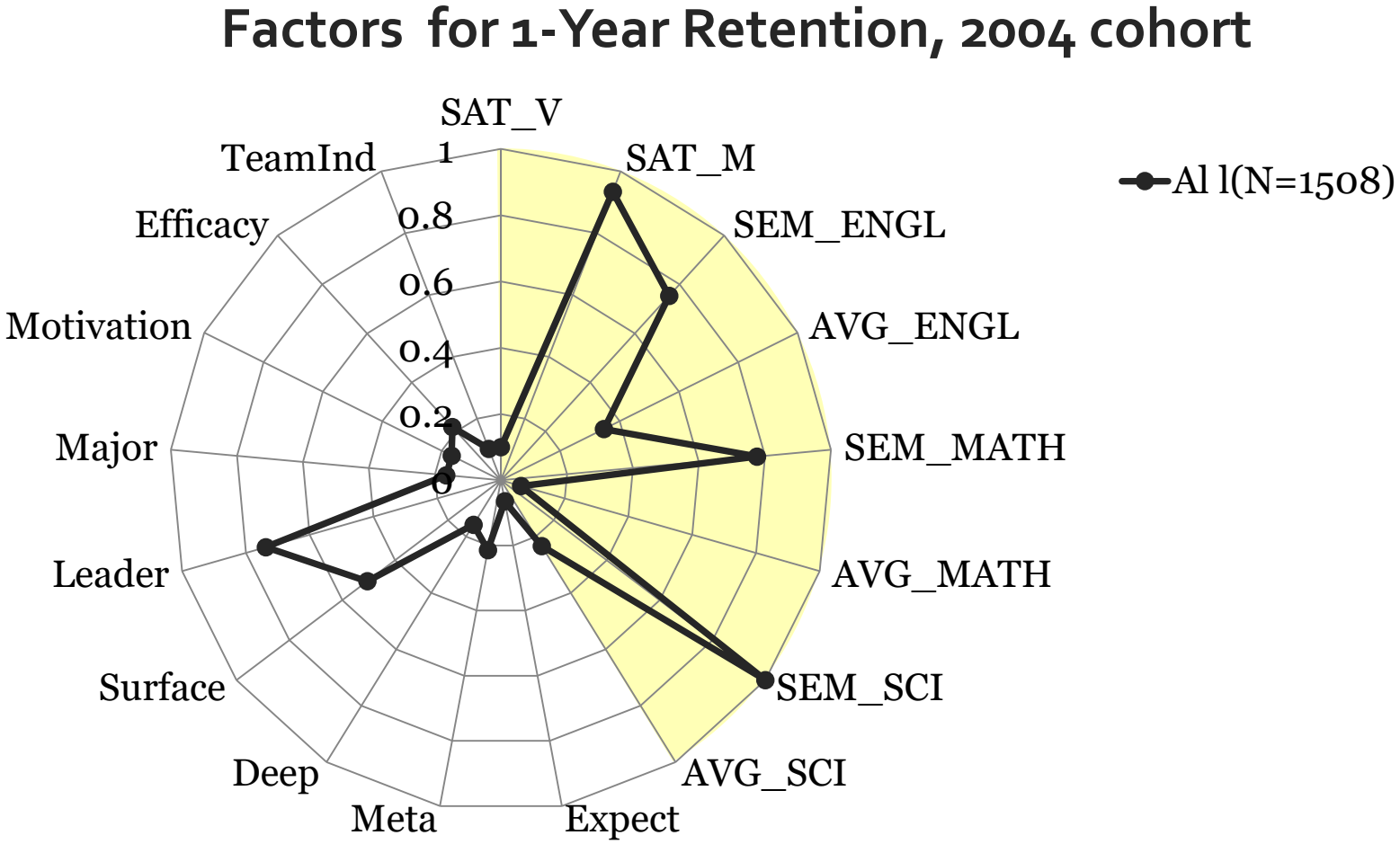
- **Individually**: identify students at risk
- **Programmatically**: make informed programmatic decisions
- **Institutionally**: Inform policy changes

Institutional View

- There are clear differences between the important predictors of 1-year retention for female and male engineering students

