Principal Component Identification of Action Variables from a Student Experiences Survey

Gretchen K. Kost
Office of Institutional Research & Analysis
North Dakota State University

AIRUM 2009

Sophomore Experiences Survey

Project of Azusa Pacific University (California) to measure **needs** and **satisfaction** of sophomores

23 Institutions Participating in the 2009 Sophomore Experiences Survey		
Albion College	Albion	MI
Alcorn State University	Alcorn State	MS
Alvernia University	Reading	PA
Beloit College	Beloit	WI
Clemson University (NDSU SBHE Peer)	Clemson	SC
Colorado State University	Fort Collins	CO
Hanover College	Hanover	IN
Hendrix College	Conway	AR
Indiana Wesleyan University	Marion	IN
Kalamazoo College	Kalamazoo	MI
Loyola College in Maryland	Baltimore	MD
Miami University	Oxford	OH
North Dakota State University	Fargo	ND
Purchase College –SUNY	Purchase	NY
Rowan University	Glassboro	NJ
Siena College	Loudonville	NY
State University of New York at Oswego	Oswego	NY
Trevecca Nazarene University	Nashville	TN
University of Minnesota Duluth	Duluth	MN
University of Portland	Portland	OR
University of Rhode Island (NDSU SBHE Peer)	Kingston	RI
University of South Carolina	Columbia	SC
Westminster College	Salt Lake City	UT

Student Experiences Survey at NDSU

- Administered to a stratified sample of NDSU students having completed 27-59 NDSU degree credits by the 4th week of spring 2009 semester.
- Up to 100 females and 100 males from each college were randomly selected for first mailing.
- Number of females/males from each college in second mailing was dependent on number received back from first mailing.

NDSU Adjustments to Survey

NDSU extracted additional information (not collected by Azusa) for consideration in data analysis.

<u>Examples:</u>

Azusa Q: Is this your second year attending college?

NDSU Q: Is this your First, Second, Third, Fourth, or Fifth or more year of attending college? (Circle one)

Azusa Q: Not Asked

NDSU Q: Are you a Freshman, Sophomore, Junior, Senior, or Not Applicable? (Circle one)

Survey Response at NDSU

- 1476 students asked to complete survey.
- 403 (27% response rate) unique responses received and analyzed.
- Only 2 of the 403 withheld identification.
- 131 students (33% of respondents) provided comments.
- Since we had student identification, we were able to tie pre- (e.g., ACT) and post- (e.g., GPA) information to interpret the open-ended comments.

Categories of Questions

Category	Number of Items	Category	Number of Items
Engaged Learning	**10**	Meaning in Life	2
Academic Hope	**6**	Perceived Academic Control	2
Socially Responsible Leadership	5	Positive Relations	3
Optimism	4	Psychological Sense of Community	3
Resilience	4	Self-Assurance	2
Academic Self-Efficacy	2	Spirituality	3
Diversity	3	Self-Regulation	2
Effort Regulation	3	Subjective Well-Being	2
Environmental Mastery	3	Additional Items	1
Mindset	1		

Sample Section of Survey (*Academic Hope* Items)

Think about the classes you are taking RIGHT NOW – this semester – as you answer the following questions.

Please rate your agreement with each of the items by using a 1 to 6 scale, with 1 indicating "strongly disagree" and 6 indicating "strongly agree."

hope1 I can think of specific ways to do well in my classes.
hope2 I am motivated to do well in school.
hope3 When given a choice, I take classes that are challenging to me.
hope4 Thinking about pursuing my goals in school fills me with energy.
hope5 The educational goals I have set for myself are clear and well defined.
hope6 I actively pursue my educational goals.

Sample Section of Survey (*Engaged Learning* Items)

eli1 I often discuss with my friends what I'm learning in class.

eli2 I regularly participate in class discussions in most of my classes.

eli3 I feel as though I am learning things in my classes that are worthwhile to me as a person.

eli4 It's hard to pay attention in many of my classes.

eli5 I can usually find ways of applying what I'm learning in class to something else in my life.

eli6 I ask my professors questions during class if I do not understand something.

eli7 In the last week, I've been bored in class most of the time.

eli8 I find myself thinking about what I'm learning in class even when I'm not in class.

eli9 I feel energized by the ideas that I am learning in most of my classes.

eli10 Often I find my mind wandering during class.

