Using Predictive Analytics to Improve the Bottom Line

http://www.unr.edu/ia/research

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Challenges for Institutional Research

- Compliance vs. Self-Improvement
- Developing a culture of evidence
- From reporting to analysis
- Converting results into ‘actionable’ statements
- From ‘data silos’ to integrated warehouse
- Leverage technology, stay abreast of tech
- Follow highest standards, best practices
- Know your customers, mission
- Empower staff, continuous honing of skills
The Institutional Context

- Student success: a strategic imperative
- Performance-based state funding impending
- Dwindling state support for higher education
- Tuition-revenue maximization
- Reputation and marketing
- Effective senior-management support by IR
- K-16 Education Collaborative
  - High school transcript study
  - High school gateway curriculum
  - Reversing the tide of college remediation
# The Institutional Context

<table>
<thead>
<tr>
<th></th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Enrollment</strong></td>
<td>16,862</td>
<td>17,679</td>
<td>18,004</td>
</tr>
<tr>
<td>Undergraduate</td>
<td>12,878</td>
<td>13,660</td>
<td>14,415</td>
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<tr>
<td>Graduate</td>
<td>3,294</td>
<td>3,248</td>
<td>2,935</td>
</tr>
<tr>
<td>First-Professional</td>
<td>241</td>
<td>246</td>
<td>249</td>
</tr>
<tr>
<td>(Medical School)</td>
<td></td>
<td></td>
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<tr>
<td>Non-Degree</td>
<td>449</td>
<td>525</td>
<td>405</td>
</tr>
<tr>
<td><strong>Ethnicity/Foreign Students</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Indian/Alaskan</td>
<td>180</td>
<td>173</td>
<td>154</td>
</tr>
<tr>
<td>Asian American*</td>
<td>1,053</td>
<td></td>
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<tr>
<td>Asian/Pacific Islander</td>
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<td>1,352</td>
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<tr>
<td>Black, Non-Hispanic</td>
<td>448</td>
<td>500</td>
<td>547</td>
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<tr>
<td>Hispanic</td>
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<td>1,617</td>
<td>1,970</td>
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<td>Multi-Ethnic*</td>
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<tr>
<td>Pacific Islander*</td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White, Non-Hispanic</td>
<td>11,537</td>
<td>12,247</td>
<td>11,919</td>
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<tr>
<td>Foreign Students</td>
<td>671</td>
<td>632</td>
<td>594</td>
</tr>
<tr>
<td>Unreported</td>
<td>1,450</td>
<td>1,128</td>
<td>907</td>
</tr>
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</table>
The Institutional Context

New full-time freshman enrollment

- **2007 Fall**: Total 2,226, Nevada residents 1,854, Out of State 372
- **2008 Fall**: Total 2,261, Nevada residents 1,909, Out of State 352
- **2009 Fall**: Total 2,131, Nevada residents 1,787, Out of State 344
- **2010 Fall**: Total 2,764, Nevada residents 2,165, Out of State 599
- **2011 Fall**: Total 2,880, Nevada residents 2,045, Out of State 835
Examples of Actionable Findings

• Study abroad enhances academic performance

• Impact of classroom facilities/schedule on learning
  – Smaller rooms are preferable
  – After-2pm courses associated with lower performance

• Student financial aid to maximize retention
  – Tuition discounts for middle-income students
  – More academic support for low-income students

• Effect of high school environment on freshmen success
  – [http://www.uark.edu/ua/der/EWPA/Research/Achievement/1808.html](http://www.uark.edu/ua/der/EWPA/Research/Achievement/1808.html)
In Need of Math Remediation* at UNR

High School Senior Year Math

<table>
<thead>
<tr>
<th>Math Course</th>
<th>Percent</th>
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<tbody>
<tr>
<td>Calculus</td>
<td>41</td>
</tr>
<tr>
<td>Pre-Calc, Trig</td>
<td>495</td>
</tr>
<tr>
<td>Stats, Pre-IB</td>
<td>408</td>
</tr>
<tr>
<td>Algebra 4(8)</td>
<td>982</td>
</tr>
<tr>
<td>Lower math</td>
<td>218</td>
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</table>

N = 41, 495, 408, 982, 218

* ACT math < 21 or SAT math < 500
First-Year Momentum* at UNR by AP Intensity

Number of AP Subjects in High School

*100-pt index of first-year GPA and completed credits
Raising Graduation Rates
Comparing 4-year and 6-year-plus Graduates

Opportunity cost of staying one more year in college = $32,000 in foregone earnings plus annual increase in tuition cost.*

