THE IMPORTANCE OF ATTITUDES IN STATISTICS EDUCATION

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ABSTRACT

People forget what they do not use. But attitudes "stick." Our article emphasizes the importance of students' attitudes toward statistics. We examine 15 surveys that purport to assess these attitudes and then describe the Survey of Attitudes Toward Statistics*, a commonly used attitude survey. We present our conceptual model of Students' Attitudes Toward Statistics (SATS-M), which is congruent with Eccles and colleagues' Expectancy-Value Theory (Eccles' EVT), as well as others. The SATS-M includes three broad constructs that impact Statistics Course Outcomes: Student Characteristics, Previous Achievement-Related Experiences, and Statistics Attitudes. We briefly describe Eccles' EVT and other theories that support our SATS-M. We relate findings from research using the SATS to our model and end with implications for statistics education.*

Keywords: *Statistics education research; Students' attitudes toward statistics; SATS-36; Expectancy-value theory*

1. INTRODUCTION

An ultimate goal of statistics education is to produce statistically literate adults who appropriately use statistical thinking. Statistics is the only discipline where it is perhaps accepted and expected that students can learn what they need in one introductory course. This introductory course, then, is where we, as statistics instructors, do or do not motivate students to learn the statistical skills that they will need in their professional and personal lives. However, being statistically literate means more than learning skills. Students need to recognize when they should apply statistical thinking, accurately use the skills they possess, know when they require additional statistical knowledge and skills, and obtain this additional statistical understanding. During their introductory statistics course, students need to

- believe that they can understand and use statistics,
- think that statistics is useful both in their professional and personal lives,
- recognize that statistics can be interesting,
- be willing to invest the effort needed to learn statistical thinking and skills, and,
- realize that statistics is not easy but it also is not too difficult to learn.

These statements describe attitudes about statistics, the "other" important outcome in statistics education (Garfield, Hogg, Schau, & Whittinghill, 2002; Schau, 2003b).

The National Council of Teachers of Mathematics has recommended that teachers attend to and assess students' attitudes as part of mathematics instruction (NCTM, 1989, 1991). Attitudes have emerged as primary factors in understanding students' mathematics achievement, their mathematics

ability beliefs, and their expectations for success in mathematics (Wigfield & Eccles, 2000). Despite this acknowledgement in mathematics education, the same degree of recognition has not yet occurred in statistics education.

Considering that statistics coursework is perhaps the major contributor to a statistically literate society, students' attitudes toward statistics deserve special attention. To assist in this endeavor, we developed a broad conceptual model of students' attitudes toward statistics. To create this model, we first reviewed a large body of literature in statistics education and educational psychology. This review demonstrated that students' attitudes have been included in many theories and empirical studies in disciplines other than statistics education to help explain students' achievement-related choices.

We emphasize the importance of students' attitudes toward statistics throughout our article. We begin by presenting a selection of surveys that purport to assess these attitudes, highlighting the *Survey of Attitudes Toward Statistics* (SATS-28 and SATS-36; Schau, 1992, 2003a). We then present our conceptual model of Students' Attitudes Toward Statistics (SATS-M), which is based on Eccles and colleagues' Expectancy-Value Theory (Eccles' EVT) as well as other educational theories. The SATS-M consists of three broad constructs that impact Statistics Course Outcomes: Student Characteristics, Previous Achievement-Related Experiences, and Statistics Attitudes. We briefly describe Eccles' EVT and provide additional theoretical support for our SATS-M. We then relate findings from research using the SATS to our model and present implications from the SATS-M for statistics education, both for instruction and research.

2. CONCEPTUALIZATIONS AND MEASURES OF STATISTICS STUDENTS' ATTITUDES

The research literature on students' attitudes reflects little consensus about how attitudes are conceptualized; this lack of consensus is evidenced by the substantial variation in the surveys designed to measure these attitudes. Yet, if we want to explore the impacts of students' attitudes toward statistics, we must be able to assess these attitudes and assess them well.