Data Preparation – Negatively Worded Questions

Refer to the Engaged Learning items on Slide #8.

Most items are worded positively, i.e., a higher numbered response is desirable.

eli9 I feel energized by the ideas that I am learning in most of my classes.

However, some items are worded negatively, i.e., a lower numbered response is desirable.

eli10 Often I find my mind wandering during class.

Data Preparation – Reversing Values

For any analysis of means, reversal of responses for the negatively-worded questions is necessary.

Reversing national norms means

Since the scale is 1-6, subtracting the national norms (means) from 7 will produce the reversed national norms.

Comparison of Populations

Prepared for:

- NDSU vs. National Norms
- Each NDSU college vs. Other NDSU colleges
  and vs. National Norms
- Each NDSU department with enough data
  vs. other departments in same college
  and vs. National Norms
- Other (Female vs. Male, Transfer vs. Non-transfer, etc.)

College X

Engaged Learning Item (Items are on a 6-point scale with 6 high) [Scale of highlighted items reversed]	College X (N=63)		Other (N=338)		National Norms (N=4520)	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
1. I often discuss with my friends what I'm learning in class.	3.85	1.05	3.95	1.24	4.48 **	1.07
2. I regularly participate in class discussions.	3.35	1.38	3.39	1.33	4.17 **	1.29
3. I feel as though I am learning things in my classes that are worthwhile to me as a person.	4.10	1.33	4.17	1.13	4.54 **	1.05
4. It's hard to pay attention in many of my classes.	3.65	1.16	3.86	1.22	3.71 **	1.20
5. I can usually find ways of applying what I'm learning in class to something else in my life.	3.52	1.16	3.91 **	1.02	4.24 **	1.03
6. I ask my professors questions during class if I do not understand something.	3.23	1.45	3.35	1.41	3.99 **	1.26
7. I am bored in class a lot of the time.	3.85	1.29	3.80	1.27	3.60	1.29
8. I find myself thinking about what I'm learning in class even when I'm not in class.	3.81	1.32	3.71	1.22	4.08 *	1.10
9. I feel energized by the ideas I'm learning in most of my classes.	3.40	1.21	3.50	1.12	3.85 **	1.11
10. Often I find my mind wandering during class.	3.37	1.30	3.29	1.20	3.20	1.18
Engaged Learning Means and SDs:	3.61	0.0506	3.69	0.0210	3.99 **xx**	0.0055
	College X equal to Other, way below National					
Calculated Z:			-1.46		-7.33	
p-value:			0.144354		3.35E-13	

** Independent t-test indicates statistically significant difference from College X at alpha=0.05

* Independent t-test indicates statistically significant difference from College X at alpha=0.15

xx z-test indicates statistically significant difference from College X at alpha=.001

x z-test indicates statistically significant difference from College X at alpha=.05

Department Y (within College X)

Academic Hope	Department Y (N=25)		Other (N=38)		National Norms (N=4520)	
Item (Items are on a 6-point scale with 6 high)	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
1. I can think of specific ways to do well in my classes.	3.63	1.31	4.03	1.08	4.56 **	0.94
2. I am motivated to do well in school.	4.25	1.45	4.82 *	1.18	5.09 **	0.99
3. When given a choice, I take classes that are challenging to me.	4.25	1.48	4.05	1.16	4.24	1.12
4. Thinking about pursuing my goals in school fills me with energy.	4.08	1.41	4.26	1.11	4.41	1.15
5. The educational goals I have set for myself are clear and well defined.	4.00	1.35	3.89	1.18	4.48 **	1.12
6. I actively pursue my educational goals.	4.42	1.06	4.39	0.79	4.68	0.93
Academic Hope Means and SDs:	4.11	0.1103	4.24	0.0723	4.58 **xx**	0.0063
	Department Y equal to Other, way below National					
Calculated Z:			-1.02		-4.27	
p-value:			0.3060592		2.043E-05	

