Why Do We Need Yet ANOTHER Instrument Measuring Student Attitudes?

JSM 2021

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Attitudes

- **Attitudes Matter in Education!** (Pearl et al., 2012)

- We want students to **thrive in the data deluge**

- **Instructor attitudes** and course environment impact **student attitudes**

- Understanding attitudes can help us identify **evidence-based best practices for teaching data science and statistics**
Outline

- Why New Instruments?
- Overview of MASDER grant
- The S-SOMAS Survey
- S-SOMAS Pilot Psychometrics
- S-SOMAS Pilot Attitude Results
- How to Get Involved
Why New Instruments?
Existing Instruments (Examples)

**Student Instruments**
- Survey of Attitudes toward Statistics (SATS; Schau, 1992)
  - Most widely used
- Issues (Whitaker, Unfried, & Bond, in press):
  - Lack of validity evidence
  - Incomplete alignment to theoretical framework
  - Ceiling effects on some scales
  - Rigid pre-post structure
  - Requires stats course enrollment
  - Use restricted - fees/permission

**Instructor/Environment Instruments**
- Statistics Teaching Inventory (STI; Zieffler et al., 2012)
  - Snapshot of instructor practices in Introductory Statistics
- Issues
  - Does not measure attitudes or learning environment characteristics
  - Not linked to student measures

No Validated Data Science Attitudes Instruments
What are we doing differently?

- Start with a strong theoretical framework
- Follow a rigorous survey development process
- Create a family of instruments
MASDER Overview
MASDER:

Motivational Attitudes in Statistics and Data Science Education Research

- 3-year NSF IUSE grant (Oct ‘20 - Sept ‘23)
- Develop **6 instruments** evaluating student and instructor attitudes toward statistics and data science, and the learning environment
- Conduct **nationally-representative sample** of students and instructors
- Promote **Stat/DS Ed Research** - improve instruction by understanding the relationships between components
**Surveys Of Motivational Attitudes toward...**

<table>
<thead>
<tr>
<th></th>
<th>Student Instrument</th>
<th>Instructor Instrument</th>
<th>Environment Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistics</td>
<td>S-SOMAS</td>
<td>I-SOMAS</td>
<td>E-SOMAS</td>
</tr>
<tr>
<td>Data Science</td>
<td>S-SOMADS</td>
<td>I-SOMADS</td>
<td>E-SOMADS</td>
</tr>
</tbody>
</table>
## Distinction between S, I, and E Surveys

<table>
<thead>
<tr>
<th><strong>Student Instruments</strong></th>
<th><strong>Instructor Instruments</strong></th>
<th><strong>Environment Inventories</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Measures attitudes toward Stat or DS</td>
<td>- Measures instructor attitudes toward teaching Stat or DS</td>
<td>- Measures institutional and course characteristics, learning environment, and enacted classroom behaviors</td>
</tr>
<tr>
<td>- Pre and post semester</td>
<td>- Perhaps administered annually</td>
<td>- Instructor completes for each course</td>
</tr>
<tr>
<td>- Can be used longitudinally</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Survey Development for S-SOMAS

- Formulate the need for a new student instrument
  - Research on Statistics Attitudes (ROSA) working groups (beginning in 2009)
  - ASA Membership Initiative grant funded 3 workshops
- Develop theoretical models
  - Workshop at USCOTS (2017) focused on model development
  - Model refinement continues
- Create Pilot-0 S-SOMAS Instrument (2017-20)
  - Construct definitions, item writing
  - Student focus groups, Subject Matter Expert Review
- Administer, Analyze and Revise Pilot-0
  - Pilot data collected from ~2,400 students (2018-20)
- Administer and Analyze Pilot-1 (2021)
The S-SOMAS Survey
Meta-Model

Surveys of Motivational Attitudes toward Statistics and Data Science

Meta-Model Explaining Student Achievement in Statistics and Data Science

Environment Model

- Institutional Structures and Characteristics
- Enacted Classroom Behaviors

Instructor Motivation
- Instructor Professional Activities
- Instructor Background