2.1. SURVEYS ASSESSING STUDENTS' ATTITUDES TOWARD STATISTICS

The most frequently used approach to assess students' attitudes toward statistics is a survey containing Likert-type items. Table 1 contains a list of 15 surveys that purport to assess at least some aspects of students' attitudes toward statistics. These surveys were published in journals or presented at major conferences. We did not include instruments that focus on attitudes toward other fields (such as psychology or research). A few of these surveys have been used in many research studies (e.g., the SAS, ATS, SATS-28, and SATS-36); others have been used in a few studies, sometimes only in the one study conducted by the researcher who created the measure. These surveys were developed in several different countries at different times. They contain from 1 to 6 attitude components.

As Table 1 shows, the constructs found in these surveys have a variety of names, although some names and constructs appear to be at least somewhat similar across surveys: anxiety, fear, enjoyment, and affect; self-efficacy, self-concept, confidence, and cognitive competence; value, utility, usefulness, and worth; interest; and effort. In spite of these similarities, the surveys do not present a consistent picture of students' attitudes toward statistics.

Out of these 15 surveys, four of them have been used the most. These are the *Statistics Attitude Survey* (SAS) by Roberts and Bilderback (1980; see also Roberts and Saxe, 1982), the *Attitudes Toward Statistics* (ATS) survey by Wise (1985), and the *Survey of Attitudes Toward Statistics-28* (SATS-28) and its expanded version, the *Survey of Attitudes Toward Statistics-36* (SATS-36).

Beginning in the 1980s, there were two frequently used surveys claiming to assess post-secondary students' attitudes toward statistics: the SAS and the ATS. The creators of these measures essentially originated survey research into students' statistics attitudes.

Roberts and Bilderback (1980) designed the SAS to predict students' achievement in statistics classes. The SAS yields one global attitude score. Despite extensive use of this survey, problems related to the content and the internal component structure of the SAS have been reported. For example, the use of a single attitude score implies that the construct of attitudes toward statistics is

Table 1. Surveys purporting to assess students' attitudes toward statistics

Number of Constructs	Name of Instrument (Citations)	Constructs
1	SAS: *Statistics Attitude Survey* (Roberts & Bilderback, 1980)	One global attitude score
	CSSE: *Current Statistics Self-efficacy* (Finney & Schraw, 2003)	Current statistics self-efficacy
	SELS: *Self-Efficacy to Learn Statistics* (Finney & Schraw, 2003)	Self-efficacy to learn statistics
	STACS: *Student Attitudes and Conceptions in Statistics* (Evans, 2007)	Statistics attitudes
2	ATS: *Attitudes Toward Statistics* (Wise, 1985)	Attitude toward course, attitude toward the field
	SAI: *Statistics Anxiety Inventory* (Zeidner, 1991)	Statistics content anxiety, statistics test anxiety
3	*Quantitative Attitudes* (Harlow, Burkholder, & Morrow, 2002)	Quantitative self-efficacy, quantitative anxiety, perceived quantitative hindrances
4	*Survey of Attitudes Toward Statistics*-28 (Schau, 1992; Schau, Stevens, Dauphinee, & Del Vecchio, 1995)	Affect, cognitive competence, value, difficulty
	Students' Attitudes Toward Statistics Questionnaire (Bayot, Mondejar, Mondejar, Monsalve, Vargas, 2005)	Interest, anxiety, present utility, professional utility
5	MSATS: *Multi-factorial Scale of Attitudes Toward Statistics* (Auzmendi, 1991)	Motivation, enjoyment, anxiety, confidence, usefulness
6	STARS: *Statistical Anxiety Rating Scale* (Cruise, Cash, & Bolton, 1985)	Perceived worth of statistics, interpretation anxiety, test and class anxiety, computation self-concept, fear of asking for help, and fear of statistics teachers
	Unnamed Instrument (Zanakis & Valenzi, 1997)	Student interest in and perceived worth of statistics, anxiety when seeking help for interpretation, computer usefulness and experience, math anxiety, understanding anxiety, test anxiety
	STSQ: *Self-efficacy Toward Statistics Questionnaire* (Lane, Hall, & Lane, 2002)	Using information technology, motivated behavior, time management, statistical theory, general competencies theme, lecture behavior
	SATS-36: *Survey of Attitudes Toward Statistics-36* (Schau, 2003a, b)	Affect, cognitive competence, value, difficulty, interest, effort
	MSQ: *Motivation toward Statistics Questionnaire* (Budé et al., 2007)	Stable explanation, control, outcome expectancy, affect, effort, persistence