** Independent t-test indicates statistically significant difference from Department Y at alpha=0.05

* Independent t-test indicates statistically significant difference from Department Y at alpha=0.15

xx z-test indicates statistically significant difference from Department Y at alpha=.001

x z-test indicates statistically significant difference from Department Y at alpha=.05

Comparisons/Tests

- Z-test of mean for each category
  – doesn't provide specific suggestions for improvement

- T-tests of individual items
  – don't really indicate what items to focus on to improve student satisfaction and learning

Principal Component Analysis

- Want to identify items of primary importance to suggest to academic units for their action to improve student learning and student satisfaction.

- According to SAS:

  To obtain reliable results, the minimal number of subjects providing usable data for the analysis should be the larger of 100 subjects or five times the number of variables being analyzed.

- Was conducted separately on each category of items (not very useful for categories with fewer than 5 items) for the **university as a whole (N=403)**.

Why Principal Component Analysis?

Hypothetically…

Think about asking, "Are you engaged in your learning at NDSU?"

A student intuitively puts herself somewhere between "definitely yes" and "definitely no."

In reality…

The survey's 10 questions probe for the reasons behind her/his self-placement within that continuum.

Principal Component Analysis

- Identifies which of the 10 items have the greatest influence on where the typical student puts herself on the continuum.
- Mines the mind, heart, & soul of each of the 403 survey respondents.
- Combines all into a general picture of the 403.

PROC PRINCOMP in SAS

Observation:

If a student does not respond to one item in any given category of items, PROC PRINCOMP (of raw data) excludes the student from the Principal Component Analysis of that category.

Preferred method:

- For the analysis to include as much of the raw data as possible, it is necessary to run a PROC CORR on the data first.
- Then run PROC PRINCOMP on the correlation matrix rather than the raw data.

Sample SAS Code

```
PROC CORR DATA=ONE;
    VAR eli1 eli2 eli3 eli4 eli5 eli6 eli7 eli8 eli9 eli10;
    WITH eli1 eli2 eli3 eli4 eli5 eli6 eli7 eli8 eli9 eli10;
    ODS OUTPUT PEARSONCORR=ELI_CORR;
RUN;

DATA ELI_CORR_2(TYPE=CORR);
    SET ELI_CORR;
    _TYPE_='CORR';
    KEEP VARIABLE _TYPE_ eli1 eli2 eli3 eli4 eli5 eli6 eli7 eli8 eli9 eli10;
    RENAME VARIABLE=_NAME_;
RUN;

PROC PRINCOMP DATA=ELI_CORR_2(TYPE=CORR);
    VAR eli1 eli2 eli3 eli4 eli5 eli6 eli7 eli8 eli9 eli10;
RUN;
```

SAS Output – Eigenvalues Engaged Learning

Select eigenvalues ≥ 1.

Eigenvalues of the Correlation Matrix

	Eigenvalue	Difference	Proportion	Cumulative
1	3.68325032	2.20232633	0.3683	0.3683
2	1.48092399	0.35939693	0.1481	0.5164
3	1.12152706	0.22552394	0.1122	0.6286
4	0.89600312	0.24506964	0.0896	0.7182
5	0.65093348	0.13171726	0.0651	0.7833
6	0.51921622	0.04426785	0.0519	0.8352
7	0.47494837	0.04386825	0.0475	0.8827
8	0.43108012	0.04526559	0.0431	0.9258
9	0.38581453	0.02951172	0.0386	0.9644
10	0.35630280		0.0356	1.0000

SAS Output – Eigenvectors (1-6 shown here) Engaged Learning

In corresponding eigenvectors, select loadings ≥ |0.4|.

