A NEW SURVEY OF STUDENT ATTITUDES TOWARD STATISTICS: THE S-SOMAS

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The Student Survey of Motivational Attitudes toward Statistics is a new instrument designed to measure affective outcomes in statistics education. This instrument is grounded in the established Expectancy-Value Theory of motivation and is being developed using a rigorous process. This paper provides an overview of the four pilot studies that have been conducted during the survey development process. Additionally, a description of the methods used for analyzing the data and the way the results are used to holistically make decisions about revisions to the survey is included. Brief confirmatory factor analysis results are included from two pilot studies to demonstrate that substantial progress has been made on the development. Once finalized (Spring 2023), the survey will be made freely available.

BACKGROUND

Student attitudes are an important outcome in statistics education research (e.g., Gal & Garfield, 1997; Gal & Ginsburg, 1994). At the undergraduate level, the Survey of Attitudes Toward Statistics (SATS; e.g., Schau, 1992) family of instruments has been used in hundreds of studies (Whitaker, Bolch, et al., 2022), but substantial challenges exist to using the SATS family of instruments for contemporary research goals (Whitaker, Unfried, & Bond, 2022). These challenges arise from empirical properties of the scales (e.g., scores from the Effort scale are strongly negatively skewed) and from the design of the instruments (e.g., the rigid pre/post design is a barrier to longitudinal research, and the SATS development was not guided by an a priori theoretical framework). Therefore, when student attitudes are found to remain unchanged at the course-level using the SATS family (e.g., Schau & Emmioğlu, 2012), the cause of the observed lack of change is unclear: is there no change, or is the instrument unable to detect attitude changes that do occur? As a response to calls for more research on student attitudes and motivation (e.g., Eichler & Zapata-Cardona, 2016; Pearl et al., 2012), the Student Survey of Motivational Attitudes Toward Statistics (S-SOMAS) is being developed to serve as an instrument for measuring student attitudes in introductory statistics courses. (Initial validation work is focused on the undergraduate level, but eventual use at the secondary level is expected.) The S-SOMAS is grounded in psychological theory, uses a rigorous and iterative design process, and will be freely available. This paper briefly describes the development and current state of the S-SOMAS.

DEVELOPMENT OF SURVEY FORMS

The theoretical framework chosen for the S-SOMAS (Whitaker et al., 2018)—like the SATS family—is Expectancy Value Theory (EVT; e.g., Wigfield & Eccles, 2000). An initial pool of 108 items was developed in 2017 and reviewed by subject matter experts (SMEs); an initial pilot study was conducted using 92 of the items. Based on the results of this study, revisions to the instrument were made, including dropping items, revising items, and creating new items. Initially, items were written to measure 11 constructs: Expectancy, Utility Value, Interest/Enjoyment Value, Attainment Value, Costs, Academic Self-Concept, Statistics Self-Concept, Perception of Difficulty, Intrinsic Goal Orientation, Extrinsic Goal Orientation, and Beliefs and Stereotypes about Statistics. After pilot data collection, one construct was dropped (Beliefs and Stereotypes) and others were combined (Intrinsic and Extrinsic Goal Orientation; Academic and Statistics Self-Concept). Full details of this iterative process of piloting the instrument then revising it before more data collection are given by Whitaker et al. (2019) and Unfried et al. (2022). A list of the pilot studies that have been conducted is shown in Table 1 (sample size refers to the number of students after data cleaning). Full implementation of the S-SOMAS using a proper subset of items from Pilot 3 is planned for the 2022–2023 academic year.

Each pilot study has had a specific purpose.

- In Pilot 0, we sought to investigate the item-construct mapping because some constructs in the EVT framework have been little researched in the context of measurement. An additional goal was to better understand the relationships among the constructs that motivated the selection of constructs for each of the two forms (see Unfried et al., 2018).

- In Pilot 1, we sought to compare the relationships among all items and constructs on a single form. Additional goals were to collect data on new and revised items and to compare student responses using a 5-point and 7-point Likert-type response scale (see Unfried et al., 2022).
- In Pilot 2, we sought to do large-scale data collection for the pool of items (consisting of items that had performed well in previous pilot studies and newly written items). The intention is that the final instrument will be a proper subset of items from Pilot 2.
- In Pilot 3, we are seeking to collect further data on the items from Pilot 2. Sixteen items were identified as performing poorly relative to other items. These would therefore be unlikely to be on a final instrument and were removed to lower the response burden for students.

Table 1. Description of the S-SOMAS pilot studies

Pilot	Collected	Items and Constructs	Sample Size
0	Fall 2017– Summer 2018	Form A: 49 items measuring 6 constructs Form B: 50 items measuring 6 constructs (92 total items measuring 11 constructs; 1 construct was on Forms A & B)	Form A: 1189 Form B: 1192
1	Spring 2021	66 items measuring 8 constructs (Form-5 used a 5-point Likert-type scale; Form-7 used a 7-point Likert-type scale)	Form-5: 136 Form-7: 452
2	Fall 2021	88 items measuring 8 constructs	2546
3	Spring 2022	72 items measuring 8 constructs (subset of Pilot 2)	*ongoing*

In all pilot studies, students were recruited through their instructors. In Pilot 0 and Pilot 1, instructors were recruited largely through personal connections and limited advertising on email distribution lists for professional organizations; these were essentially convenience samples that served to provide preliminary item-level data. In Pilot 2 and Pilot 3, more extensive advertising on email lists was used to ensure broader representation of students and institutions. Ultimately, we aim to collect data in the full implementation to provide nationally representative (United States) summaries.

