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
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• 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
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
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
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

Prospects

Applicants

Admits

Deposits

Yield
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

<table>
<thead>
<tr>
<th>Metric</th>
<th>All Applicants</th>
<th>Total</th>
<th>Women</th>
<th>Men</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall GPA</td>
<td>Median 3.9</td>
<td></td>
<td></td>
<td>3.7</td>
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</tr>
<tr>
<td></td>
<td>N 4457</td>
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<td></td>
<td>17441</td>
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</tr>
<tr>
<td>Core GPA</td>
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<tr>
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<td>N 4603</td>
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<tr>
<td>Class Rank</td>
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<td>86</td>
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<td></td>
<td>N 3029</td>
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<td>11346</td>
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</tr>
<tr>
<td>SAT Verbal</td>
<td>Median 620</td>
<td></td>
<td></td>
<td>600</td>
<td>0.0000</td>
</tr>
<tr>
<td></td>
<td>N 4611</td>
<td></td>
<td></td>
<td>18148</td>
<td></td>
</tr>
<tr>
<td>SAT Math</td>
<td>Median 670</td>
<td></td>
<td></td>
<td>680</td>
<td>0.0000</td>
</tr>
<tr>
<td></td>
<td>N 4611</td>
<td></td>
<td></td>
<td>18148</td>
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<tr>
<td>SAT Total</td>
<td>Median 1300</td>
<td></td>
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<td>1280</td>
<td>0.0000</td>
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<td>N 4611</td>
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<td></td>
<td>18148</td>
<td></td>
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</tbody>
</table>
Boxplot of Overall GPA - Applicants

Boxplot of Overall GPA's for Men and Women
All Applicants to Engineering
Boxplot of SAT Total Scores - Applicants

Boxplot of SAT Total Scores for Men and Women
All Applicants to Engineering
### Analysis of Metric Medians for Admits to Engineering

<table>
<thead>
<tr>
<th>All Admits to Engineering</th>
<th>Total</th>
<th>Women</th>
<th>Men</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall GPA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>4.0</td>
<td>3.8</td>
<td></td>
<td>0.0000</td>
</tr>
<tr>
<td>N</td>
<td>3829</td>
<td>12790</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Core GPA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>3.80</td>
<td>3.60</td>
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</tr>
<tr>
<td>N</td>
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<td>13201</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Class Rank</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>94</td>
<td>90</td>
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<tr>
<td>N</td>
<td>2558</td>
<td>7963</td>
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<tr>
<td><strong>SAT Verbal</strong></td>
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<td></td>
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<td></td>
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<tr>
<td>Median</td>
<td>630</td>
<td>620</td>
<td></td>
<td>0.0000</td>
</tr>
<tr>
<td>N</td>
<td>3911</td>
<td>13127</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SAT Math</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>680</td>
<td>700</td>
<td></td>
<td>0.0000</td>
</tr>
<tr>
<td>N</td>
<td>3911</td>
<td>13127</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SAT Total</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>1320</td>
<td>1330</td>
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<td>0.0100</td>
</tr>
<tr>
<td>N</td>
<td>3911</td>
<td>13127</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Boxplot of Overall GPA - Admits

Boxplot of Overall GPA's for Men and Women
All Admits to Engineering
Boxplot of SAT Total Scores - Admits

Boxplot of SAT Total Scores for Men and Women
All Admits to Engineering
## Analysis of Metric Medians forDenied Students

<table>
<thead>
<tr>
<th>Metric</th>
<th>All Denies</th>
<th>Total</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women</td>
<td>Men</td>
<td></td>
</tr>
<tr>
<td>Overall GPA</td>
<td>Median</td>
<td>3.4</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>241</td>
<td>2071</td>
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<tr>
<td>Core GPA</td>
<td>Median</td>
<td>3.06</td>
<td>2.91</td>
</tr>
<tr>
<td></td>
<td>N</td>
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<tr>
<td>Class Rank</td>
<td>Median</td>
<td>75</td>
<td>66</td>
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<td></td>
<td>N</td>
<td>171</td>
<td>1485</td>
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<tr>
<td>SAT Verbal</td>
<td>Median</td>
<td>490</td>
<td>510</td>
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<td>N</td>
<td>277</td>
<td>2324</td>
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<tr>
<td>SAT Math</td>
<td>Median</td>
<td>550</td>
<td>590</td>
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<td>N</td>
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<td>2324</td>
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<tr>
<td>SAT Total</td>
<td>Median</td>
<td>1050</td>
<td>1110</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>277</td>
<td>2324</td>
</tr>
</tbody>
</table>
Boxplot of Overall GPA - Denied