Eigenvectors

	Prin1	Prin2	Prin3	Prin4	Prin5	Prin6
eli1	0.221468	0.337165	-.217682	0.721699	0.144543	0.353743
eli2	0.218337	0.417364	0.504791	0.224231	0.310948	-.362950
eli3	0.375149	0.008333	-.113290	-.328951	0.418660	-.277618
eli4	0.290469	-.501849	0.156528	0.069224	-.013690	0.413324
eli5	0.325738	0.198280	-.315115	-.373192	0.356588	0.464263
eli6	0.183229	0.354993	0.589034	-.334019	-.326174	0.380437
eli7	0.354388	-.379732	0.164297	0.107845	0.148970	-.141856
eli8	0.357616	0.162631	-.258624	0.060440	-.609334	-.128298
eli9	0.388770	0.116590	-.282294	-.127424	-.253752	-.309004
eli10	0.365885	-.332613	0.201584	0.183055	-.124658	-.053726

SAS Output – Eigenvalues Academic Hope

Eigenvalues of the Correlation Matrix

	Eigenvalue	Difference	Proportion	Cumulative
1	3.13628835	2.35936763	0.5227	0.5227
2	0.77692072	0.07499452	0.1295	0.6522
3	0.70192621	0.15129283	0.1170	0.7692
4	0.55063338	0.07330890	0.0918	0.8610
5	0.47732448	0.12041762	0.0796	0.9405
6	0.35690686		0.0595	1.0000

SAS Output – Eigenvectors (1-3 shown here) Academic Hope

Eigenvectors

	Prin1	Prin2	Prin3
hope1	0.379955	0.306085	0.703436
hope2	0.434131	0.075226	0.044524
hope3	0.387007	0.577389	-.146897
hope4	0.404075	-.008875	-.644856
hope5	0.366492	-.718792	0.229792
hope6	0.468825	-.224799	-.113901

PCA – Process

PCA produces the same number of eigenvalues (and, thus, components in each eigenvector) as there are variables.

For example, there are 10 Engaged Learning variables. Subsequently, PCA produces 10 eigenvalues and associated eigenvectors.

An eigenvalue is the amount of variance accounted for by a given component (Total variance = number of variables).

PCA – Component Selection

Select components with eigenvalues ≥ 1 and, in the corresponding eigenvectors, select variables with loadings ≥ 0.4.

Also consider the proportion of variability explained by each eigenvalue. No set rule, but need to ensure variability is not too small when selecting components.

Note that each subsequent component accounts for a maximal amount of variance in the data set not accounted for by the previous components.

PCA Results for NDSU Data

Engaged Learning	Eigenvalue		% Variability Explained	Variable1	Loading1	Variable2	Loading2	Variable3	Loading3
	1	3.68	37%	eli9	0.39				
	2	1.48	15%	eli4	-0.50	eli2	0.42		
	3	1.12	11%	eli6	0.59	eli2	0.50		
Academic Hope	Eigenvalue		% Variability Explained	Variable1	Loading1	Variable2	Loading2	Variable3	Loading3
	1	3.14	52%	hope6	0.47	hope2	0.43	hope4	0.40

PCA of Engaged Learning – Items Identified

eli9 I feel energized by the ideas that I am learning in most of my classes.

eli4 It's hard to pay attention in many of my classes.

eli6 I ask my professors questions during class if I do not understand something.

eli2 I regularly participate in class discussions in most of my classes.

Conclusions:

- Being an active participant in classroom activities is critically important to student learning.
- Faculty should focus on directly involving students in classroom discussions and activities.

PCA of Academic Hope – Items Identified

hope2	I am motivated to do well in school.
hope4	Thinking about pursuing my *goals* in school fills me with energy.
hope6	I actively pursue my educational *goals*.

Conclusions:

- Both having goals and feeling success in achieving those goals are very important to students.
- Faculty and student affairs personnel (advising students) should direct their focus on helping students **set** and **pursue goals**.

