Measuring student enjoyment and effective teaching practices: what works?

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Attitudes in Statistics & Data Science

- **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**

Some Existing Instruments

- **Instructor/Environment Instruments (Statistics)**
  - Statistics Teaching Inventory (STI; Zieffler et al., 2012)
    - Snapshot of instructor practices in Introductory Statistics
    - Does not measure attitudes or learning environment characteristics
    - Not linked to student measures
- **Student Instruments (Statistics)**
  - Many instruments to measure attitudes and/or anxiety
  - Most widely used: Survey of Attitudes Toward Statistics (SATS; Schau, 1992, 2003)
- **Data Science Attitudes Instruments**
  - No publicly available instruments with published validity evidence

Survey of Attitudes Toward Statistics

- The current version of the SATS uses 36 items to measure six constructs (Schau, 2003):
  - Affect, Cognitive Competence, Value, Difficulty, Interest, & Effort
- Many challenges to use (e.g., Whitaker et al., 2022) including:
  - Incomplete alignment to theoretical framework
  - Some validity evidence challenges for certain uses
  - Ceiling effects on some scales
  - Permission and/or fees requires to use

SATS-36: Measuring Change

- SATS researchers have proposed a ½-point change in scale scores as being a threshold for important change:
  - … we considered differences of about ½ point or more as important. That value represents a change of about 8% of the possible range in the Likert scale for each item. As examples, we describe how students could change their scores by ½ point on the Interest component, one of the components with 4 items (the fewest number of items in a component), and on the Value component (the component with 9 items, the greatest number of items). For Interest, students' scores would change by ½ point if they changed their Likert scale responses by 1 point on two items (half of the items in the component) or by 2 points on one item. Students could change their scores by slightly over ½ point on the Value component by changing their scale responses by 1 point on 5 items (about half of the items) or in several other ways. We believe that this degree of change is important. (Schau & Emmioğlu, 2012, p. 88)
- Used in the literature for *individuals* and *means* of courses/sections.

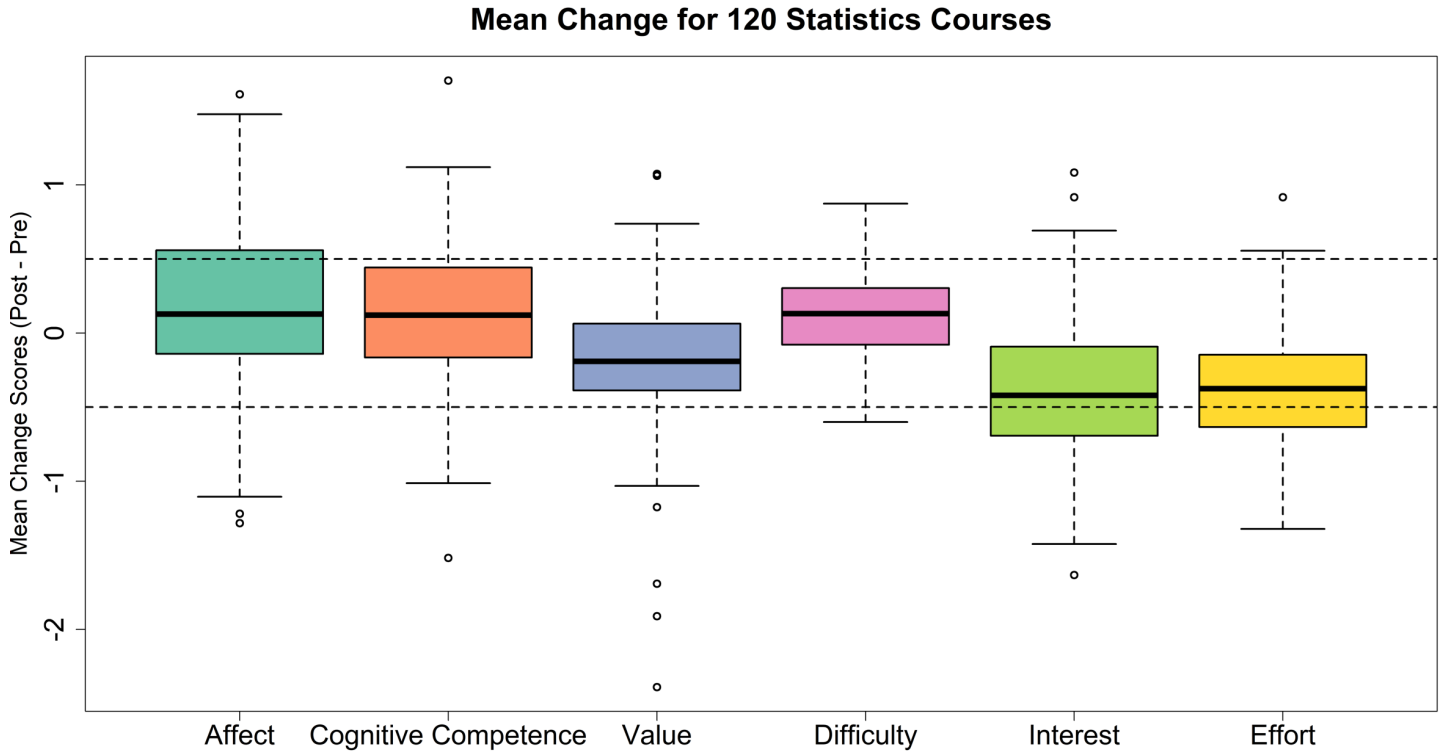
SATS-36: Measuring Change? (Individuals)