EVT Model for Instructors

EVT Model for Students

- Student Motivation
- Student Background
- Student Achievement

Assessed by other instruments not in family of instruments

Student Survey
- S-SOMAS
- S-SOMADS

Environment Inventories
- E-SOMAS
- E-SOMADS

Instructor Survey
- I-SOMAS
- I-SOMADS
Student Model

Survey of Motivational Attitudes toward Statistics (SOMAS)
Survey of Motivational Attitudes toward Data Science (SOMADS)

Goals and Self-Schemata
- Minimum Standard for Achievement
- Career/Life Goals
- Goal Orientation (Intrinsic/Extrinsic)
- Academic Self-Concept

Subjective Task Value
- Interest/Enjoyment Value
- Attainment Value
- Utility Value
- Costs and Benefits

Beliefs & Stereotypes about Statistics/Data Science

Student Background, Aptitude, and Perceptions of Others’ Attitudes and Expectations

Self-Concept of Statistics/Data Science Ability

Perception of Difficulty

Expectancies

Performance Behaviors

Achievement

Based on Eccles’ Expectancy-Value Theory (EVT)
(e.g. Eccles, 1983, 2014; Eccles & Wigfield, 2002)
<table>
<thead>
<tr>
<th>Construct</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expectancy</td>
<td>How the student thinks they will perform in the field of statistics</td>
</tr>
<tr>
<td>Perception of Difficulty</td>
<td>How difficult the student perceives statistics to be</td>
</tr>
<tr>
<td>Beliefs and Stereotypes</td>
<td>Student concepts and conceptions about statistics</td>
</tr>
<tr>
<td>Utility Value</td>
<td><strong>How much the student values statistics for serving or achieving their goals.</strong></td>
</tr>
<tr>
<td>Interest/Enjoyment Value</td>
<td>The interest a student has in statistics, or their enjoyment from it</td>
</tr>
<tr>
<td>Attainment Value</td>
<td>How important success in statistics is to the student</td>
</tr>
<tr>
<td>Costs and Benefits</td>
<td>Factors that deter from learning stats, or benefits of learning stats</td>
</tr>
<tr>
<td>Academic Self-Concept</td>
<td>Student perceptions about the academic achievement (general and stats-specific)</td>
</tr>
<tr>
<td>Goal Orientation</td>
<td>What drives the students to learn statistics</td>
</tr>
<tr>
<td>Item</td>
<td>Strongly Disagree</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>I need to know statistics to satisfy employers.</td>
<td>☐</td>
</tr>
<tr>
<td>I will rarely use statistics in the future.</td>
<td>☐</td>
</tr>
<tr>
<td>No one in my career field uses statistics.</td>
<td>☐</td>
</tr>
<tr>
<td>I value statistics because it makes me an informed citizen.</td>
<td>☐</td>
</tr>
<tr>
<td>Studying statistics is pointless.</td>
<td>☐</td>
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S-SOMAS Pilot 1 Results
15 Institutions, 16 Instructors, 20 Sections

How is the course (or these courses) being offered? Check all that apply.
16 responses

- Face-to-face: 2 (12.5%)
- Online (only due to COVID): 8 (50%)
- Online (regardless of COVID): 4 (25%)
- Hybrid - online and face-to-face: 2 (12.5%)
- Hyflex - students online and face-to-face simultaneously: 0 (0%)
Students

- 50% Response Rate
- \( n = 588 \) Students
  - Focus on 7-point Likert (\( n = 452 \))
  - Also did 5-point Likert (\( n = 136 \))
- 65% Females
- Age: 20 / 21 (Median / Mean)
Analysis Overview

- Exploratory Factor Analysis
- Principal Components Analysis
- Item Response Theory (Graded Response Model)
- Confirmatory Factor Analysis (comparing models)

A brief summary of attitudes using the items from one preliminary model will be shown (using classical test theory).
Exploratory Factor Analysis

- Exploratory Factor Analysis (EFA)
  - Promax rotation
  - MLE
  - Polychoric correlations
- Empirical relationships similar to theory
- Misalignments inform survey revisions.