one-dimensional, which is an untenable assumption according to most attitude theories (Albarracin, Johnson, & Zanna, 2005). It is difficult to use assessment results to effectively improve instruction and student course outcomes without theoretical guidance. The SAS also has been criticized as some of the items assess students' knowledge about statistics concepts or problems, not their attitudes (Curda, 1997; Gal & Ginsburg, 1994; Rhoads & Hubele, 2000; Sorge, 2001; Wise, 1985). Accordingly, it should not be used at the beginning of the introductory course (Rhoads & Hubele, 2000; Waters, Martelli, Zakrajsek, & Popovich, 1988). Like most of these surveys, the SAS was developed without input from its intended users, statistics students and instructors (except for the surveys' creators).

In an attempt to solve some of these problems, Wise (1985) developed his ATS. According to Wise, the ATS does not require knowledge about statistics and so can be used on the first day of class.

He claimed that the ATS measures two separate components of students' attitudes: "Field" – "attitudes of students toward the use of statistics in their field of study" and "Course" – "students' attitudes toward the course in which they were enrolled" (p. 402). Although the ATS has been widely used, it also exhibits problems. For example, it is not clear why Wise chose to develop these two specific components and only these two. These two components do not cover the construct of attitudes toward statistics (Curda, 1997; Gal & Ginsburg, 1994; Rhoads & Hubele, 2000; Sorge, 2001). Even though the definitions of his two components are quite broad, some items do not appear to fit into their designated component or even into the other component. The ATS also was not based on theory and was developed without input from users.

2.2. THE SURVEY OF ATTITUDES TOWARD STATISTICS

Beginning in the early 1990s, Schau developed the *Survey of Attitudes Toward Statistics-28* (SATS-28) followed by the *Survey of Attitudes Toward Statistics-36* (SATS-36) to ameliorate the issues associated with earlier attitude surveys. The SATS-28 contained 28 items assessing four attitude components: *Affect*, *Value*, *Cognitive Competence*, and *Difficulty*. A decade later, Schau updated the SATS-28 by adding 8 more items measuring two additional attitude components, *Effort* and *Interest,* and named the revised version the *Survey of Attitudes Toward Statistics-36* (SATS-36). The eight-step qualitative and quantitative development process used across the development of the two versions of the SATS included

1. initial examination of surveys purporting to assess students' attitudes toward statistics,
2. introductory statistics students' written descriptions of their attitudes,
3. words and phrases describing statistics students' attitudes generated and sorted into a consensus component structure by a focus group of introductory statistics' students and instructors,
4. pilot testing and subsequent revision of items written from these words and phrases,
5. validation of the four-component internal structure generated in Step 3 using Confirmatory Factor Analysis techniques,
6. validation of component scores based on their relationships and lack of relationships with scores from other measures,
7. addition of two more attitude components, and
8. validation of the six-component internal structure using Confirmatory Factor Analysis techniques.

The SATS-36 contains 36 items that assess six attitude components that are congruent with theories and research findings. These components include: *Affect*, *Cognitive Competence*, *Value*, *Difficulty, Interest*, and *Effort*. Students respond to each of the SATS items using a 7-point Likert response scale (1 = "Strongly Disagree", 4 = "Neither Disagree nor Agree" or neutral, 7 = "Strongly Agree"). Because higher item responses reflect more positive attitudes, responses to items that are negatively worded are reversed before combining students' responses into component scores. Thus, higher scores for every component (except for *Difficulty*) also reflect more positive attitudes. Students with higher *Difficulty* scores believe that statistics is easier whereas those with lower scores believe that it is harder. Although the name of the *Difficulty* component is not ideal, the focus group that contributed to the development of the SATS-28 named this component, and it has been known as such throughout the history of the use of the SATS. Table 2 contains each of the six SATS-36 components, its definition, and example item(s) from the pretest version.