<table>
<thead>
<tr>
<th>Metric</th>
<th>4-year Graduates</th>
<th>6-year Graduates</th>
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<tr>
<td>HS GPA</td>
<td>3.5</td>
<td>3.2</td>
</tr>
<tr>
<td>ACT</td>
<td>24.5</td>
<td>22.2</td>
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<tr>
<td>CoreHum 201 Grade</td>
<td>3.3 vs 2.6</td>
<td></td>
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<tr>
<td>MathGPA</td>
<td>3.12 vs 2.4</td>
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<tr>
<td>Honors Courses</td>
<td>14% vs 5%</td>
<td></td>
</tr>
<tr>
<td>Final GPA</td>
<td>3.4 vs 2.9</td>
<td></td>
</tr>
<tr>
<td>Change in Major</td>
<td>25% vs 55%</td>
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<tr>
<td>Capstone GPA</td>
<td>3.5 vs 3.2</td>
<td></td>
</tr>
<tr>
<td>Avg annual remaining need</td>
<td>$2,610 vs $3,270</td>
<td></td>
</tr>
<tr>
<td>Internship</td>
<td>31% vs 24%</td>
<td></td>
</tr>
<tr>
<td>Difference in avg semester load</td>
<td>3 credits</td>
<td></td>
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</table>

Predicting Student Success

Relevant Previous Research

At-Risk Forecasting Model

- Identify at-risk freshmen students after initial matriculation for *early* intervention program
- Develop coefficients for predictors determining student fall-to-spring/fall dropout risk
  - Logistic regression model using historical cohorts as training dataset
  - Maximize prediction accuracy with balanced dataset
- Dropout risk scoring for new freshmen
  - Transformation of the logit($\rho$) into probability scores
  - Decile grouping of scored students
  - Compare deciles with actual enrollment and other predicted enrollment (MAP-Works: [http://www.unr.edu/mapworks](http://www.unr.edu/mapworks))
- Reporting of dropout risk via secure online access
Predicting Student Success

Data Description

- Data sources
  - Matriculation system (SIS legacy, Peoplesoft, DW)
  - MAP-Works

- Student cohorts
  - New full-time freshmen (excl. foreign students)
  - Fall entry ‘02-’09 for model dev. (training set, N=17,311)
  - Fall entry 2010 for model validation (holdout set, N=2,527)

- Data elements at start of first semester
  - Student demographics (age, gender, ethn/race, residency)
  - Academic preparation (high school GPA/test score index)
  - Financial aid profile (unmet need, Pell, loans, scholarships)
  - Credits enrolled, campus housing (y/n), athlete (y/n)

- Data elements after start of first semester
  - MAP-Works survey risk scores (Sep., Nov., Feb)
Data Management Tasks

• Exploratory data analysis
  – Variable selection (bivariate regression on outcome variable)
  – Variable coding (continuous/categorical/dummy in logit model)
  – Missing data imputation, constant-$ conversion (fin. aid data)
  – Composite variable(s)
    • Acad prep index = (HSGPA*12.5)+(ACTM*.69)+(ACTE*.69)
  – Variables excluded: college remediation, ACT/SAT test date

• Logistic regression model
  – Maximize model fit (-2LL test-score, pseudo R², HL sig.)
  – Create balanced sample in training dataset to optimize correct classification rate (CCR) for enrollees vs. non-enrollees (i.e. model sensitivity vs. specificity): all non-enrollees plus random sample of enrollees of ~ equal N)
Data Management Tasks

• Scoring of relative dropout/retention risk

\[ p = \frac{\exp(a + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 \ldots)}{1 + \exp(a + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 \ldots)} \]

Where:
- \( p \) = probability of enrollment/non-enrollment
- \( \exp \) = base of natural logarithms (~ 2.72)
- \( a \) = constant/intercept of the equation
- \( b \) = coefficient of predictors (parameter estimates)

Approximation of \( p \): \((p \times [1-p] \times b)\)

Where:
- \( p \) = baseline probability of dependent variable
- \( b \) = logit coefficient
Predicting Student Success

Selected Factors and Spring Retention
Fall Cohorts 2002-09 (N=17,311)

Retention Rate

- Rem Need
- Pell $
- Loan $
- % Credits w/F,W
- AcadIndex

Retention Rate vs Decile (Low to High)
Selected Factors and 2nd Fall Retention
Spring-Retained Fall Cohorts 2002-09 (N=15,570)

- Rem Need
- Pell $
- Loan $
- % Credits w/F,W
- AcadIndex

Retention Rate

None 1 2 3 4 5 6 7 8 9 10

Decile (Low to High)
Data Analysis

Balanced Model Classification Rates<br>

<table>
<thead>
<tr>
<th></th>
<th>Predicted</th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Spring Retention</td>
<td>(%) Correct</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring Retention</td>
<td>No</td>
<td>1122</td>
<td>302</td>
<td>78.8</td>
</tr>
<tr>
<td>Spring Retention</td>
<td>Yes</td>
<td>673</td>
<td>610</td>
<td>47.5</td>
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<tr>
<td>Overall Percentage</td>
<td></td>
<td></td>
<td></td>
<td>64.0</td>
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</tbody>
</table>

a. The cut value is .55; HL sig. = .364; Nagelkerke R-sq = .161

Model tries to maximize correct prediction of at-risk students (non-enrollees), so they can be focused on, without raising the chance of selecting non-risk students (i.e. beyond OR = 1 or CCR = 0.5).
## Predicting Student Success

