

Using Canonical Correlation Analysis to Examine Student Engagement and Learning

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Presentation Overview

- Introduction and Background (Gary)
- Research Methods (Anthony)
- Results and Discussion (John)



Prominence of Student Engagement

- Origins in the work of Tyler (1932), Pace (1980, 1984), Astin (1984), Chickering & Gamson (1987), & Kuh & Associates (1991).
- Provides an indicator of institutional quality and can be used to explain student learning (Axelson & Flick, 2011).



Premises of Student Engagement

- Student learning and success are related to the amount of time and energy students devote to educational activities.
- Institutions can influence the extent to which students engage in educationally purposeful activities.



NSSE

- Piloted in 2000 and publicly available in 2001.
 - Questionnaire administered to first-year students and seniors.
 - More than 1500 participating institutions.
- In 2013, a new version of NSSE was introduced.
- Is the new NSSE superior to the original NSSE?



Original NSSE

- Original survey contained 5 institutional benchmarks.
 - Pike (2006) suggested 12 “scalelets.”
- Substantial amount written about the reliability and validity of benchmarks.
- Pike (2013) provided evidence of reliability and validity when institutions were the units of analysis.



The New NSSE

- Revised and updated the content of the original questionnaire.
- Reports 4 engagement themes and 10 engagement indicators.
- Designed to be appropriate for both individual- and institution-level assessment.



The Validation Criteria

- **Convergence:** Are the NSSE scales (scalelets and engagement indicators) positively related to (converge with) students' perceptions of their learning and development?
- **Discrimination:** Are the NSSE scales *differentially* related to students' perceptions of their learning and development?



Data Source

NSSE 2011 Sample

185,000 first year students

573 institutions

- 44% public,
56% private
- Classification
 - 21% doctoral
 - 44% Master's
 - 35% baccalaureate

NSSE 2013 Sample

135,000 first year students

456 institutions

- 43% public,
57% private
- Classification
 - 23% doctoral
 - 46% Master's
 - 31% baccalaureate



Measures

NSSE scalelets (Pike, 2006a, 2006b)
used for analysis of 2011 data

Course Challenge, Writing Experiences, Higher-Order Thinking, Active Learning, Collaborative Learning, In-Class Student-Faculty Interaction, Out-of-Class Student-Faculty Interaction, Support for Student Success, Interpersonal Environment

Scalelets derived from Enriching
Educational Experience Benchmark
omitted



Measures

NSSE Engagement Indicators used for analysis of 2013 data

Higher-Order Learning, Reflective & Integrative Learning, Quantitative Reasoning, Learning Strategies, Collaborative Learning, Discussions with Diverse Others, Student-Faculty Interaction, Effective Teaching Practices, Quality of Interactions, Supportive Environment



Outcome Measures

Primary factor analysis of 10 learning gains items common to both surveys

Two correlated outcome measures

Academic and Interpersonal Gains

Application Gains



Academic and Interpersonal Gains

How much has your experience at this institution contributed to your knowledge, skills, and personal development in the following areas?

- Writing clearly and effectively
- Speaking clearly and effectively
- Thinking critically and analytically
- Developing or clarifying a personal code of values and ethics
- Understanding people of other backgrounds (economic, racial/ethnic, political, religious, nationality, etc.)
- Being an informed and active citizen

($E\rho^2 = 0.86$, 2011; $E\rho^2 = 0.88$, 2013)



Application Gains

How much has your experience at this institution contributed to your knowledge, skills, and personal development in the following areas?

- Analyzing numerical and statistical information
- Acquiring job- or work-related knowledge and skills
- Working effectively with others
- Solving complex real-world problems

($E\rho^2 = 0.86$ 2011; $E\rho^2 = 0.79$, 2013)



Canonical Correlation

Examines relationships between two sets of measures in which the measures themselves are correlated

Function of weighted linear combinations

$$a_1 Y_{1i} + a_2 Y_{2i} + \dots + a_p Y_{pi} = b_1 X_{1i} + b_2 X_{2i} + \dots + b_m X_{mi}$$

Correlation between Y and X variates is the canonical correlation



Canonical Correlation

Weights (a_p & b_m) maximize the correlation

Number of canonical functions equal to number of dependent or independent variables, whichever is less

Statistically independent

Multivariate tests used for significance

Squared canonical coefficient analogous to R^2

Regression and structure coefficients used to calculate and interpret variates



Canonical Correlation

Adequacy

- Mean squared structure coefficients of a given variate
- Extent to which variables contribute to the variate

Communality

- Sum of squared structure coefficients
- Proportion of the variance in variables explained by variates

Redundancy

- Indication of whether the canonical correlation represents the relationship between all independent and dependent variables



Method

Primary factor analysis

Canonical correlation analysis

Multivariate test for significance

Adequacy, communality, and
redundancy



Results

NSSE 2011

Canonical correlation of 0.79

(Wilks lambda = 0.23; $F = 67.97$; $df = 18,1124$; $p < 0.001$)