Empirical Factors

Theoretical Constructs

7-point data, 6-factor EFA, cutoff = 0.40

Value/Reasons for Learning Statistics

Doing Statistics is Challenging/Unenjoyable

Expectancy/Perception of Statistics Ability

Satisfaction from Learning Statistics/Statistics is Challenging

Utility Value (Career/Future)

Extrinsic Goal Orientation/Statistics and Intelligence

Note: items may load onto more than one factor.
Dimensionality: Utility Value

- PCA used to assess unidimensionality assumption for IRT
- Roughly homogenous loadings on the first two components suggests items are measuring the same construct (Mair, 2018)
Dimensionality: Utility Value

Utility Value Items

1. I need to know statistics to satisfy employers.
2. I need to know statistics because it will be expected of me in the future.
3. I will use statistics in my career.
4. Knowing statistics will help me look more appealing to employers.
5. I will rarely use statistics in the future.
6. No one in my career field uses statistics.
7. I want to know statistics to make informed choices for myself (e.g., health, politics, etc.).
8. Statistics is helpful for understanding the world around me.
9. Statistics will help me understand news reports.
10. I value statistics because it makes me an informed citizen.
11. Studying statistics is pointless.
# Dimensionality: Utility Value

## Utility Value Items

1. I need to know statistics to satisfy employers.
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11. Studying statistics is pointless.
The Graded Response Model (GRM; Samejima, 1969) was used for each scale because the fit was preferable to other models. Few items in each scale exhibited any misfit.
Confirmatory Factor Analysis: Model Overview

Brief description of each model:

- **Model A** contains all items from Pilot-1 (66 items) loading on their hypothesized constructs
- **Model B** is Model A but with a higher-order factor for Subjective Task Values (STV) comprised of Interest, Attainment, and Utility
- **Model C** contains a subset of 38 items loading on their hypothesized constructs [see figure]
- **Model D** is Model C but with the STV higher-order factor
- **Model E** contains a subset of 35 items loading on their hypothesized constructs
  - Model E is not a proper subset of Model C

![Table showing model comparison](image)
## Confirmatory Factor Analysis

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<tr>
<th>Model</th>
<th>Chi-Square</th>
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<td>0.097</td>
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<td>15138.93</td>
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<td>0.954</td>
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### Interpretation (Hooper et al., 2008)

- **Good fit**
- **Acceptable fit**
- **Poor fit**

- We compare Models C and D using a Chi-Squared Difference Test with the null hypothesis that Models C and D fit equally well and alternative that Model D fits worse than Model C.
- We reject the null (Chi-Square = 148.56, p-value < 0.0001) and conclude that Model C fits better than Model D.
# Reliability Coefficients

The reliability of a scale is the ratio of the variance of the true scores to the variance of the observed scores. This is a signal-to-noise ratio with larger values indicating a greater proportion of the total variability that is not attributable to random error. Many reliability estimates exist, but coefficient alpha and coefficient omega are quite common.

Using the items from Model C, internal consistency reliability coefficients are calculated for each scale:

<table>
<thead>
<tr>
<th>Model C</th>
<th>Interest</th>
<th>Attainment</th>
<th>Utility</th>
<th>Expectancy</th>
<th>Cost</th>
<th>Difficulty</th>
<th>AcadSC</th>
<th>EGO</th>
</tr>
</thead>
<tbody>
<tr>
<td>alpha</td>
<td>0.92</td>
<td>0.86</td>
<td>0.86</td>
<td>0.87</td>
<td>0.90</td>
<td><strong>0.72</strong></td>
<td>0.74</td>
<td>0.76</td>
</tr>
<tr>
<td>omega</td>
<td>0.91</td>
<td><strong>0.66</strong></td>
<td>0.78</td>
<td>0.84</td>
<td>0.88</td>
<td><strong>0.74</strong></td>
<td>0.64</td>
<td>0.77</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model E</th>
<th>Interest</th>
<th>Attainment</th>
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<td>0.74</td>
<td>0.71</td>
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<tr>
<td>omega</td>
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<td><strong>0.83</strong></td>
<td>0.78</td>
<td>0.83</td>
<td>0.88</td>
<td><strong>0.56</strong></td>
<td>0.64</td>
<td>0.67</td>
</tr>
</tbody>
</table>
S–SOMAS Pilot 1 Attitude Results
Attitude Overview

Computed using the items for each scale in Model C
Future Work
Please Join Us for our **Next Steps**

**Serve as a Subject Matter Expert (SME)**

**Use the instruments in your own education research**

Pilot the surveys in your classrooms and as an instructor

Help spread the word about the instruments and our website!