The SATS-36 also contains additional items that assess Student Characteristics, such as gender and age, and students' Previous Achievement-Related Experiences, such as "number of high school mathematics and/or statistics courses completed." The items that do not use a Likert response scale are either in a "select" response format (e.g., gender) or a "fill-in" format (e.g., number of courses). Students usually spend about 10-15 minutes responding to the items on the SATS administered in either a paper-and-pencil or a Web format. The SATS pre-tests can be viewed at www.evaluationandstatistics.com.

Table 2. SATS-36 attitude components, definitions, and example item(s) from www.evaluationandstatistics.com

Component	Definition	Example Item(s)
Affect (6 items)	"students' feelings concerning statistics"	"I am scared by statistics."
Cognitive Competence (6 items)	"students' attitudes about their intellectual knowledge and skills when applied to statistics"	"I can learn statistics."
Value (9 items)	"students' attitudes about the usefulness, relevance, and worth of statistics in personal and professional life"	"I use statistics in my everyday life." "Statistics is not useful to the typical professional."
Difficulty (7 items)	"students' attitudes about the difficulty of statistics as a subject"	"Most people have to learn a new way of thinking to do statistics."
Interest (4 items)	"students' level of individual interest in statistics"	"I am interested in using statistics."
Effort (4 items)	"amount of work the student expends to learn statistics"	"I plan to work hard in my statistics course."

Several studies have shown that scores from the SATS have good to excellent psychometric properties. These properties include moderate to high values for internal consistencies for each of the attitude components evaluated using Cronbach's coefficient alpha (i.e., how well the items as a group fit together into their component) and concurrent validity (i.e., if the component scores show expected patterns of relationships with scores from other measures). Also, the six-component internal structure fits student responses to the 36 items well. This psychometric evidence comes from studies that included female and male students with varying educational levels (undergraduate or graduate), majors, ethnicities (e.g., White, Hispanic), and nationalities (e.g., German, Dutch, Italian, South African); different times of administration (usually beginning and end of the course); and a variety of course, instructor, instructional, and institutional characteristics. See, for example, Bechrakisa, Gialamasb, and Barkatsas (2011), Carnell (2008), Chiesi and Primi (2009), Dauphinee, Schau, and Stevens (1997), Emmioğlu (2011), Hilton, Schau, and Olsen (2004), Schau et al. (1995), Tempelaar and Nijhuis (2007), Tempelaar, Schim van der Loeff, and Gijselaers (2007), and Verhoeven (2009). Additional references are found at http://www.evaluationandstatistics.com.

3. A MODEL OF STUDENTS' ATTITUDES TOWARD STATISTICS

Why do some students perform better or value statistics more than other students? Why do they make certain academic and life choices regarding statistics and not others? We developed a broad conceptual model called a Model of Students' Attitudes Toward Statistics (or SATS-M) that will help us start to systematically explore the possible answers to these kinds of questions. The SATS-M contains three main constructs that influence Statistics Course Outcomes.

Student Characteristics is the first general construct. These characteristics can include, for example, gender and age, as well as any other demographic characteristic of interest. The second construct is Previous Achievement-Related Experiences; these experiences can include, for example, grade point average and past experiences with statistics and mathematics.

The third general construct is Statistics Attitudes; this construct includes any attitudinal variable considered to be important. In our case, it includes the six attitude components from the SATS-36. Before devoting the time and energy (*Effort*) to learn and do statistics, our model indicates that students evaluate their skills (*Cognitive Competence*) and the *Difficulty* of statistics and statistics tasks. They choose to expend *Effort* on statistics tasks and courses that they like (*Affect*) and are interested in doing (*Interest*) while they avoid others. They also consider how useful statistics is and will be in their lives (*Value*).