Boxplot of Men's and Women's Overall GPA
Denied Students

Overall GPA

Women

Men

***

**

***

***
Boxplot of SAT Total Scores - Denied

Boxplot of Men's and Women's SAT Total Scores
Denied Students
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.
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...
Model of Student Success

See appendix for more details regarding factors

Imbrie, Lin & Malyscheff 2008, Reid 2009
Model of Student Success – for this Investigation

A Student Success Framework

SASI
Student Attitudinal Success Instrument

- Team vs. Individual
- Meta-Cognition
- Expectancy Value
- Leadership
- Acad. Self-Efficacy
- Acad. Motivation
- Major Decision
- Social Climate
- Implicit Beliefs
- Intent to Persist
- Self-Worth
- Goal Orientation

Factors added in 2008:
- High School Grades (Math, Science, English)
- Standardized Test Scores
- High School GPA
- No. of Semesters High School Math, Science, English

Affective & Attitudinal Factors

Academic Performance Factors

Change in A&A Factors with Time

Retention
Academic Performance
Career Performance
Other Factors

First-Year

WEPAW
Women in Engineering ProActive Network
Transforming culture in engineering education
Participants

- Incoming engineering students completing each component of the instrument

<table>
<thead>
<tr>
<th>Cohort</th>
<th>Population</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004 cohort</td>
<td>N = 1615</td>
<td>N = 312 (19.3%)</td>
<td>N = 1303 (80.6%)</td>
</tr>
<tr>
<td>2005 cohort</td>
<td>N = 1781</td>
<td>N = 276 (15.5%)</td>
<td>N = 1505 (84.5%)</td>
</tr>
<tr>
<td>2006 cohort</td>
<td>N = 1779</td>
<td>N = 297 (16.7%)</td>
<td>N = 1482 (83.3%)</td>
</tr>
<tr>
<td>2007 cohort</td>
<td>N = 1711</td>
<td>N = 348 (20.3%)</td>
<td>N = 1363 (79.7%)</td>
</tr>
</tbody>
</table>

- 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.
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

2004-2007 cohorts

normalized Z scores for each construct

Cluster 1
Cluster 2
Cluster 3

2004
2005
2006
2007
Normative taxonomy: female vs. male

Female and 2 of 4 Male Profiles (2004-2007 aggregate)

<table>
<thead>
<tr>
<th>Cluster</th>
<th>n (female)</th>
<th>n (male p1)</th>
<th>n (male p2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1 (lower)</td>
<td>570 (32%)</td>
<td>611 (35%)</td>
<td>401 (25%)</td>
</tr>
<tr>
<td>Cluster 2 (middle)</td>
<td>892 (50%)</td>
<td>840 (47%)</td>
<td>804 (50%)</td>
</tr>
<tr>
<td>Cluster 3 (upper)</td>
<td>317 (18%)</td>
<td>326 (18%)</td>
<td>400 (25%)</td>
</tr>
</tbody>
</table>
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

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

* = Statistically significant difference, small (0.11 < d < 0.35) to near-zero (d < 0.11) effect size
Results: Trends in Effect Size (2004 – 2007)

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

Factors for 1-Year Retention, 2004 cohort

SAT_V
SAT_M
SEM_ENGL
AVG_ENGL
SEM_MATH
AVG_MATH
SEM_SCI
AVG_SCI
TeamInd
Efficacy
Motivation
Major
Leader
Surface
Deep
Meta
Expect

Al l(N=1508)
Institutional View – 1 Year Retention

Factors for 1-Year Retention, 2004 cohort

- SAT_V
- SAT_M
- SEM_ENGL
- AVG_ENGL
- SEM_MATH
- AVG_MATH
- SEM_SCI
- AVG_SCI
- Expect
- Meta
- Deep
- Surface
- Leader
- Motivation
- Efficacy
- TeamInd

Male (N=1219)
Female (N=289)
Al l(N=1508)

Actually retained male: 989/ 81.1%
Actually retained female: 227/ 78.5%
Actually retained all: 1216/ 80.6%
Institutional View – Graduation

Factors for 10-Semester Graduation, 2004 cohort

10-sem. graduated male: 391/ 32.1%
10-sem. graduated female: 100/ 34.6%
Institutional View – First-Year Retention, International and URM Aggregated 2004-2006 Cohorts – 1 Year Retention
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:
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Acknowledgments

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


Asking Questions and Discussion

• Participant microphones are muted for webinar quality.

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