http://SDSAttitudes.com

**Click here to fill out the interest form**
Thank You!
<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Institution</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alana Unfried</td>
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<td><a href="mailto:aunfried@csumb.edu">aunfried@csumb.edu</a></td>
</tr>
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<td>Co-Principal Investigator</td>
<td>Monmouth College (Illinois)</td>
<td><a href="mailto:mebond@monmouthcollege.edu">mebond@monmouthcollege.edu</a></td>
</tr>
<tr>
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<td>Winona State University</td>
<td><a href="mailto:akerby@winona.edu">akerby@winona.edu</a></td>
</tr>
<tr>
<td>Michael A. Posner</td>
<td>Co-Principal Investigator</td>
<td>Villanova University</td>
<td><a href="mailto:michael.posner@villanova.edu">michael.posner@villanova.edu</a></td>
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<tr>
<td>Douglas Whitaker</td>
<td>Co-Principal Investigator</td>
<td>Mount Saint Vincent University</td>
<td><a href="mailto:douglas.whitaker@msvu.ca">douglas.whitaker@msvu.ca</a></td>
</tr>
<tr>
<td>Leyla Batakci</td>
<td>Other Senior Personnel</td>
<td>Elizabethtown College</td>
<td><a href="mailto:batakci@etown.edu">batakci@etown.edu</a></td>
</tr>
<tr>
<td>Wendine Bolon</td>
<td>Other Senior Personnel</td>
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<td><a href="mailto:wbolon@monmouthcollege.edu">wbolon@monmouthcollege.edu</a></td>
</tr>
<tr>
<td>Jennifer Green</td>
<td>External Evaluator</td>
<td>Michigan State University</td>
<td><a href="mailto:jg@msu.edu">jg@msu.edu</a></td>
</tr>
</tbody>
</table>
Appendix


Epksamp, S. (2019). semPlot: Path diagrams and visual analysis of various SEM packages’ output (R package version 1.1.2) [Computer software]. https://CRAN.R-project.org/package=semPlot


Raiche, G. (2010). nFactors: An R package for parallel analysis and non graphical solutions to the Cattell scree test (R package version 2.3.3) [Computer software]. http://CRAN.R-project.org/package=nFactors


Wright Map: IRT item-person map with ConQuest integration (R package version 1.2.3) [Computer software]. http://github.com/david-ti/wrightmap


All analyses were performed in Microsoft Open R version 4.0.2 (Microsoft, 2020; R Core Team, 2020) with Intel MKL. The following packages were used:

- **IRT packages**: ltm (Rizopoulos, 2006), mirt (Chalmers, 2012), Gifi (Mair & De Leeuw, 2019), WrightMap (Torres Irribarra & Freund, 2014)
- **EFA packages**: nFactors (Raiche, 2010), networkD3 (Allaire et al., 2017)
- **CFA packages**: lavaan (Rosseel, 2012), semPlot (Epskamp, 2019), semTools (semTools Contributors, 2016)
- **Other packages**: psych (Revelle, 2021), ggplot2 (Wickham, 2009), RColorBrewer (Neuwirth, 2014)
The development focus for the S-SOMAS is moving toward finalizing the instrument. Ultimately, we will use **Confirmatory Factor Analysis** (CFA) to provide validity evidence about the internal structure of the instrument. This process will begin with all 66 items administered during Pilot 1; items will be chosen for exclusion/inclusion based on evidence from other analyses and alignment to the EVT construct definitions.

Other analyses that will inform the revisions to the CFA models include:
- Exploratory Factor Analysis
- Principal Components Analysis
- Item Response Theory (Graded Response Model)

A brief summary of attitudes using the items from one preliminary model will be shown (using classical test theory).
We evaluated the Partial Credit Model (PCM; Masters, 1982), Generalized Partial Credit Model (GPCM; Muraki, 1992), and Graded Response Model (GRM; Samejima, 1969) for each scale.
- A likelihood ratio test was used to compare the PCM and GPCM.
- AIC was recorded for each.