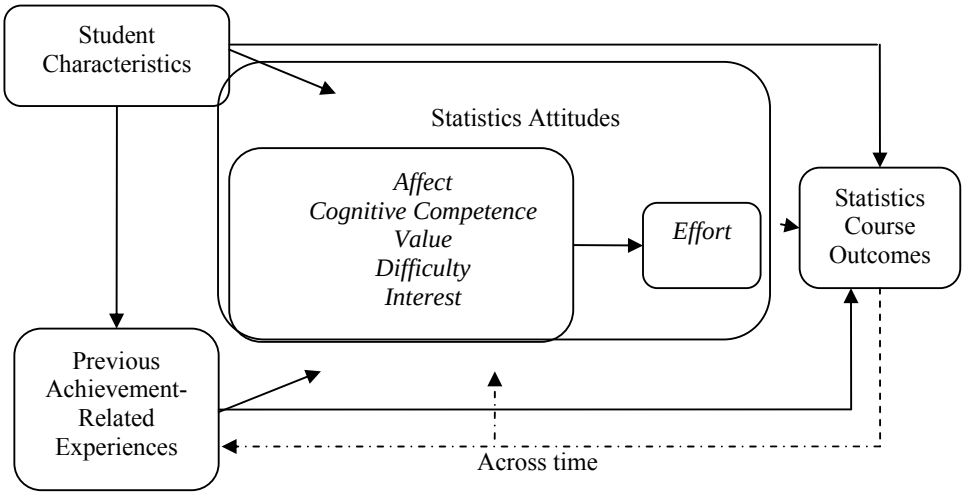

Figure 1. Students' Attitudes Toward Statistics - Model (SATS-M)

The constructs in our model emphasize the multi-dimensional and longitudinal nature of students' attitudes and Course Outcomes. Our model suggests that Student Characteristics influence Previous Achievement-Related Experiences and both impact Statistics Attitudes; all three then influence Statistics Course Outcomes. For example, male and female students may have taken different mathematics courses and achieved at different levels in those courses. Those experiences may impact their Statistics Attitudes and together result in different Statistics Outcomes by student gender. Longitudinally, Statistics Course Outcomes then impact Previous Achievement-Related Experiences and Statistics Attitudes. This kind of framework can help instructors and researchers consider factors that directly and indirectly influence students' attitudes toward statistics and their course outcomes, as well as how these relationships work.

4. THEORETICAL SUPPORT FOR THE IMPORTANCE OF STATISTICS ATTITUDES AND THE SATS-M

We primarily used Eccles' Expectancy-Value Theory as a general framework to develop the SATS-M. In addition, we reviewed other theories to verify the importance of the constructs found in our model. See below for a brief description of Eccles' EVT, as well as three additional theories. For more information on these theories and others, see Wentzel and Wigfield (2009).

4.1. ECCLES' EVT

Eccles and colleagues' revision of earlier Expectancy-Value Theories is one of the most influential and comprehensive theories designed to explain the nature of individuals' academic behaviors (Wigfield & Eccles, 2002). Eccles and colleagues, as well as many other researchers, have successfully applied their EVT to K-12 students' academic choices and achievement in many domains, including mathematics.

Eccles' EVT posits that students' beliefs about how well they will do on a task and how much they value that task are related and that they predict students' achievement-related outcomes. In other words, Eccles' EVT indicates that students are more likely to choose to engage and achieve in tasks that they value in broad terms and in which they expect to do well. In statistics education, these tasks include, for example, enrolling in and completing statistics courses, working hard to learn and to achieve, and using statistics in life.

Eccles and colleagues conceptualize value (called Subjective Task Value) as a "super-construct" that cannot be measured but that includes several measurable components, including students' interest in (*Interest)* and enjoyment from (*Affect)* engaging in a task, the importance a student attaches to the task and the usefulness of the task to students' futures (*Value)*, and how much *Effort* it will take to

accomplish the task. In addition, Eccles' EVT includes the constructs of task difficulty (*Difficulty*) and self-concept of abilities (*Cognitive Competence*).