### Data Analysis

#### Balanced Model Parameter Estimates

<table>
<thead>
<tr>
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<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
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<td>Age</td>
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<td>.033</td>
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<td>1</td>
<td>.255</td>
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<td>.106</td>
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<td>.454</td>
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<td>Alndex</td>
<td>.029</td>
<td>.005</td>
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<td>.000</td>
<td>1.030</td>
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<td>.268</td>
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<td>.103</td>
<td>33.603</td>
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<td>.000</td>
<td>1.815</td>
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<td>.227</td>
<td>12.800</td>
<td>1</td>
<td>.000</td>
<td>2.256</td>
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<tr>
<td>OnCampFlag</td>
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<td>.096</td>
<td>38.738</td>
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<td>.000</td>
<td>1.814</td>
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<tr>
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<td>.012</td>
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<tr>
<td>Constant</td>
<td>-5.599</td>
<td>.803</td>
<td>48.632</td>
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<td>.000</td>
<td>.004</td>
</tr>
</tbody>
</table>

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*a. Single-step variable entry*
Data Analysis

Predicting Student Success

Predicted Retention Decile
Spring Status of Fall 2010 Cohort

Actual  Retained  Departed

Predicted Retention Decile

Spring Status of Fall 2010 Cohort

1  2  3  4  5  6  7  8  9  10

71  48  33  20  18  18  13  15  10  10

0%  20%  40%  60%  80%  100%
Predicting Student Success

Data Analysis

Vendor Survey Risk Assessment, Fall 2010 Cohort

*Assesses fall 2011 dropout risk of spring-retained
## Gauging Survey Value

### Predicting Student Success

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Baseline</th>
<th>MW Sep Survey</th>
<th>MW Nov Survey</th>
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<td>Sig.</td>
<td>Wald</td>
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<td>Age</td>
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<td>*</td>
<td>2.4</td>
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<td>Asian</td>
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<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Credits Enrolled</td>
<td>5.3</td>
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<tr>
<td>ClarkRural</td>
<td>13.6</td>
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<td>13.6</td>
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<tr>
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<td>*</td>
<td>0.7</td>
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<tr>
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<td>*</td>
<td>1.7</td>
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<td>*</td>
<td>2.6</td>
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<tr>
<td>MWR HI</td>
<td></td>
<td></td>
<td>9.9</td>
</tr>
<tr>
<td>MWR MO</td>
<td></td>
<td></td>
<td>4.1</td>
</tr>
<tr>
<td>LR test pass</td>
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<td></td>
<td>yes</td>
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<tr>
<td>Nagelkerke R²</td>
<td>0.19</td>
<td>0.21</td>
<td>0.25</td>
</tr>
<tr>
<td>CCR of At-Risk</td>
<td>76.0%</td>
<td>75.6%</td>
<td>78.0%</td>
</tr>
</tbody>
</table>
Gauging Survey Value

- A sustained 2% point rise in prediction accuracy over 5 years due to MAP-Works may translate into:
  - $237,500 in additional net revenue (5x1900x5x5) per cohort
  - Assuming no freshmen enrollment growth

**But...**

- Five-year cost of survey implementation
  - Product cost/fee, on-campus HR/IT investment
- Data not available until late in the semester!
- Balanced model (2002-10 data) yields 79% CCR for at-risk students, i.e. better than survey prediction
- Survey prediction furnishes no at-risk deciles
Value of Student Self-Reported Data for At-Risk Prediction

• Sources:
  – On-campus surveys
  – ACT Student Profile Q
  – SAT Student Descriptive Q
  – NSSE, CIRP (HERI-UCLA)

• Limitations:
  – Validity of acad exp questions
  – Convergent validity of construct
  – Cognitive vs. affective questions
  – Interpretive ambiguity
  – Mental recall
  – Vague quantifiers
Improving the Bottom Line

• Rise in freshmen retention by 4 percentage points due to better at-risk forecasting
  – AY 2010-11 additional net tuition revenues = $215,119 (for 94 NV, 19 WUE, excl OS students) for one cohort in one year, without OS $!
  – Downstream cumulative additional net tuition revenues result in $ millions!