For Utility Value:
- GPCM was preferred to PCM based on the likelihood ratio test.
- GRM was preferred overall because of lowest AIC.
  - GRM: AIC = 13970.64
  - GPCM: AIC = 14083.93
  - PCM: AIC = 14159.65

For every scale, GRM was preferred.
## Item Response Theory: Utility Value

<table>
<thead>
<tr>
<th>item</th>
<th>outfit</th>
<th>z.outfit</th>
<th>infit</th>
<th>z.infit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility_1</td>
<td>0.9883</td>
<td>-0.1222</td>
<td>0.9650</td>
<td>-0.4574</td>
</tr>
<tr>
<td>Utility_2</td>
<td>0.8740</td>
<td>-1.4648</td>
<td>0.8836</td>
<td>-1.4766</td>
</tr>
<tr>
<td>Utility_3</td>
<td>0.7982</td>
<td>-1.6404</td>
<td>0.8588</td>
<td>-1.7097</td>
</tr>
<tr>
<td>Utility_4</td>
<td>0.9646</td>
<td>-0.3617</td>
<td>0.9537</td>
<td>-0.5387</td>
</tr>
<tr>
<td>Utility_5</td>
<td>0.9654</td>
<td>-0.2745</td>
<td>0.9984</td>
<td>0.0069</td>
</tr>
<tr>
<td>Utility_6</td>
<td>0.9335</td>
<td>-0.4445</td>
<td>0.8910</td>
<td>-1.3632</td>
</tr>
<tr>
<td>Utility_7</td>
<td>1.0161</td>
<td>0.2181</td>
<td>0.9486</td>
<td>-0.6302</td>
</tr>
<tr>
<td>Utility_8</td>
<td>0.8832</td>
<td>-1.2432</td>
<td>0.8746</td>
<td>-1.4353</td>
</tr>
<tr>
<td>Utility_9</td>
<td>0.9963</td>
<td>-0.0113</td>
<td>0.9355</td>
<td>-0.7597</td>
</tr>
<tr>
<td>Utility_10</td>
<td>1.0113</td>
<td>0.1683</td>
<td>0.9705</td>
<td>-0.3629</td>
</tr>
<tr>
<td>Utility_11</td>
<td>0.9284</td>
<td>-0.5745</td>
<td>0.9179</td>
<td>-0.9077</td>
</tr>
</tbody>
</table>

For Utility Value, no items seem to be problematic based on either outfit or infit.
## Confirmatory Factor Analysis

<table>
<thead>
<tr>
<th>Model</th>
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<tr>
<td>Model C</td>
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<td>637</td>
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### Interpretation (Hooper et al., 2008)

- **CFI**: Greater than 0.95 generally indicates good fit.
- **TLI**: Greater than 0.95 generally indicates good fit.
- **RMSEA**: Less than 0.06 generally indicates good fit; cutoff values for acceptable fit of 0.07 to 0.10 have been proposed.
- **SRMR**: Less than 0.05 generally indicates good fit; values above 0.05 but below 0.08 may be acceptable.

- We compare Models C and D using a Chi-Squared Difference Test with the null hypothesis that Models C and D fit equally well and alternative that Model D fits worse than Model C.
- We reject the null (Chi-Square = 148.56, p-value < 0.0001) and conclude that Model C fits better than Model D.
## Confirmatory Factor Analysis: Model C

<table>
<thead>
<tr>
<th>Item Code within Each S-SOMAS Pilot 1 Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model C</strong></td>
</tr>
<tr>
<td>STV Higher-Order Factor? No</td>
</tr>
<tr>
<td>Interest</td>
</tr>
<tr>
<td>1   2   3   4   5   6   7   8   9</td>
</tr>
<tr>
<td>Attainment</td>
</tr>
<tr>
<td>1   2   3   4   5   6   7   8   9   10   11</td>
</tr>
<tr>
<td>Utility</td>
</tr>
<tr>
<td>1   2   3   4   5   6   7   8   9   10   11</td>
</tr>
<tr>
<td>Expectancy</td>
</tr>
<tr>
<td>1   2   3   4   5   6</td>
</tr>
<tr>
<td>Cost</td>
</tr>
<tr>
<td>1   2   3   4   5   6</td>
</tr>
<tr>
<td>Difficulty</td>
</tr>
<tr>
<td>1   2   3   4   5</td>
</tr>
<tr>
<td>Academic Self-Concept</td>
</tr>
<tr>
<td>1   2   3   4   5   6   7   8   9</td>
</tr>
<tr>
<td>Extrinsic Goal Orientation</td>
</tr>
<tr>
<td>1   2   3   4   5   6   7</td>
</tr>
</tbody>
</table>
## Confirmatory Factor Analysis

A table indicating which items are included in each of the models.