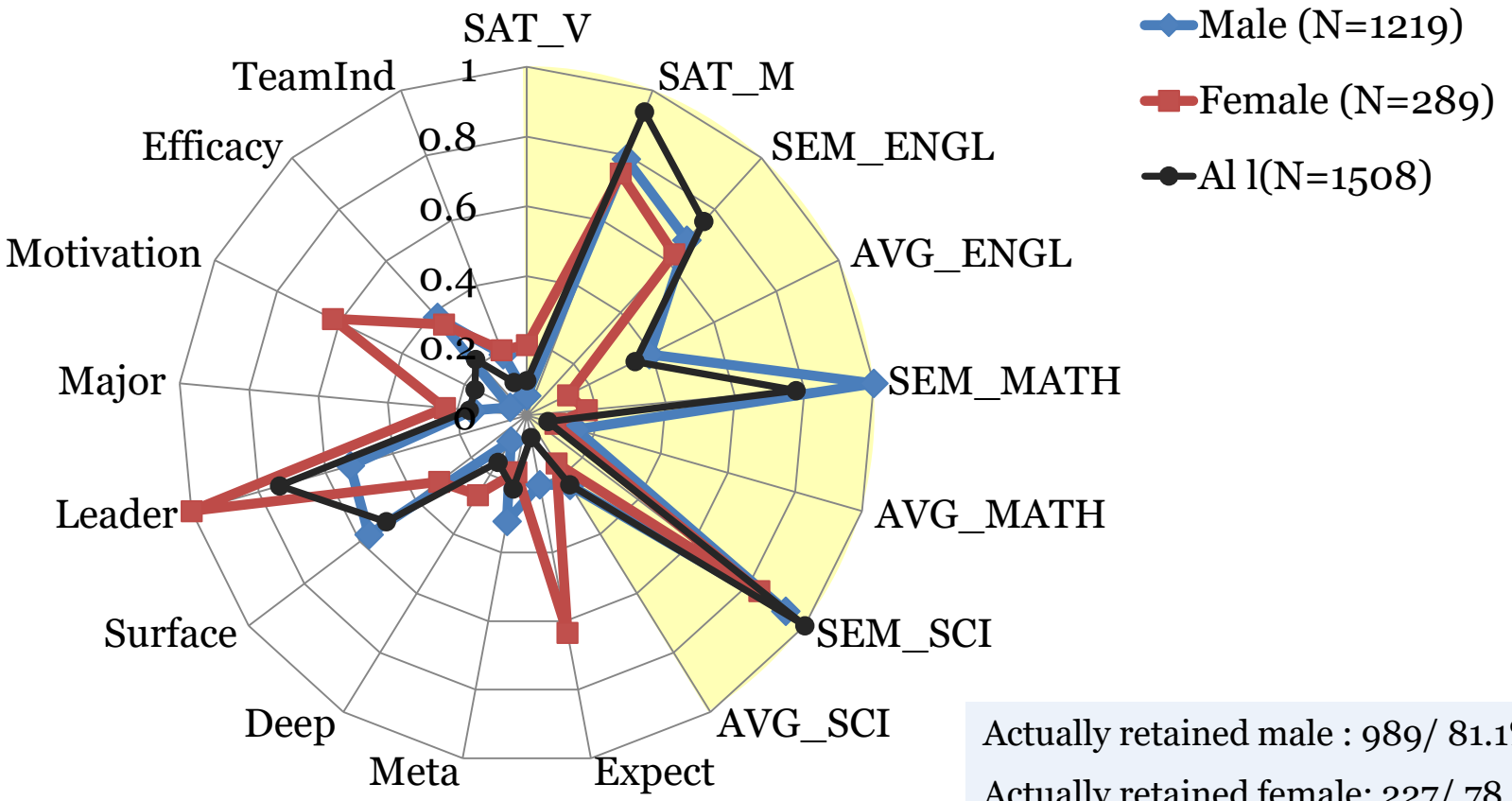


Institutional View – 1 Year Retention



Institutional View – 1 Year Retention

Factors for 1-Year Retention, 2004 cohort



Actually retained male : 989/ 81.1%

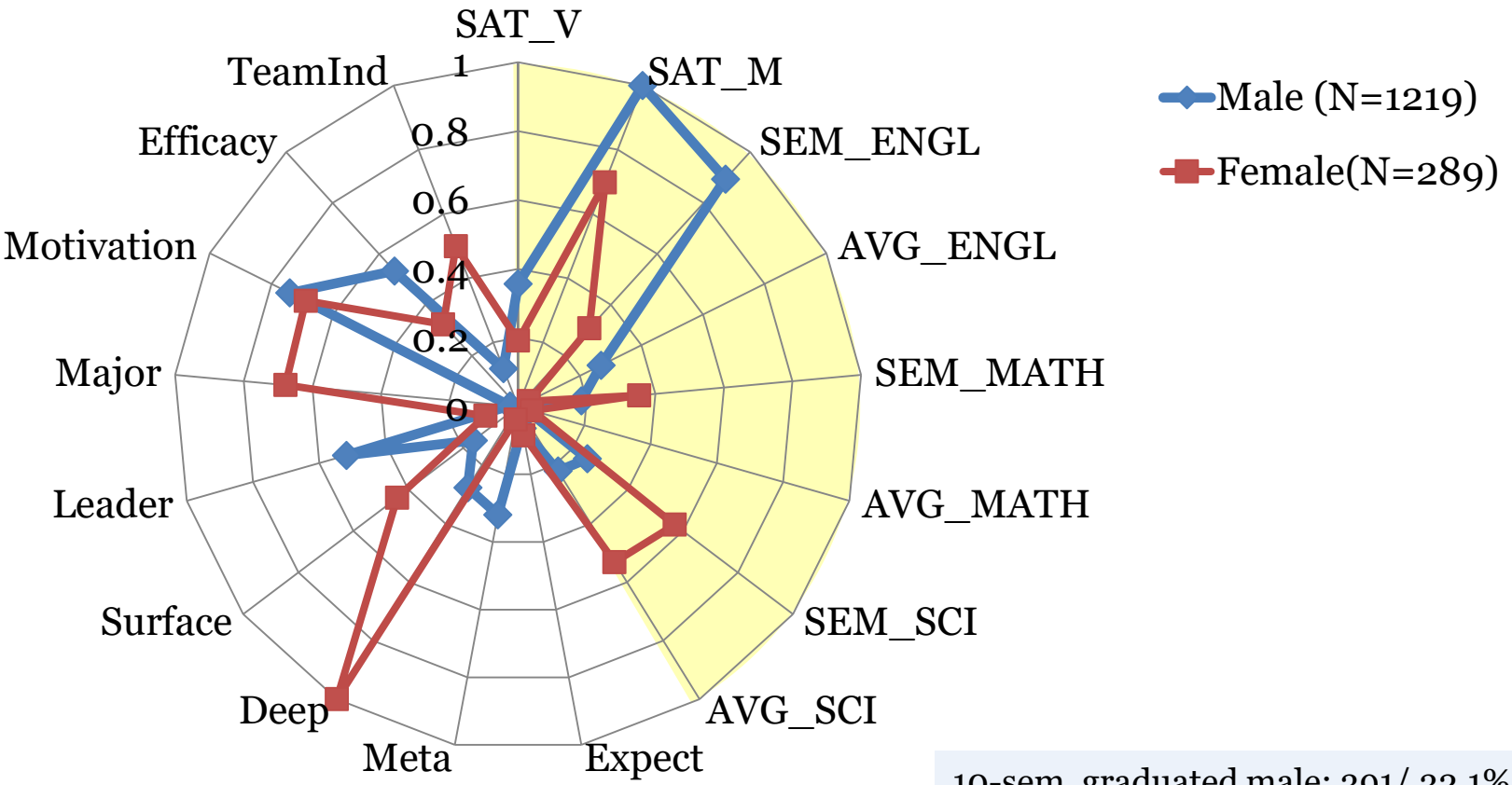
Actually retained female: 227/ 78.5%

Actually retained all: 1216/ 80.6%

WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

Institutional View – Graduation

Factors for 10-Semester Graduation, 2004 cohort



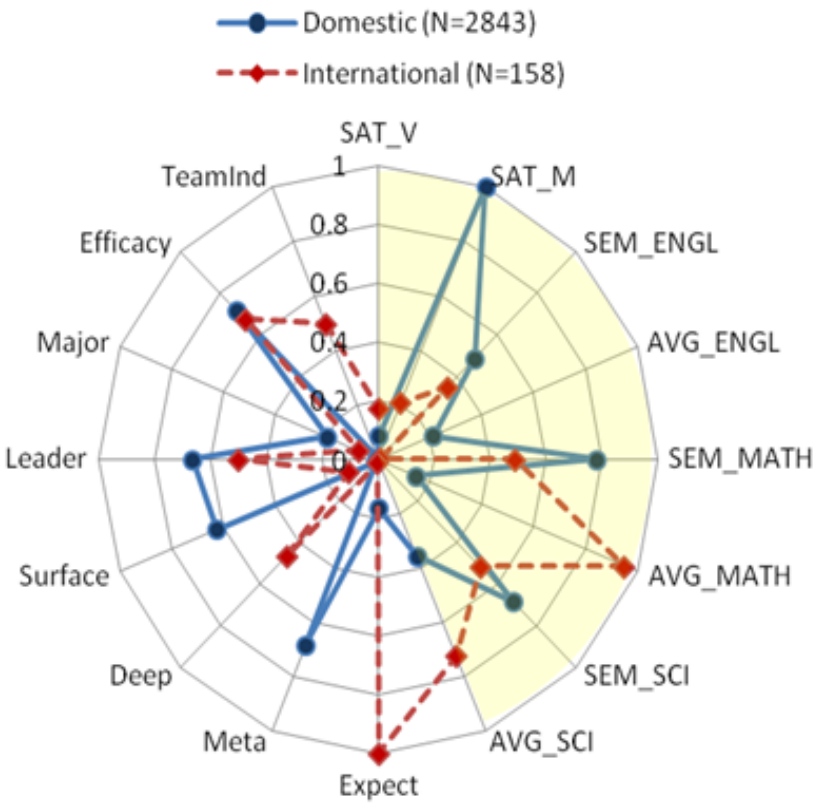
10-sem. graduated male: 391/ 32.1%

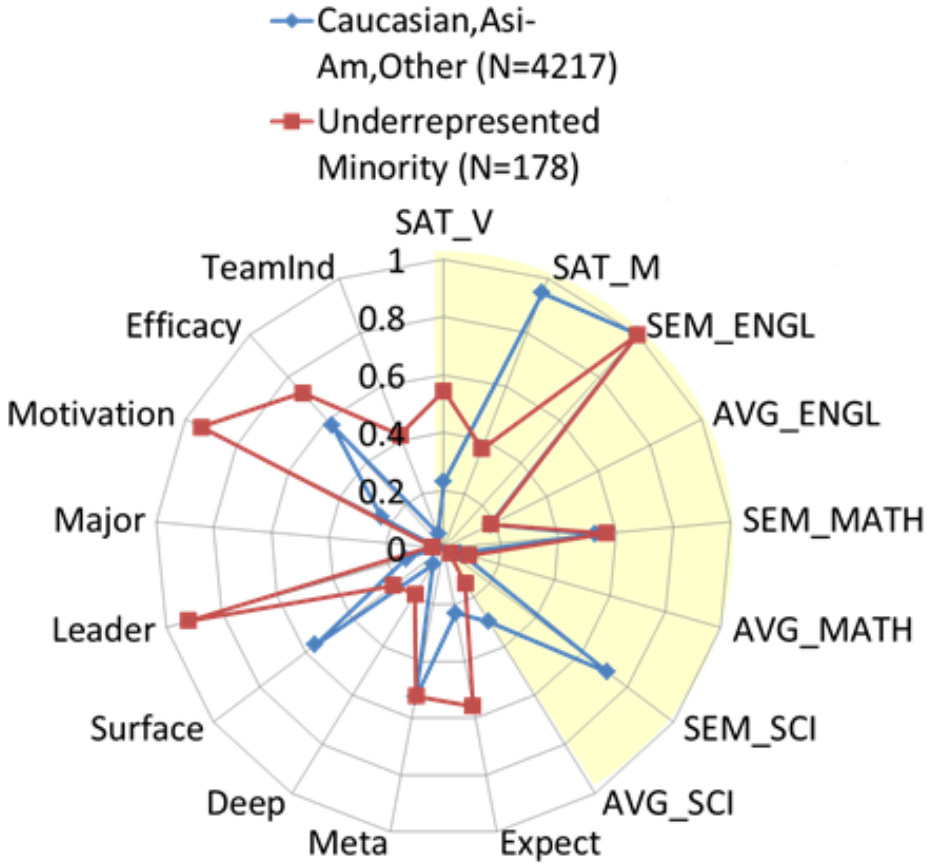
10-sem. graduated female: 100/ 34.6%

WEPAN Women in Engineering ProActive Network — Transforming culture in engineering education

Institutional View – First-Year Retention, International and URM

Aggregated 2004-2006 Cohorts – 1 Year Retention





1 Year Retention

WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