- Based on the SATS Data Warehouse ($n \approx 2300$), Whitaker et al. (2022) examined individual and mean differences with the ½-point threshold.

Component	% with Change Score Less than -½ Point	% with Change Score Greater than +½ Point
Affect	26%	34%
Cognitive Competence	25%	31%
Value	36%	20%
Difficulty	20%	30%
Interest	39%	17%
Effort	31%	8%

SATS-36: Measuring Change? (Course Means)

- Based on the SATS Data Warehouse ($n \approx 2300$), Whitaker et al. (2022) examined individual and mean differences with the ½-point threshold.



SATS-36: Measuring Change? (Course Means)

- Based on the SATS Data Warehouse ($n \approx 2300$), Whitaker et al. (2022) examined individual and mean differences with the ½-point threshold.

Component	Mean Difference	Cohen's d	Interpretation
Affect	0.15	0.29	Small
Cognitive Competence	0.11	0.23	Small
Value	-0.20	-0.40	Small
Difficulty	0.12	0.35	Small
Interest	-0.36	-0.57	Medium
Effort	-0.39	-1.23	Large

Possible Explanations

- The overall pattern of attitude changes measured by the SATS-36 is… "no change" – why?
- Some possible explanations:
  1. Students' attitudes toward statistics **do not change** within a semester. (That is, a longer timeframe is needed.)
  2. Students' attitudes toward statistics do not change **enough** within a semester to be detected by the SATS-36.
  3. Students' attitudes toward statistics **do change** within a semester, but the **SATS-36 cannot reliably detect** these changes.
  4. Perhaps a "traditional" statistics course does not change course attitudes within a semester, but **there are interventions that might** – and the dataset does not distinguish between these.
  5. The populations of students that have been studied are **not representative of *all* students** at the undergraduate level.

SATS-36: Measuring Change?

- SATS-36 (Schau, 2003) has more challenges to its use for addressing these explanations, especially with longitudinal research

- **Rigid pre/post structure** (e.g., Kerby & Wroughton, 2017; Millar & White, 2014)
  - "I will like statistics." [Pre] vs. "I like statistics." [Post]
  - "I will be under stress during statistics class." [Pre] vs. "I am under stress during statistics class." [Post]

- Respondent **assumed to be enrolled** in a course, for example:
  - "I will have no idea of what's going on in this statistics course."