• Incentive for student to speed up graduation
  – Opportunity cost per year in foregone earnings = $32,000 per year (published constant 2010-$)
Sample Data for Advisors

- [http://www.unr.edu/ia](http://www.unr.edu/ia)

<table>
<thead>
<tr>
<th>R Number</th>
<th>Last Name</th>
<th>First Name</th>
<th>Email Addr</th>
<th>Age</th>
<th>College</th>
<th>Dept</th>
<th>Major</th>
<th>Dropout Risk Decile Relative (10=highest Spring; 1=lowest) Retention %tile</th>
</tr>
</thead>
<tbody>
<tr>
<td>18LBA</td>
<td>ART</td>
<td></td>
<td></td>
<td>18</td>
<td>LBA</td>
<td>ART</td>
<td>BA-AHI</td>
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<tr>
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</table>
## Sample Data for Advisors

- [http://www.unr.edu/ia](http://www.unr.edu/ia)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Ethnicity</th>
<th>Credits</th>
<th>Resident</th>
<th>State/Cnty</th>
<th>HS GPA</th>
<th>ACTE</th>
<th>ACTM</th>
<th>Has Pell$ ((1=\text{yes}))</th>
<th>Has Loan$ ((1=\text{yes}))</th>
<th>Clark Cnty Resi ((1=\text{yes}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>AS</td>
<td>12 NV</td>
<td>NWA</td>
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<td>18</td>
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<tr>
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<td>WH</td>
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<td>1</td>
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Impact of this At-Risk Forecasting Model

- University Retention Rates Hold Steady As States Balance Access with Success. Scripps Howard Foundation Wire, April 15, 2011.


- Consulting services to IR offices at institutions in Arizona, California, Hawaii, and Texas.
Predictive Analytics at U. of Hawaii

- New freshmen at the University of Hawaiʻi at Mānoa, Hawaiʻi’s flagship public research university.
- 78% retention rate. 4 percentage points below peer group average. Rate flat for last 15 years.
- Excellent data storage, infrastructure, and IR reporting.
- Growing need to convert data results into actionable strategies.
Predictive Analytics at U. of Hawaii

- Relevant previous research has provided a suitable starting point for developing at-risk student forecasting model.
- Freshmen regression model has been well-received by campus stakeholders.
- Mānoa IR now moving from model building to implementation.
- IR and Advising staff from U. of Nevada-Reno travelled to Mānoa to share insights on implementing predictive analytics.
Takeaway from Collaboration

- Early-alert data key
- Identify results that are actionable.
- Support for student advising
- Involve colleges and departments.
- Ways to increase awareness of retention and graduation rates
  - Campaigns
  - Showing impact on the bottom line
Improving the Bottom Line at the University of Hawaii

• **388** freshmen from 2010 dropped out in year one.
• Retaining **26** students from 2010 would have improved Mānoa’s overall retention rate from 78.6% to **80%**.
• Additional Revenue from Tuition and Fees = **$259,920** (for 18 HI, 8 WUE, excludes OS).
• Are there 26 students in this group that we can help/retain?
Progress on Implementation at the University of Hawaii

• Currently doing:
  – Campus road show to share prediction model to stakeholders (including faculty and students).
    • Improved presentation for non-IR audience
  – Collaborating with student employment office to use data
    • Better marketing of on-campus job opportunities to freshmen
  – Integrating data with WASC and CCA reports
  – Mentioning odds ratios in campus campaigns and advertisements
  – Working more closely with College/Department personnel
  – Considering qualitative surveys to supplement quantitative data
  – Clarifying the role of analytics in MIRO’s mission and University’s strategic retention plan
Barriers to Implementation at the University of Hawaii

- Culture change
- Wary of misuse of data
- More accountability
- Faculty buy-in
Next Steps in Implementation at the University of Hawaii

- Beta-test with selected student advisors in spring 2013.
  - At-risk students monitored and called in for advising.
  - Decile data used to contextualize advising sessions.
- Collaboration with co-curricular office.
  - Enrolling in the First Year Experience class is a significant predictor in Hawai‘i’s model.
- “De-siloing” of data for analytical purposes.
- Continued relationship-building at the college level and beyond.
- Ride the analytics wave and maintain momentum.
Summary

• Predicting students at-risk
  – Keep prediction model parsimonious
  – Keep prediction data for student advising intuitive and simple (actionable)
  – Triangulate prediction data with multiple sources of information
  – Use prediction data as component part of student dropout-risk assessment
  – Follow ‘best practices’ in IR and keep abreast of changes in analytical and data reporting tools

• Using prediction data for student advising
  – Embrace the use of available data
  – Ensure users conceptually understand what’s behind the data
  – Use data as a complementary piece of information when advising students
  – Timing can be critical in terms of student intervention as well as maximizing advising resources

• Stay abreast of new research on predictive analytics:

___________________________________
Link to presentation:
http://www.unr.edu/ia/research