VALIDITY EVIDENCE GUIDING REVISIONS

Throughout the development process, multiple sources of validity evidence (American Educational Research Association et al., 2014) have been used to guide decision-making about the S-SOMAS instrument. The most salient sources of validity evidence for the revision to the instrument beginning with the initial item pool to the present are outlined below. All analyses were performed in R using standard packages.

Review by Subject Matter Experts

Prior to Pilot 0 and Pilot 1, SMEs with expertise in statistics education, educational measurement, and/or EVT were identified and asked to rate each item in the pool on a 3-point scale (1 = Essential, 3 = Not Necessary) and provide written comments about the items. This was also done before Pilot 2 with items written after Pilot 1. Lawshe's Content Validity Ratio (CVR; Lawshe, 1975) was calculated for each item, and the S-SOMAS development team met to discuss each item considering its CVR value, any written comments from SMEs, and the definition of the construct. Items were removed based on consensus after evaluating this evidence holistically.

Item Response Theory

Psychometric properties of the items and scales are evaluated for every pilot study using item response theory (IRT; e.g., Mair, 2018). The graded response model (GRM) has been chosen for modeling the polytomous items from the S-SOMAS. Within the IRT paradigm, evidence about the dimensionality of the scales is collected (using principal components analysis) and potential item misfit. These results have been used to compare response scales (which support the continued use of 7-point items) as well as identifying items to revise and/or drop from the instrument.

Exploratory Factor Analysis

Exploratory factor analysis (EFA) has been extensively used to analyze responses to the S-SOMAS pilot surveys; the results provide useful information about the item-construct mapping (e.g., items written to measure the same construct are expected to load on the same factor) and the relationships among constructs (e.g., constructs may be similar if items written for those constructs load together). In Pilot 0, EFA was the primary analytical tool for evaluating how well items aligned to their hypothesized constructs. In subsequent pilot studies, EFA was performed after confirmatory factor analysis (CFA) to identify potential areas of misfit to inform model revisions and the removal of items. For technical details of the EFA analyses, see Unfried et al. (2022).

Confirmatory Factor Analysis

Although CFA has been used as part of the analysis of data from all the pilot studies, CFA analyses are most important to the later pilot studies and ultimately the operational assessment. In CFA, a hypothesized model is evaluated to determine the extent to which it is compatible with the observed data. For this project, the hypothesized models indicate which items measure the same construct (and should therefore load together); additionally, some higher-order factor relationships are evaluated (e.g., to determine if there is evidence that Subjective Task Value constructs should be viewed as subconstructs of a higher-order factor). Internal consistency is also calculated using the CFA paradigm by computing coefficient omega and other measures (e.g., coefficient alpha).

Because many items have been included on the pilot instruments with the intention of dropping poorly performing items to create the final instrument, substantial misfit is expected when evaluating the naïve model where every item loads on its hypothesized factor. Instead, for Pilot 1 and Pilot 2, an iterative approach is used to select which items to include or exclude in the CFA models. The process of revising the CFA models is guided by empirical results from other analyses of the data (e.g., EFA and IRT), the EVT framework, and a careful examination of the items juxtaposed with the definitions of the constructs they are meant to assess. Although the process of revising CFA models to address initial misfit is a standard practice (Kline, 2016), we are making explicit the process of holistically evaluating empirical results and theoretical considerations to provide strong validity evidence supporting the use of the S-SOMAS.

PRELIMINARY RESULTS

While proposing a final instrument is outside the scope of this paper, subsets of items have been identified in both Pilot 1 and Pilot 2 that have at least acceptable item properties and CFA fit indices (see Table 2); the cutoffs used for acceptable CFA fit are CFI and TLI greater than 0.95, RMSEA less than 0.07, and SRMS less than 0.08 (Hooper et al., 2008). For Pilot 1, coefficient omega values for this subset of items were above 0.70 for six scales; for the two other scales the values were 0.56 (Difficulty) and 0.67 (Goal Orientation). For Pilot 2, all omega values were above 0.70. Substantial progress has been made, and the S-SOMAS is on track for full implementation.

Table 2. Fit indices from CFA analyses for selected subsets of items

Study	Items	Constructs	Higher Order Factor?	CFI	TLI	RMSEA	SRMR
Pilot 1	35	8	No	0.988	0.986	0.062	0.061
Pilot 2	45	8	Yes	0.980	0.979	0.067	0.056
Pilot 2	39	7	No	0.990	0.989	0.051	0.044

CONCLUSION

The S-SOMAS is a new survey for measuring students' attitudes toward statistics that is currently in development; substantial progress has been made and it is expected to be finalized for Spring 2023. The instrument addresses recognized research priorities of the statistics education community (e.g., Eichler & Zapata-Cardona, 2016; Pearl et al., 2012) and will be made freely available at http://sdsattitudes.com along with research guides supporting its use. The S-SOMAS is part of a larger family of instruments for use with students and instructors in both statistics and data science, and details for the entire family of instruments are available at the website.

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