- Instructions say, "If you have no opinion, choose 'Neither disagree nor agree.'"
  - Tendency for students to respond with a "4"?

MASDER Project

***M**otivational*
***A**ttitudes in*
***S**tatistics and*
***D**ata Science*
***E**ducation*
***R**esearch*

DUE-2013392

- 3-year **NSF** IUSE grant (Oct ‘20 - Sept ‘23)
- Strong **theoretical framework** (EVT) and rigorous development process
- Family of **6 instruments** evaluating student and instructor attitudes toward statistics and data science, and the learning environment
- Establish **nationally-representative** summaries of students and instructors
- Create **website** interface for each implementation and dissemination of general and instructor-specific results
  - sdsattitudes.com

Surveys Of Motivational Attitudes toward...

	Student	Instructor	Environment
Statistics	S-SOMAS	I-SOMAS	E-SOMAS
Data Science	S-SOMADS	I-SOMADS	E-SOMADS

MASDER Development Process

- Staggered design process where:
  - **Student** instruments developed before **instructor**/**environment** instruments
  - **Statistics** instruments developed before **data science** instruments
  - Focus on validity evidence throughout (Whitaker et al., 2019)

- **S**-SOMA**S** is almost in its final form
- **I**-SOMA**S**, **E**-SOMA**S**, **S**-SOMA**DS** are in pilot phases
- **I**-SOMA**DS**, **E**-SOMA**DS** are being drafted

We are already sharing the current versions of these instruments with some research teams who have approached us.

I-SOMAS Overview

- To be completed by **instructors** *once* (during the grant and periodically updated after)

- **Psychometric scale item pool** (90 items measuring 11 constructs)
  - Both the number of items and number of constructs will be cut
- **Personal characteristics questions** (e.g., gender; see upcoming IASE presentation for more details)
- **Professional characteristics questions** (e.g., rank, field of study, years of experience)
- **Other questions** (e.g., department, familiarity with GAISE, professional development)

E-SOMAS Overview

- To be completed by **instructors** for *each course/section*

- **Institutional characteristics** (as measured by Carnegie Classification)
- **Course characteristics questions** (e.g., prerequisites, modality, learning environment)
- **Instructors' enacted classroom behaviours**
  - *Faculty Inventory of Methods and Practices Associated with Competent Teaching* (F-IMPACT) from the University of Nebraska Omaha STEM TRAIL Center (PI: Christopher Moore)
- **Statistics-specific pedagogy practices**

S-SOMAS Overview

- To be completed by **students** at the *beginning & end of course*

- **Psychometric scales** (54 items measuring 8 constructs)
  - Very likely to be cut to about 40 items measuring 8 constructs
- **Non-construct items** (8 items about perceptions of statistics/mathematics)
- **Personal characteristics questions** (e.g., gender; see upcoming IASE presentation for more details)
- **Student standing questions** (e.g., major, academic level, expected grade, prior statistics courses)

S-SOMAS Goals

- Our main goal is to develop a psychometrically-valid instrument for measuring student attitudes in statistics that is part of a larger family of instruments and can be used in many contexts.

- But we are really interested in being able to answer the following:

Can students' attitudes about statistics change in a semester, and can we build an instrument to measure this change?

S-SOMAS: Intended Population/Uses

- Due to the source of the funding, we are developing the S-SOMAS to be used in a **pre/post format** with **undergraduate students** enrolled in **statistics courses** in the **United States**…
- … but throughout the instrument development process we aimed to make the S-SOMAS so that it could be used much more broadly!

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- … but throughout the instrument development process we aimed to make the S-SOMAS so that it could be used much more broadly!

- Items do not require enrollment in a statistics course and there are not separate pre/post forms: we expect the S-SOMAS to be used longitudinally, even after students stop taking statistics courses.