<table>
<thead>
<tr>
<th></th>
<th>Model A</th>
<th>Model B</th>
<th>Model C</th>
<th>Model D</th>
<th>Model E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STV Higher-Order</strong></td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Interest</strong></td>
<td>1,2,3,4,5,6,7,8,9</td>
<td>1,2,3,4,5,6,7,8,9</td>
<td>2,3,5,9</td>
<td>2,3,5,9</td>
<td>2,3,5,9</td>
</tr>
<tr>
<td><strong>Attainment</strong></td>
<td>1,2,3,4,5,6,7,8,9,10,11,12,13</td>
<td>1,2,3,4,5,6,7,8,9,10,11,12,13</td>
<td>1,2,5,7,11,12,13</td>
<td>1,2,5,7,11,12,13</td>
<td>2,5,7,12,13</td>
</tr>
<tr>
<td><strong>Utility</strong></td>
<td>1,2,3,4,5,6,7,8,9,10,11</td>
<td>1,2,3,4,5,6,7,8,9,10,11</td>
<td>1,5,6,10,11</td>
<td>1,5,6,10,11</td>
<td>1,5,6,10,11</td>
</tr>
<tr>
<td><strong>Expectancy</strong></td>
<td>1,2,3,4,5,6</td>
<td>1,2,3,4,5,6</td>
<td>1,2,3,4,6</td>
<td>1,2,3,4,6</td>
<td>1,2,3,5,6</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>1,2,3,4,5,6</td>
<td>1,2,3,4,5,6</td>
<td>1,2,5,6</td>
<td>1,2,5,6</td>
<td>1,2,5,6</td>
</tr>
<tr>
<td><strong>Difficulty</strong></td>
<td>1,2,3,4,5</td>
<td>1,2,3,4,5</td>
<td>2,3,4,5</td>
<td>2,3,4,5</td>
<td>2,3,5</td>
</tr>
<tr>
<td><strong>Academic Self-Concept</strong></td>
<td>1,2,3,4,5,6,7,8,9</td>
<td>1,2,3,4,5,6,7,8,9</td>
<td>1,2,3,7,8</td>
<td>1,2,3,7,8</td>
<td>1,2,3,7,8</td>
</tr>
<tr>
<td><strong>Extrinsic Goal Orientation</strong></td>
<td>1,2,3,4,5,6,7</td>
<td>1,2,3,4,5,6,7</td>
<td>1,5,6,7</td>
<td>1,5,6,7</td>
<td>1,2,3,6</td>
</tr>
</tbody>
</table>
Person-Item Map: Utility Value

Wright Map with Thurstonian Thresholds for Utility Value

Computed using the items for each scale in Model C
Attitude Overview

Mean Scale Scores for S-SOMAS Pilot 1
Classical Test Theory Scoring

Scale
- IntEnj
- Attain
- Utility
- Expectancy
- CostBen
- Difficulty
- AcadSC
- EGO

Computed using the items for each scale in Model C
Exploratory Factor Analysis (EFA) conducted using promax rotation, maximum likelihood estimation, and polychoric correlations.

- Parallel analysis suggests 6-factor solution appropriate, and there is a hypothesized 8-factor solution (from theory).
- Empirical relationships are similar to what is hypothesized by theory; misalignments will inform survey revisions.