Canonical correlation of 0.32

(Wilks lambda = 0.70; $F = 30.65$; $df = 8,563$; $p < 0.001$)



Table 1
Canonical Correlation Results for the NSSE 2011 Data

| | Canonical Function I | | Canonical Function II | | Communality |
|--------------------------------|---------------------------|------------------------|---------------------------|------------------------|-------------|
| | Standardized Coefficients | Structure Coefficients | Standardized Coefficients | Structure Coefficients | |
| Academic & Interpersonal Gains | 0.58 | 0.90 | -1.09 | -0.44 | 1.00 |
| Application Gains | 0.55 | 0.88 | 1.11 | 0.47 | 1.00 |
| Adequacy Coefficients | | 0.79 | | 0.21 | |
| Redundancy Coefficients | | 0.49 | | 0.02 | |

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| Writing Experiences | -0.01 | 0.39 | -0.30 | -0.49 | 0.39 |
| Higher-Order Thinking | 0.06 | 0.71 | -0.20 | -0.18 | 0.54 |
| Active Learning | 0.10 | 0.57 | 0.04 | -0.17 | 0.35 |
| Collaborative Learning | 0.14 | 0.67 | 0.77 | 0.45 | 0.65 |
| Faculty-Student Interaction In Class | 0.15 | 0.75 | -0.83 | -0.40 | 0.72 |
| Faculty-Student Interaction Out-of-Class | 0.13 | 0.59 | 0.37 | -0.02 | 0.35 |
| Support for Student Success | 0.48 | 0.89 | -0.54 | -0.08 | 0.80 |
| Interpersonal Environment | 0.01 | 0.70 | 0.38 | 0.02 | 0.49 |
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Results

NSSE 2013

Canonical correlation of 0.83

(Wilks lambda = 0.14; $F = 72.22$; $df = 20,888$; $p < 0.001$)

Canonical correlation of 0.74

(Wilks lambda = 0.46; $F = 58.03$; $df = 9,445$; $p < 0.001$)



Table 2
Canonical Correlation Results for the NSSE 2013 Data

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| | Standardized Coefficients | Structure Coefficients | Standardized Coefficients | Structure Coefficients | |
| Academic & Interpersonal Gains | 1.11 | 0.97 | -0.31 | 0.25 | 1.00 |
| Application Gains | -0.29 | 0.27 | 1.12 | 0.96 | 1.00 |
| Adequacy Coefficients | | 0.50 | | 0.50 | |
| Redundancy Coefficients | | 0.35 | | 0.27 | |

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| | Standardized Coefficients | Structure Coefficients | Standardized Coefficients | Structure Coefficients | |
| Higher-Order Learning | 0.26 | 0.76 | 0.09 | 0.31 | 0.67 |
| Reflective & Integrative learning | 0.47 | 0.81 | -0.41 | -0.04 | 0.66 |
| Quantitative Reasoning | -0.16 | 0.02 | 0.73 | 0.90 | 0.81 |
| Learning Strategies | 0.09 | 0.63 | 0.12 | 0.29 | 0.48 |
| Collaborative Learning | -0.29 | -0.07 | 0.28 | 0.55 | 0.31 |
| Discussions with Diverse Others | -0.24 | 0.24 | -0.02 | 0.17 | 0.09 |
| Student-Faculty Interaction | 0.28 | 0.42 | 0.01 | 0.42 | 0.35 |
| Effective Teaching Practices | 0.22 | 0.71 | 0.20 | 0.31 | 0.60 |
| Quality of Interactions | -0.07 | 0.43 | 0.18 | 0.30 | 0.27 |
| Supportive Environment | 0.29 | 0.54 | -0.04 | 0.31 | 0.39 |
| Adequacy Coefficient | | 0.29 | | 0.18 | |



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Limitations

Different sets of institutions

Response rates of approximately 40%

Limited sample of possible learning outcomes

Self-reports v. objective measures



Discussion

Although both canonical correlation analysis displayed positive relationships between engagement and learning, the 2011 and 2013 demonstrated different aspects of validity.



NSSE 2011 (Convergent validity)

All NSSE scalelets related positively to both learning measures

Second canonical function underpowered



Table 1
Canonical Correlation Results for the NSSE 2011 Data

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| | Standardized Coefficients | Structure Coefficients | Standardized Coefficients | Structure Coefficients | |
| Academic & Interpersonal Gains | 0.58 | 0.90 | -1.09 | -0.44 | 1.00 |
| Application Gains | 0.55 | 0.88 | 1.11 | 0.47 | 1.00 |
| Adequacy Coefficients | | 0.79 | | 0.21 | |
| Redundancy Coefficients | | 0.49 | | 0.02 | |

