

## A FRAMEWORK AND SURVEY FOR MEASURING STUDENTS' MOTIVATIONAL ATTITUDES TOWARD STATISTICS

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*The Survey of Motivational Attitudes toward Statistics (SOMAS) for Students is part of a family of instruments designed to assess attitudes toward statistics. In the SOMAS project, attitudes toward statistics are conceptualized broadly, and the instruments are designed drawing from Expectancy-Value Theory (EVT) (Eccles, 1983). In this way, the SOMAS project aims to build upon and extend the work of other attitude measures, e.g. the SATS-36. This paper describes the EVT model for students' motivational attitudes, the constructs to be assessed by the student SOMAS instrument, and future directions for the project.*

### INTRODUCTION

Attitudes toward statistics are important outcomes of statistics courses because they are linked with student achievement and because they affect students' lasting impressions of the discipline (Gal, Ginsburg, & Schau, 1997; Ramirez, Schau, & Emmioğlu, 2012). In short, "People forget what they do not use. But attitudes 'stick'" (Ramirez et al., 2012, p. 57). Therefore, it is crucial that we study student attitudes toward statistics in order to more broadly improve statistics education. The Survey of Attitudes Toward Statistics (SATS) instruments (Schau, 1992, 2003) are among the most widely-used and researched attitude surveys in the statistics education literature since their initial release and subsequent updates. However, research on the SATS instruments have revealed limitations in both the underlying framework and the psychometric properties of the instruments (Hommik & Luik, 2017; Vanhoof, Kuppens, Sotos, Verschaffel, & Onghena, 2011). This paper describes an application of Eccles' Expectancy-Value Theory (EVT) of achievement motivation to the development of a Survey of Motivational Attitudes toward Statistics (SOMAS).

### BACKGROUND

The EVT framework explains achievement-related outcomes by relating them to an individual's beliefs about success on a given a task (expectancies) and beliefs about the value of the task (values) (Eccles & Wigfield, 2002). In this motivational model, the choice of task, performance on the task, and persistence on the task are affected by one's expectancies and values: expectancies and values are constructs through which all other variables and constructs that may have an effect on achievement are mediated (Eccles, 1983; Eccles & Wigfield, 2002; Eccles (Parsons), Adler, & Meece, 1984; Wigfield & Cambria, 2010). Because much of the research in statistics education has centered on attitudes, we broadly refer to the expectancies and values as "motivational attitudes."

Student attitudes about statistics are a widely-studied outcome in statistics education. However, only three of the 15 previously-identified statistics attitudes surveys have identified an educational theory (Nolan, Beran, & Hecker, 2012). The SATS-28 and SATS-36 instruments were aligned with EVT *a posteriori* (Ramirez et al., 2012). However, because the SATS instruments were not initially developed to align with the EVT framework, there are oversimplifications (e.g. all types of task values are assessed in a single construct) and omissions (e.g. the goal orientation construct is not measured) that jeopardize the alignment of the instruments to the theoretical framework.

In addition to misalignment with the EVT framework, there are increasing concerns about the use of the SATS-36 instrument that motivate the development of new instruments. First, while a description of the development of the SATS-28 instrument is available (Schau, Stevens, Dauphinee, & Vecchio, 1995), validity evidence about the content and response processes for the additional scales included on SATS-36 is lacking. Secondly, while there is a hypothesized six-factor structure for the SATS-36, empirical studies have found that a four-factor model that

combines three constructs has been shown to be a reasonable model (Cashin & Elmore, 2005; Vanhoof et al., 2011). Thirdly, EVT includes a cost construct that is “especially important” to the choices made by students (Wigfield & Cambria, 2010, p. 4) which is only partially measured by the SATS-36 Effort construct (Ramirez et al., 2012); further, the Effort construct may not be useful in practice due to ceiling effects (Vanhoof et al., 2011). It is therefore critical that a survey of statistics attitudes must be grounded in a theoretical framework starting with initial development.