College X – Revised

Engaged Learning Item (Items are on a 6-point scale with 6 high)	**College X (N=63)**		**Other (N=338)**		**National Norms (N=4520)**	
[Scale of highlighted items reversed]	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
♦♦♦, ♦♦, ♦: Items identified by principal components to be of most importance (♦♦♦ highest)						
1. I often discuss with my friends what I'm learning in class.	3.85	1.05	3.95	1.24	4.48 **	1.07
2. I regularly participate in class discussions. ♦♦	3.35	1.38	3.39	1.33	4.17 **	1.29
3. I feel as though I am learning things in my classes that are worthwhile to me as a person.	4.10	1.33	4.17	1.13	4.54 **	1.05
4. It's hard to pay attention in many of my classes. ♦♦	3.65	1.16	3.86	1.22	3.71 **	1.20
5. I can usually find ways of applying what I'm learning in class to something else in my life.	3.52	1.16	3.91 **	1.02	4.24 **	1.03
6. I ask my professors questions during class if I do not understand something. ♦	3.23	1.45	3.35	1.41	3.99 **	1.26
7. I am bored in class a lot of the time.	3.85	1.29	3.80	1.27	3.60	1.29
8. I find myself thinking about what I'm learning in class even when I'm not in class.	3.81	1.32	3.71	1.22	4.08 *	1.10
9. I feel energized by the ideas I'm learning in most of my classes. ♦♦♦	3.40	1.21	3.50	1.12	3.85 **	1.11
10. Often I find my mind wandering during class.	3.37	1.30	3.29	1.20	3.20	1.18
Engaged Learning Means and SDs:	3.61	0.0506	3.69	0.0210	3.99 **xx**	0.0055
	College X equal to Other, way below National					
Calculated Z:			-1.46		-7.33	
p-value:			0.144354		3.35E-13	

** Independent t-test indicates statistically significant difference from College of Science and Mathematics at alpha=0.05

* Independent t-test indicates statistically significant difference from College of Science and Mathematics at alpha=0.15

xx z-test indicates statistically significant difference from College of Science and Mathematics at alpha=.001

x z-test indicates statistically significant difference from College of Science and Mathematics at alpha=.05

Department Y (within College X) – Revised

Academic Hope	Biological (N=25)		Other (N=38)		National Norms (N=4520)	
Item (Items are on a 6-point scale with 6 high)	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
♦♦♦, ♦♦, ♦: Items identified by principal components to be of most importance (♦♦♦ highest)						
1. I can think of specific ways to do well in my classes.	3.63	1.31	4.03	1.08	4.56 **	0.94
2. I am motivated to do well in school. ♦♦	4.25	1.45	4.82 *	1.18	5.09 **	0.99
3. When given a choice, I take classes that are challenging to me.	4.25	1.48	4.05	1.16	4.24	1.12
4. Thinking about pursuing my goals in school fills me with energy. ♦	4.08	1.41	4.26	1.11	4.41	1.15
5. The educational goals I have set for myself are clear and well defined.	4.00	1.35	3.89	1.18	4.48 **	1.12
6. I actively pursue my educational goals. ♦♦♦	4.42	1.06	4.39	0.79	4.68	0.93
Academic Hope Means and SDs:	4.11	0.1103	4.24	0.0723	4.58 **xx**	0.0063
	Department equal to Other, way below National					
Calculated Z:			-1.02		-4.27	
p-value:			0.306059		2.04E-05	

** Independent t-test indicates statistically significant difference from at alpha=0.05

* Independent t-test indicates statistically significant difference from at alpha=0.15

xx z-test indicates statistically significant difference from at alpha=.001

x z-test indicates statistically significant difference from at alpha=.05

Campus Quality Survey – A Second Example

	Faculty	Staff
2004	128	164
2006	60	68
2008	61	79
Total	249	311

Due to small sample sizes for individual years, PCA was conducted on the average of the 3 years.

Sample Section of CQS (*Employee Training and Recognition* Items)

How It Should Be vs. How It Is Now (1-5 scale)

pgap8 Processes for selecting, orienting, training, empowering and recognizing employees are carefully planned.

pgap19 Employees are empowered to resolve problems quickly.

pgap24 Students believe faculty care about what they think.

pgap26 Employees are rewarded for outstanding job performance.

pgap31 Administrators recognize faculty and staff when they do a good job.

pgap48 Employee suggestions are used to improve our institution.

pgap50 Prof. development training programs are available to assist employees in improving their job performance.