| | Canonical Function I | | Canonical Function II | | Communality |
|--|---------------------------|------------------------|---------------------------|------------------------|-------------|
| | Standardized Coefficients | Structure Coefficients | Standardized Coefficients | Structure Coefficients | |
| Course Challenge | 0.28 | 0.70 | 0.47 | 0.21 | 0.53 |
| Writing Experiences | -0.01 | 0.39 | -0.30 | -0.49 | 0.39 |
| Higher-Order Thinking | 0.06 | 0.71 | -0.20 | -0.18 | 0.54 |
| Active Learning | 0.10 | 0.57 | 0.04 | -0.17 | 0.35 |
| Collaborative Learning | 0.14 | 0.67 | 0.77 | 0.45 | 0.65 |
| Faculty-Student Interaction In Class | 0.15 | 0.75 | -0.83 | -0.40 | 0.72 |
| Faculty-Student Interaction Out-of-Class | 0.13 | 0.59 | 0.37 | -0.02 | 0.35 |
| Support for Student Success | 0.48 | 0.89 | -0.54 | -0.08 | 0.80 |
| Interpersonal Environment | 0.01 | 0.70 | 0.38 | 0.02 | 0.49 |
| Adequacy Coefficients | | 0.46 | | 0.02 | |



NSSE 2013 (Discriminant Validity)

Different engagement indicators related to different types of learning

Strong redundancy coefficients for both functions



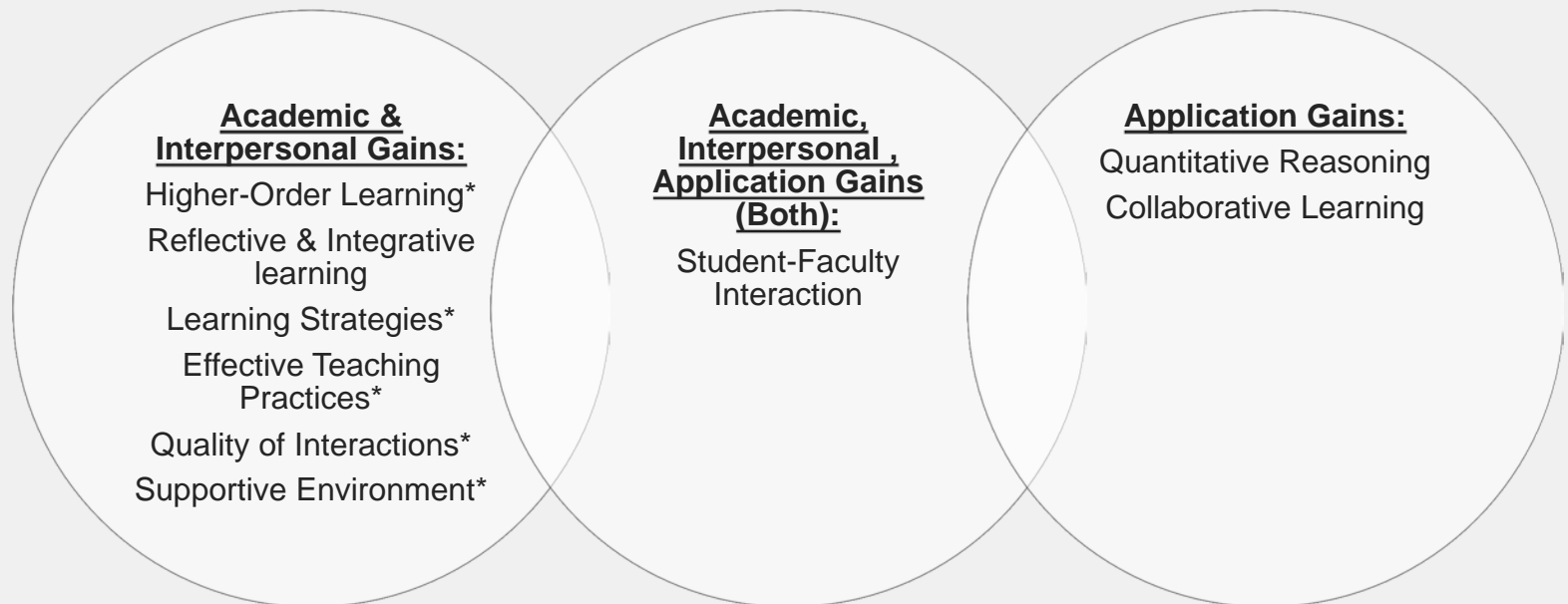
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Implications for NSSE Users



*Moderate positive relationships with application gains



Canonical Correlation Analysis

Multiple Regression Analysis

Independent outcomes (Type One Errors)

Canonical Correlation Analysis

Intercorrelated sets



Thank You

John Zilvinskis - Center for Postsecondary Research
Indiana University School of Education

Anthony Masseria - Robert H McKinney School of Law
Indiana University - Purdue University-Indianapolis

Gary R. Pike - Higher Education and Student Affairs
Indiana University School of Education - Indianapolis