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- … but throughout the instrument development process we aimed to make the S-SOMAS so that it could be used much more broadly!

- Nothing about the way the items were created should prevent their use with secondary school students, graduate students, or adults not enrolled in statistics courses.

S-SOMAS: Intended Population/Uses

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- … but throughout the instrument development process we aimed to make the S-SOMAS so that it could be used much more broadly!

- Our ethics clearance limits our data collection for the grant to the United States, but the items should be readily useful in other Anglophone contexts (and we are open to translations!).

Academic Year 2022-23 Pilot Study: Preliminary Results

- Purposes:
  1. Continue S-SOMAS & I-SOMAS data collection for psychometric validation purposes
  2. Pilot all three instruments simultaneously
  3. Testing different survey backend options

- The aim of this study is not to provide definitive answers

- The sample is not nationally representative
  - Academic Year 2023-24 study will be

Academic Year 2022-23 Pilot Study: Preliminary Results

- Data collected from approximately **2000 students** enrolled in courses from **23 instructors** from **12 institutions**
  - Administered S-SOMAS (Pilot 4), E-SOMAS (Pilot 1), and I-SOMAS (Pilot 2)
  - S-SOMAS administered in pre/post format

- Still in the data cleaning and processing phase, so data are not yet linked across instruments
- We will look at preliminary results from the S-SOMAS pre/post
  - Data from best 39 candidate items (identified in Pilot 3)

Pre and Post Means (All Students)

SATS Data Warehouse

All students
$(n \approx 2300)$

Component	Pre	Post
Affect	4.26	4.40
Cognitive Competence	4.94	5.01
Value	5.21	4.97
Difficulty	3.58	3.71
Interest	4.89	4.46
Effort	6.37	6.00

S-SOMAS Pilot 4

All students
$(n \approx 2000)$

Component	Pre	Post
Academic Self-Concept	5.26	5.12
Attainment Value	5.18	5.12
Cost	4.65	4.51
Difficulty	4.13	4.09
Expectancy	5.09	5.24
Goals	3.91	4.07
Interest/Enjoyment Value	4.64	4.44
Utility Value	4.89	4.80

Changed Attitudes (All Students)

SATS Data Warehouse

All students
$(n \approx 2300)$

(Whitaker et al., 2022)

Component	% with Change Score Less than -½ Point	% with Change Score Greater than +½ Point
Affect	26%	34%
Cognitive Competence	25%	31%
Value	36%	20%
Difficulty	20%	30%
Interest	39%	17%
Effort	31%	08%

S-SOMAS Pilot 4

All students
$(n \approx 2000)$

Component	% with Change Score Less than -½ Point	% with Change Score Greater than +½ Point
Academic Self-Concept	32%	18%
Attainment Value	24%	21%
Cost	25%	18%
Difficulty	30%	25%
Expectancy	16%	25%
Goals	23%	36%
Interest/Enjoyment Value	30%	19%
Utility Value	30%	22%

SATS Data Warehouse

120 sections

(Whitaker et al., 2022)

Component	Mean Difference	Cohen's d	Interpretation
Affect	0.15	0.29	Small
Cognitive Competence	0.11	0.23	Small
Value	-0.20	-0.40	Small
Difficulty	0.12	0.35	Small
Interest	-0.36	-0.57	Medium
Effort	-0.39	-1.23	Large

S-SOMAS Pilot 4

16 instructors with pre/post data

Component	Mean Difference	Cohen's d	Interpretation
Academic Self-Concept	0.01	0.03	Negligible
Attainment Value	-0.31	-0.78	Medium
Cost	-0.04	-0.19	Negligible
Difficulty	-0.02	-0.06	Negligible
Expectancy	-0.12	-0.37	Small
Goals	0.07	0.17	Negligible
Interest/Enjoyment Value	-0.32	-0.78	Medium
Utility Value	-0.12	-0.26	Small