7-point data, 6-factor EFA, cutoff = 0.40

Theoretical Constructs

- Empirical Factors

Note: Items may load onto more than one factor.
Exploratory Factor Analysis

- Exploratory Factor Analysis (EFA) conducted using promax rotation, maximum likelihood estimation, and polychoric correlations.
- Parallel analysis suggests 6-factor solution appropriate, and there is a hypothesized 8-factor solution (from theory).
- Empirical relationships are similar to what is hypothesized by theory; misalignments will inform survey revisions.
Confirmatory Factor Analysis: Model Overview

Brief description of each model:

- **Model A** contains all items from Pilot-1 (66 items) loading on their hypothesized constructs
- **Model B** is Model A but with a higher-order factor for Subjective Task Values (STV) comprised of Interest, Attainment, and Utility
- **Model C** contains a subset of 38 items loading on their hypothesized constructs [see figure]
- **Model D** is Model C but with the STV higher-order factor

<table>
<thead>
<tr>
<th>Model C</th>
<th>Item Code within Each S-SOMAS Pilot 1 Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>STV Higher-Order Factor?</td>
<td>No</td>
</tr>
<tr>
<td>Interest</td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>Attainment</td>
<td>1 2 3 4 5 6 7 8 9 10 11 12 13</td>
</tr>
<tr>
<td>Utility</td>
<td>1 2 3 4 5 6 7 8 9 10 11</td>
</tr>
<tr>
<td>Expectancy</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>Cost</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>Difficulty</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Academic Self-Concept</td>
<td>1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>Extrinsic Goal Orientation</td>
<td>1 2 3 4 5 6 7</td>
</tr>
</tbody>
</table>

*Highlighting* indicates that the item was included in the model.
## Confirmatory Factor Analysis

<table>
<thead>
<tr>
<th></th>
<th>Chi-Square</th>
<th>df</th>
<th>CFI</th>
<th>TLI</th>
<th>RMSEA</th>
<th>SRMR</th>
<th>Warnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model A</td>
<td>14527.43</td>
<td>2051</td>
<td>0.958</td>
<td>0.956</td>
<td>0.116</td>
<td>0.097</td>
<td>Estimated parameter covariance matrix not positive definite, Heywood case</td>
</tr>
<tr>
<td>Model B</td>
<td>15138.93</td>
<td>2061</td>
<td>0.956</td>
<td>0.954</td>
<td>0.119</td>
<td>0.098</td>
<td>Estimated parameter covariance matrix not positive definite, latent variable covariance matrix not positive definite, Heywood case</td>
</tr>
<tr>
<td>Model C</td>
<td>1952.86</td>
<td>637</td>
<td>0.986</td>
<td>0.984</td>
<td>0.068</td>
<td>0.062</td>
<td>Heywood case</td>
</tr>
<tr>
<td>Model D</td>
<td>2268.08</td>
<td>647</td>
<td>0.983</td>
<td>0.981</td>
<td>0.075</td>
<td>0.067</td>
<td>Latent variable covariance matrix not positive definite, Heywood case</td>
</tr>
</tbody>
</table>

### Interpretation (Hooper et al., 2008)

<table>
<thead>
<tr>
<th>Good fit</th>
<th>Acceptable fit</th>
<th>Poor fit</th>
</tr>
</thead>
</table>

- We compare Models C and D using a Chi-Squared Difference Test with the null hypothesis that Models C and D fit equally well and alternative that Model D fits worse than Model C.
- We reject the null (Chi-Square = 148.56, p-value < 0.0001) and conclude that Model C fits better than Model D.
Reliability Coefficients

The reliability of a scale is the ratio of the variance of the true scores to the variance of the observed scores. This is a signal-to-noise ratio with larger values indicating a greater proportion of the total variability that is not attributable to random error. Many reliability estimates exist, but coefficient alpha and coefficient omega are quite common.

Using the items from Model C, internal consistency reliability coefficients are calculated for each scale:

<table>
<thead>
<tr>
<th>Model C</th>
<th>Interest</th>
<th>Attainment</th>
<th>Utility</th>
<th>Expectancy</th>
<th>Cost</th>
<th>Difficulty</th>
<th>AcadSC</th>
<th>EGO</th>
</tr>
</thead>
<tbody>
<tr>
<td>alpha</td>
<td>0.92</td>
<td>0.86</td>
<td>0.86</td>
<td>0.87</td>
<td>0.90</td>
<td>0.72</td>
<td>0.74</td>
<td>0.76</td>
</tr>
<tr>
<td>omega</td>
<td>0.91</td>
<td>0.66</td>
<td>0.78</td>
<td>0.84</td>
<td>0.88</td>
<td>0.74</td>
<td>0.64</td>
<td>0.77</td>
</tr>
</tbody>
</table>