Their theory also includes the impacts of Student Characteristics and Previous Achievement-Related Experiences on attitudes and other outcomes. A large body of research in disciplines other than statistics education has used Eccles' EVT as a theoretical framework. The results from this research support the predictions made by their theory (e.g., Bøe, Henriksen, Lyons, & Schreiner, 2011; Bruinsma, 2004; Durik, Vida, & Eccles, 2006; Luttrell et al., 2010; Simpkins, Davis-Kean, & Eccles, 2006).

4.2. OTHER THEORIES

We briefly mention three other theories that support our work. These theories include Self-determination Theory, Self-efficacy Theory, and Achievement Goal Theory.

Self-determination Theory Like Eccles' EVT, this theory proposes that students' learning is influenced by how they feel about statistics (*Affect*), their *Interest* in statistics, how much they *Value* statistics, and their beliefs in their cognitive abilities to cope with statistics (*Cognitive Competence*). Considerable research in this area has shown that students who feel competent and are engaged in interesting, enjoyable, and valued tasks tend to learn more than students whose attitudes in these four areas are less positive (e.g., Ryan & Deci, 2009).

Self-efficacy Theory This theory suggests that students who have positive judgments of their capabilities (*Cognitive Competence*) perform better than those who do not (e.g., Bandura, 1986, 1997; Gist & Mitchell, 1992). Usher and Pajares (2008) claimed that students' interpretation of their previous achievement is the most influential source of their self-efficacy. According to this theory, students typically base their self-efficacy on their evaluation and interpretation of their prior experience in current or similar past courses; their resulting self-efficacy then will inform their decisions to engage in behaviors that result in Statistics Course Outcomes (both good and bad).

Achievement Goal Theory According to this theory, students value or devalue statistics for many possible reasons. The ways in which students *Value* a particular outcome or task informs their choices and influences their behavior, as well as the *Effort* that they are willing to expend toward achieving a goal.

5. SATS EMPIRICAL FINDINGS RELATED TO THE SATS-M

Because the developers of the surveys designed to assess students' attitudes toward statistics disagreed about such fundamentals as the number of attitude components (ranging from 1 to 6), as well as the constructs they assess, it is difficult (if not impossible) to summarize results from research using different attitude surveys. Given the extensive research supporting the psychometric qualities of scores from the SATS-28 and the SATS-36 and our choice to include the six SATS-36 components in our model, we summarized findings from research that has used one or the other version of the SATS.

We identified 59 studies that used the SATS-28 or the SATS-36: 15 conference proceedings, 12 dissertations, and 32 journal articles. About 90% percent of these studies were done in the last 12 years; there has been an increase in the number of studies that have used the SATS-28 or SATS-36 since 2003, soon after the development of the SATS-28. Of these studies, three (5%) used a pretest-posttest design, 11 (18%) exploreded the psychometric propoerties of the SATS-28/36, 10 (16%) tested structural equation models, 14 (23%) evaluated an intervention, and 21 (35%) were correlational studies.

Results from the research using the SATS generally support the existence of the relationships contained in our Students' Attitudes Toward Statistics – Model. However, it is difficult to discuss definitive patterns in the research findings from these studies for at least five reasons. First, 38 researchers used the SATS-28, three used only selected components from the SATS-28, and 18 used the complete SATS-36. This variation means that some of the SATS components, especially *Interest* and *Effort* that are found only in the SATS-36, were not included in almost 70% of the studies.

Second, the samples varied greatly in terms of demographic and achievement-related characteristics, including, for example, the proportion of females to males, age, educational level (undergraduate students, graduate students, mixed), students' nationality (e.g., US, Netherlands, Italy, South Africa, Israel, Greece), and major (e.g., business, psychology, pre-service teaching training, mixed). Third, these characteristics themselves were interrelated; for example, the sample from Israel was almost entirely female and all were enrolled in the pre-service teacher training program. Fourth, Previous Achievement and course achievement (the most commonly studied Course Outcome) were measured in a variety of ways (e.g., course grades, exam scores, self-reported math ability). Fifth, sample sizes (and so the ease of finding statistical significance) varied widely.