Summary of Findings

- Preliminary results generally indicate that **students' attitudes may not measurably change** more than a small amount during a semester
  - Similar findings from prior SATS data and new S-SOMAS data

- Larger data collection combined with data about instructors and courses **may reveal factors related to increasing/decreasing attitudes**
  - The S-, E-, and I-SOMAS family of instruments designed to answer this

- Typical statistics courses **may not affect students' attitudes much** in a one semester course at the undergraduate level
  - Are students' attitudes more malleable in secondary school?
  - How do students' attitudes change over a longer time period?

Next Steps

- *Within* the MASDER grant:
  - Link datasets for analysis
  - Large-scale national (US) data collection
  - Finish development of the six instruments
  - Collect data using other instruments alongside the S-SOMAS

- *Beyond* the MASDER grant:
  - Use the instruments longitudinally
  - Use the instruments when doing interventions
  - Use the instruments with other populations

Upcoming MASDER Presentations: Summer 2023

Date	Conference	Title
29 May at 10:50 – 11:20 AM	SSC	Measuring student enjoyment and effective teaching practices: what works?
2 June at 9:30 – 10:45 AM	USCOTS	Different perspectives on course topics in Intro data science…Including yours!
3 June at 11:00 AM – 12:00 PM	USCOTS	MASDER your educational research: how to cohesively study students, instructors, and the learning environment
11 – 13 July (TBD)	IASE (Virtual)	MASDERing attitude research in statistics and data science education: instruments for measuring students, instructors, and the learning environment
6 August in 4:00 – 5:50 PM	JSM	Measuring Student Attitudes Toward Statistics using S-SOMAS: National Data and Individualized Report

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Questions?

Thank you!

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Abstract

Knowledge is not the only important outcome from statistics courses: students' attitudes and beliefs about statistics have been widely recognized as important outcomes since the 1990s. Within the statistics education research literature, there has been a proliferation of work using surveys to measure student attitudes (e.g., their interest/enjoyment). However, with most widely used research tools for measuring attitudes about statistics, finding evidence of change in attitudes from pre-course to post-course has been a recurring challenge. A new family of instruments - the Surveys of Motivational Attitudes toward Statistics (SOMAS) - has been developed to measure student attitudes, instructor attitudes and practices, and characteristics of the learning environment to provide researchers with a robust view of statistics attitudes within a course. With an eye toward 'what works', this presentation provides an overview of these tools along with results from a large pilot implementation.

Mesure de l'enthousiasme des étudiants et pratiques d'enseignement efficaces : qu'est-ce qui fonctionne?

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Société statistique du Canada
Statistical Society of Canada

Résumé

La connaissance n’est pas le seul aboutissement important des cours de statistique; les attitudes et convictions des étudiants au sujet de la statistique ont été largement reconnues comme des résultats importants depuis les années 1990. Dans la documentation de recherche sur l’enseignement de la statistique, on trouve une abondance de travaux utilisant les enquêtes pour mesurer les attitudes des étudiants (par ex. : leur intérêt/enthousiasme). Cependant, avec la plupart des outils de recherche largement utilisés pour mesurer les attitudes à l’égard de la statistique, la découverte d’une preuve d’un changement des attitudes entre les précours et postcours a été un problème récurrent. Une nouvelle famille d’instruments – l’Enquête sur les attitudes motivationnelles envers les statistiques (SOMAS) (Surveys of Motivational Attitudes toward Statistics) – a été développée pour mesurer les attitudes des étudiants, les attitudes et pratiques des enseignants et les caractéristiques de l’environnement d’apprentissage afin de fournir aux chercheurs une vue statistique robuste des attitudes pendant un cours. Dans une perspective de « ce qui fonctionne », cette présentation fournit une vue d’ensemble de ces outils de même que des résultats d’une vaste implémentation pilote.