Our Process of Getting People On Board

- Initial data analysis done in 2008 with modeling added in 2009
- Presentation to the Diversity Action Committee (April 2010)
  - Faculty (and eventually staff) committee serves in an advisory capacity to the Dean of Engineering, created in 1999
- Presentation to the Dean of Engineering (April 2010)
- Presentation to the Dean of Admissions and admissions counselors (Domestic Admissions only) (June 2010)
- Presentation to the Provost's Office (July 2010)
- Presentation to CoE Presidential Scholarship Selection Committee (November 2010)
- Presentation to the International Admissions Office (November 2011)

Results: 2011 Admission Class

- For 2011 Admission process
  - female applicants were up an additional 11% (Now 55% over the past 6 years)
  - Female admits were up 19%
- Presidential Scholarship offer results
  - Female awards up from 28 to 51%
- Final Word?
  - Female yield was up 33%
  - First-year class was 26.1% female with a Headcount of 466 – Highest in Purdue's history!
- Used this information for a discussion with the International Admissions office staff

Results: 2012 Admission Class

- For 2012 Admission process,
  - female applicants were up an additional 1% (Now 56% over the past 7 years)
  - Female admits were down by 4.5%

- Final Word
  - Female yield was up another 6.2%
  - First-year class is 27% female with a Headcount of 477– Another all time high in Purdue's history! (unofficial numbers)

In case you are interested!

- We are working on a NSF – STEP II Proposal, Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP), NSF 111-550 (due 9/26/2012)

  Collaborative Research: The Success Scale: Modeling Student Success in Engineering-A Systematic Approach to Measuring the Impact of Both Cognitive and Affective Indicators

- We are interested in adding partners:
  1. Research partners
  2. Data partners
  3. Collaborators

Contact:
P.K. Imbrie
Purdue University
imbrie@purdue.edu
or
Teri Reed-Rhoads
Purdue University
trhoads@purdue.edu

WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

Acknowledgments

- The researchers wish to acknowledge the support provided by a grant from the National Science Foundation, Division of Engineering Education and Centers (Award No. 0416113)
- Joe Lin, Ph.D. Student, School of Engineering Education, Purdue University.
- Qu Jin, Ph.D. Student, School of Engineering Education, Purdue University.
- Dr. Ken Reid, Director of First-Year Engineering, Program Director of Engineering Education and an Associate Professor in Electrical and Computer Engineering, Ohio Northern University.

WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

Scale	Subfactors	General Description	References
Motivation	Control, challenge, curiosity, career outlook	Defined in terms of one's pursuit of an activity for its own sake	Pintrich & Schunk, 1996
Metacognition	Planning, self-checking, cognitive strategy, awareness	Strategies for planning, monitoring and modifying one's own cognitions.	Pintrich & DeGroot, 1990
Propensity towards Deep and/or Surface Learning	Deep: Motive, strategy Surface: Studying, memorization	Propensity of a student within a learning environment to adjust their learning style (deep or surface) to achieve the learning goal.	Biggs, Kember and Leung, 2001
Academic Self Efficacy		"Individuals' beliefs of their competence affect everything they do, and proposes that self-efficacy should prove to be an excellent predictor of their choice and direction of behavior. "	Bandura, 1993 Studies have related self efficacy to retention: Besterfield-Sacre et al., 1999; Pajares, 1996; House, et al., 1995; Bandura, 1986; Lent, Brown and Larkin, 1986
Leadership	Motivation, planning, self-assessment, teammates	The student's self appraisal of their leadership abilities was identified as a non-cognitive characteristic effecting student retention	Tracy & Sedlacek, 1984; Hayden & Holloway, 1985; Ting, 2000
Team vs. Individual Orientation	Individual, team dynamic	Industry continues to seek graduates who can function as a team member and leader	McMaster, 1996
Expectancy-Value	Community involvement, employment opportunities, persistence, social engagement	Perception of the expectancy and value of academic, social and employment expectancies	Wigfield & Eccles, 2000; Besterfield-Sacre et al., 1999; Hayden & Holloway, 1985; Schaefers et al., 1997
Major Decision	Certainty of decision, difficulty in decision, personal issues, urgency of decision, independence	Related to student success	Schaefers et al., 1997; Smith & Baker, 1987; Haislett & Hafer, 1990; Osipow, 1999

References

- American Association for the Advancement of Science & Association of American Universities. (2010). Handbook on Diversity and the Law: Navigating a Complex Landscape to Foster Greater Faculty and Student Diversity in Higher Education. Washington, DC.
- Holloway, Beth M., P.K. Imbrie, Teri Reed-Rhoads (2011), "A Holistic Review of Gender Differences in Engineering Admissions and Early Retention", *15th International Conference for Women Engineers and Scientists*, Adelaide, Australia.
- Holloway, Beth M. and Teri Reed-Rhoads (2008), "Between Recruiting and Retention: A Study of Admissions Practices and Their Impact on Women in Engineering," *Global Colloquium on Engineering Education*, Capetown, South Africa.
- Hu, L. and P. Bentler, (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural Equation Modeling, 6 (1): 1-55.
- Imbrie P.K., Lin, J.J., and Malyscheff, A. (2008). "Artificial intelligence methods to forecast engineering students' retention based on cognitive and non-cognitive factors", ASEE Annual Conference and Exposition, Pittsburg, PA.
- Marsh, H. W., J. R. Balla, and R. P. McDonald, (1988). Goodness-of-Fit in Confirmatory Factor Analysis: The effect of sample size. Psychological Bulletin, 103 (3): 391-410.
- Reid, K. J. (2009). *Development of the student attitudinal success instrument: Assessment of first year engineering students including differences by gender.* Purdue University. *ProQuest Dissertations and Theses,* Retrieved from http://search.proquest.com/docview/304989887?accountid=13360. (304989887).
- Sevo, R., & Chubin, D. E. (2008). Bias Literacy: A Review of Concepts and Research on Discrimination Retrieved March 26, 2012, from http:\\momox.org\BiasLiteracy.pdf
- Tuckman, B. W., (1999). Conducting educational research (5th edition), New York, NY, Wadsworth Group.
- Tanguma, J., (2001). Effects of sample size on the distribution of selected fit indices: A graphical approach. Educational and Psychological Measurements, 61 (5): 759-776.

Asking Questions and Discussion

- **Participant microphones are muted for webinar quality.**
- **Questions and discussion are hosted at: www.wepanknowledgecenter.org > Log In or Register > My Professional Interest Groups > Gender Bias in Admissions Forum**
- **Presenters will stay on the webinar for 30 minutes for expanded discussion!**

Enjoy WEPAN's webinar?

Please support WEPAN's work—make a donation!

Pay a personal tribute to someone who has made a difference in your life or in the lives of others.

www.wepan.org

WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education

Thank You!





- **Links to the PowerPoint and recorded webinar will be posted at www.wepan.org > Webinars.**
- **Share with your colleagues!**
- **Sign up for more webinar notifications at: www.wepanknowledgecenter.org**

WEPAN
Women in Engineering ProActive Network
Transforming culture in engineering education