Next, we examine and discuss the empirical results in two sections, organized by the constructs found in our model. We first summarize findings from research that examined the relationships among prior factors and Statistics Attitudes. We then summarize research results relating previous factors and Statistics Course Outcomes.

5.1. RELATIONSHIPS AMONG PRIOR SATS-M FACTORS AND STATISTICS ATTITUDES

Two SATS-M factors impact Statistics Attitudes. These factors include Student Characteristics and Previous Achievement-Related Experiences.

Student Characteristics Student Characteristics is the first factor in our model that impacts Statistics Attitudes. The most commonly studied characteristics include gender, ethnicity/nationality, and age.

We identified 17 studies that investigated possible gender differences in attitude components; these studies did not reveal consistent findings. Nine, all from countries other than the United States, reported some statistically significant gender differences on some attitude components (Bechrakisa et al., 2011; Coetzee & van der Merwe, 2010; Mahmud & Zainol, 2008; Tempelaar, Schim van der Loeff, Gijselaers, & Nijhuis, 2011; Tempelaar, Gijselaers, & Schim van der Loeff, 2006; Tempelaar & Nijhuis, 2007; Tempelaar & Schim van der Loeff, 2011; Verhoeven, 2009, 2011). Males, on average, reported more positive attitudes than females on *Affect*, *Cognitive Competence*, and *Difficulty*. Researchers only found one component, *Effort*, with females reporting more positive mean attitudes (i.e., more *Effort*) than males. Another eight studies, all conducted in the United States, reported that female and male students' attitudes, on average, did not differ on any component (Carnell, 2008; Cashin & Elmore, 2005; Faghihi & Rakow, 1995; Pierce, 2006; Schau, Dauphinee, & Del Vecchio, 1992; Scott, 2001; Watson, Lang, & Kromrey, 2002; Watson et al., 2003). Results from these studies suggest that gender differences may vary based on the component assessed, students' nationalities, when their attitudes are measured, and what subjects they are studying at the time of assessment.

Seven studies investigated mean differences in component scores associated with ethnicity/nationality. Five of them reported statistically significant mean differences in Statistics Attitudes across different ethnic/nationality groups (Ruggeri et al., 2008; Tempelaar et al., 2006; Tempelaar & Nijhuis, 2007; Watson et al., 2002, Watson et al., 2003), and two studies did not (Schau et al., 1992; Pierce, 2006). These studies included students who identified themselves as: Spanish, British, American, Austrian, German or other (Ruggeri et al., 2008); Dutch or International (Tempelaar et al., 2006); Dutch or German (Tempelaar & Nijhuis, 2007); White American, Non-white American, or Foreign (Watson et al., 2002, Watson et al., 2003); White American, Native American, African-American, or Hispanic American (Schau et al.); and White American, Asian American, African American, or Other American (Pierce, 2006). Because the ethnic/nationality groups studied varied widely across studies, it is not possible to summarize or generalize these findings.

Three studies have examined the relationships among student age and component scores (Coetzee & van der Merwe, 2010; Scott, 2001; Verhoeven, 2009). However, the components and the direction of the relationships with age differed. In addition, each of these studies was conducted in a different country and so the nationalities of the students involved differed. These findings cannot be summarized or generalized.

Previous Achievement-Related Experiences We identified 10 studies that investigated the relationships among selected Previous Achievement-Related Experiences, the second factor in the SATS-M, and Attitudes; all 10 found at least some statistically significant relationships. The most commonly studied Experiences included those related to statistics or to mathematics. In all cases, scores from these measures were statistically significantly and positively related to attitude components (Carmona, Martinez, & Sanchez, 2005; Cashin & Elmore, 2005; Chiesi & Primi, 2010; Coetzee & van der Merwe, 2010; Dempster & McCorry, 2009; Mills, 2004; Scott, 2001; Sorge, 2001; Tempelaar & Schim van der Loeff, 2011; Verhoeven, 2009). Students with more experience and higher past achievement reported more positive attitudes for some components, especially *Affect, Cognitive Competence,* and *Difficulty*.