### A MOTIVATIONAL MODEL FOR STATISTICS

The version of the SOMAS instrument intended for use by students of statistics (S-SOMAS) is based on EVT (Eccles, 1983; Eccles & Wigfield, 2002). The EVT framework as enacted in S-SOMAS is represented in Figure 1 and contains the following constructs: Beliefs & Stereotypes about Statistics; Perception of others’ attitudes and expectations; Aptitude for Learning Statistics; Interpretation of Past Events; Goals and Self-Schemata; Self-Concept of Statistics Ability; Perception of Difficulty; Subjective Task Value; Expectancies; Performance Behaviors; and Achievement. This model adapts EVT to the specific context of statistics learning and teaching rather than incorporating every EVT construct (e.g. Eccles, 2014).

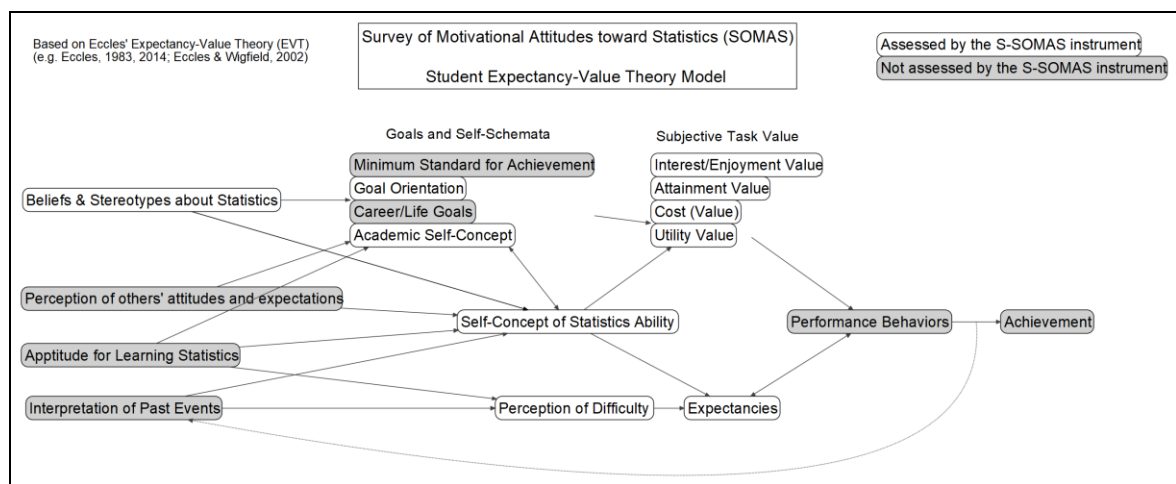


Figure 1. The Expectancy-Value Theory model as enacted in the S-SOMAS project

Because the model shown in Figure 1 is based on EVT, it is ultimately a model for explaining statistics achievement. Not every construct included in the model shown in Figure 1 will be measured by the S-SOMAS instrument: some constructs were determined to be too difficult to measure (e.g. interpretation of past events) while others were determined to be outside the scope of an attitude survey (e.g. aptitude for learning statistics). Performance behaviors and achievement are not included as constructs to be measured by the SOMAS project because statistics content assessments that are appropriate for measuring these constructs already exist. Selected constructs measured by the S-SOMAS instrument are defined below.

#### *Expectancies*

The Expectancies construct is closely related to Bandura’s (1977) concept of self-efficacy (Eccles & Wigfield, 2002). In the EVT model, Expectancies refers to expectancies related to success on a given task: Expectancies are viewed as mediating a student’s Self-Concept of Statistics Ability and Perception of Difficulty (of statistics) and affecting the student’s Performance Behaviors. In this sense, Eccles and Wigfield (2002) define expectancies for success by synthesizing the extant work of Eccles and her colleagues: “individuals’ beliefs about how well they will do on upcoming tasks, either in the immediate or longer term future” (p. 119). While Eccles and Wigfield include two different theoretical types of beliefs in their definition – beliefs about the immediate future and beliefs about the longer-term future – they note that these “are highly related and empirically indistinguishable” (p. 119). While Expectancies is one of only two constructs that have a direct effect on Performance Behaviors, many other constructs are indirectly related to important outcomes through Expectancies.