CQS – Employee Training and Recognition Faculty – Eigenvalues

Eigenvalues of the Correlation Matrix

	Eigenvalue	Difference	Proportion	Cumulative
1	3.58010949	2.74830917	0.5114	0.5114
2	0.83180032	0.12366459	0.1188	0.6303
3	0.70813573	0.05663115	0.1012	0.7314
4	0.65150458	0.12047649	0.0931	0.8245
5	0.53102809	0.11941183	0.0759	0.9004
6	0.41161627	0.12581074	0.0588	0.9592
7	0.28580553		0.0408	1.0000

CQS – Employee Training and Recognition Faculty – Eigenvectors (1-4 shown here)

Eigenvectors

	Prin1	Prin2	Prin3	Prin4
PGAP8	0.377880	0.076494	0.212005	0.511682
PGAP19	0.374445	0.341743	-.404162	0.410086
PGAP24	0.288219	0.722779	0.473585	-.397715
PGAP26	0.405737	-.258769	-.235084	-.513537
PGAP31	0.439615	-.221219	-.130080	-.311230
PGAP48	0.410550	-.006479	-.296897	0.123476
PGAP50	0.327859	-.488885	0.638037	0.189744

CQS – Employee Training and Recognition Staff – Eigenvalues

Eigenvalues of the Correlation Matrix

	Eigenvalue	Difference	Proportion	Cumulative
1	3.68702933	2.87204118	0.5267	0.5267
2	0.81498815	0.04270395	0.1164	0.6431
3	0.77228420	0.19323227	0.1103	0.7535
4	0.57905193	0.12975031	0.0827	0.8362
5	0.44930162	0.00883765	0.0642	0.9004
6	0.44046397	0.18358316	0.0629	0.9633
7	0.25688081		0.0367	1.0000

CQS – Employee Training and Recognition Staff – Eigenvectors (1-4 shown here)

	Eigenvectors			
	Prin1	Prin2	Prin3	Prin4
PGAP8	0.372429	0.072210	-.332202	0.710299
PGAP19	0.411336	-.056637	0.006089	0.257706
PGAP24	0.283027	-.575820	0.724311	0.086434
PGAP26	0.416910	-.069464	-.228464	-.482931
PGAP31	0.433042	-.104963	-.245109	-.424987
PGAP48	0.421966	0.042265	-.041198	0.030045
PGAP50	0.269443	0.801487	0.501006	-.082782

PCA Results for CQS Data
Employee Training and Recognition

	Eigenvalue		% Variability Explained	Variable1	Loading1	Variable2	Loading2	Variable3	Loading3	Variable4	Loading4
Faculty	1	3.58	51%	PGAP31	0.44	PGAP48	0.41	PGAP26	0.41		
Staff	1	3.69	53%	PGAP31	0.43	PGAP48	0.42	PGAP26	0.42	PGAP19	0.41

CQS Data
PCA of Employee Training and Recognition

4 items identified by PCA:

pgap31 Administrators recognize faculty and staff when they do a good job.

pgap48 Employee suggestions are used to improve our institution.

pgap26 Employees are rewarded for outstanding job performance.

pgap19 Employees are empowered to resolve problems quickly.

PCA Conclusions:

- Faculty and staff results demonstrated nearly identical results for this section.
- There is definite overlap between faculty and staff across the different sections of the survey.

In Conclusion…

Principal Component Analysis

- Allows for the further identification of variables of primary importance within a given construct.
- Provides specific direction of efforts to improve institutional effectiveness.
- Can also provide an avenue for identifying different constructs within a survey.

Reference

Hatcher, Larry. "Principal Component Analysis." *A Step-by-Step Approach to Using SAS for Factor Analysis and Structural Equation Modeling.* SAS Press. 1994: 1-55. (http://support.sas.com/publishing/pubcat/chaps/55129.pdf)

Contact Information

Gretchen K. Kost
gretchen.kost@ndsu.edu
701.231.6694