### *Subjective Task Values*

In EVT, subjective task value contains four individual constructs: interest/enjoyment value, utility value, attainment value, and cost (Eccles, 1983). An individual's interest in a task and their enjoyment of the task are conceptualized a single interest/enjoyment value construct in EVT (Eccles, 1983). This construct is a type of intrinsic value that is contrasted with utility value. The utility value of a task refers to the value the task serves for achieving one's goals and so "this component captures the more 'extrinsic' reasons for engaging in the task" (Eccles & Wigfield, 2002, p. 120). In the domain of statistics, utility value captures of the usefulness of statistics for achieving a student's goals, including goals for their career.

For an individual, a task's attainment value is the importance of success on the task to that individual (Eccles, 1983; Eccles & Wigfield, 2002). However, the importance of the task as conceptualized in this construct also includes the effect of engaging in the task on the individual's identity (Wigfield & Cambria, 2010). That is, doing well on a task that an individual conceives of as being central to their identity necessarily has a higher attainment value because of their identity.

Cost is conceptualized as the sacrifice necessary to complete a certain task. Statements concerning the sacrifice necessary to understand statistics. This includes the negative aspects of engaging in a task (e.g. performance anxiety, fear of failure), the amount of effort needed to succeed, and missed opportunities because one task was chosen over another (Eccles & Wigfield, 2002; Flake, Barron, Hulleman, McCoach, & Welsh, 2015).

### *Self-Concept*

Academic self-concept is one of two self-concept constructs in the EVT model shown in Figure 1. Bong and Skaalvik (2003) define academic self-concept as "individuals' knowledge and perceptions about themselves in achievement situations" (p. 6). Academic self-concept is often discussed in conjunction with (academic) self-efficacy, which appears in our model in the Expectancies construct. This construct includes what others have referred to as grit and perseverance (in academic situations) as well as responses to intellectual and achievement challenges.

Within academic self-concept, there are different subconstructs for different academic settings (e.g. English self-concept or science self-concept) (Shavelson & Bolus, 1982). The subconstruct most germane to the SOMAS project is self-concept of statistics ability. However, due to its importance for the domain of statistics, this component is treated as its own construct in the model consistent with other implementations of EVT (e.g. Eccles, 2014). Self-concept of statistics ability refers to students' perceptions of who they are in the domain of statistics.

### *Other Constructs*

Other constructs measured by the S-SOMAS instrument include students Beliefs and Stereotypes about Statistics, their Perception of the Difficulty of Statistics, and their Goal Orientations. Beliefs and Stereotypes and Perception of Difficulty are components of the EVT model and have been studied previously in the statistics education literature using other instruments (e.g. Roberts & Bilderback, 1980; Schau 2003). Goal Orientations are described as the "broader approaches children take to their learning and their approaches to competence, rather than goals for specific activities" (Wigfield & Cambria, 2010, p. 6). With a mastery goal orientation, the learner's goals are focused on personal improvement or learning the material, while with a performance goal orientation their goals are defined in terms of their abilities relative to other people (Wigfield & Cambria, 2010). We hypothesize that this construct is important for the learning and teaching of statistics because students may be enrolled in a statistics course for a variety of reasons and their goals in the course are relevant to understanding their outcomes in statistics.

### CONCLUSION

The SOMAS project has developed the EVT model shown in Figure 1 to explain statistics achievement in students, and an instrument is being developed to measure motivational attitudes guided by this model. This model is hypothesized and may be revised based on empirical results.

As of Fall 2017, an item pool has been written by a team interested in research on statistics attitudes and has been reviewed by more than 20 subject-matter experts. A preliminary pilot study is planned for Fall 2017, with a larger pilot planned for Spring 2018; these will lead to revisions of the instrument. In subsequent administrations, additional instruments will also be given to students to as part of collecting validity evidence for the S-SOMAS instrument. These instruments will include measures of statistics content knowledge, statistics anxiety, and other attitude surveys.

Additionally, the S-SOMAS instrument is one of a family of instruments being developed by the SOMAS project. The EVT framework is powerful and widely-used in the literature, and the SOMAS project is also developing models and instruments for use with in-service and pre-service teachers of statistics as well as a survey of course characteristics to be completed by instructors.

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