5.2. RELATIONSHIPS AMONG PRIOR SATS-M FACTORS AND COURSE OUTCOMES

The SATS-M indicates that three factors impact Statistics Course Outcomes. These factors include Student Characteristics, Attitudes, and Previous Achievement-Related Experiences.

Student Characteristics We identified three studies that included the use of the SATS-28 or the SATS-36 but also investigated the relationships among Student Characteristics and Statistics Outcomes (Schutz, Drogosz, White & Distefano, 1998; Tempelaar et al., 2006; Verhoeven, 2009). Because of the dearth of studies and the differences in measures used to assess Outcomes, these findings cannot be summarized or generalized.

Previous Achievement-Related Experiences We identified six studies that examined the relationships among Previous Experiences and achievement. All six studies reported statistically significant and positive relationships (Carlson & Winquist, 2011; Chiesi & Primi, 2010; Schutz et al., 1998; Sorge, 2001; Verhoeven, 2011; Wisenbaker, Scott & Nasser, 1999). As expected, students with more experience and prior success achieved at higher levels in their statistics courses.

Statistics Attitudes We found 17 studies that examined the relationships among attitudes and achievement. Of these studies, 15 reported statistically significant and positive relationships among selected attitude components and achievement (Carlson & Winquist, 2011; Cashin & Elmore, 2005; Chiesi & Primi, 2009, 2010; Dempster & McCorry, 2009; Emmioğlu, 2011; Estrada, Batanero, Fortuny & Diaz, 2005; Nasser, 2004; Schutz et al., 1998; Sorge, 2001; Schau, 2003b; Verhoeven, 2009, 2011; Tempelaar et al., 2006; Tempelaar et al., 2007). That is, more positive attitudes were associated with higher achievement in students' statistics courses. The components that exhibited these relationships most often included *Affect, Cognitive Competence,* and *Value*; *Difficulty* rarely was related to achievement. These four components are found in both versions of the SATS. Two studies did not report statistically significant relationships among any of the four SATS-28 components and achievement (Scott, 2001; Wisenbaker et al., 1999).

6. IMPLICATIONS AND CONCLUSIONS

What outcomes are important from an introductory statistics course? We want students to complete their courses able to engage in statistical thinking. We want them to use statistical thinking accurately in their other courses, in their professions, and in their lives. We hope that some of these students choose to take other statistics courses and even minor or major in statistics. How do we accomplish these goals?

A plethora of theories suggest that students' attitudes can lead them to make these choices and engage in these behaviors. The results from many research studies in disciplines other than statistics education show that the constructs found in Eccles' EVT predict achievement-related choices and performance both in and out of classes in a variety of domains (e.g., Bruinsma, 2004; Cocks & Watt, 2004; Eccles, 1983; Greene, DeBacker, Ravindran, & Krows, 1999; Simpkins et al., 2006; Watt, 2005; Wigfield & Tonks, 2002). Even though we believe that students' attitudes toward statistics are important, we know relatively little about them and their impacts on statistics course outcomes. Fifteen years ago, Gal, Ginsburg, and Schau (1997) noted that the lack of theory-based work has

contributed to the dearth of research in this area (and to the difficulty in applying results from this research to instruction). We hope that we have started to bridge this gap with the creation of our SATS-M.

Our model indicates that all of its constructs should be interrelated and that they impact important Course Outcomes (including Attitudes themselves). Results from much of the research using the SATS-28 and the SATS-36 support the existence of the relationships among the constructs contained in our model. These research findings suggest that the relationships among Student Characteristics and Statistics Attitudes are complex. Gender differences were not found in the studies conducted in the United States. However, in other countries, males in general liked statistics better, thought they had better knowledge and skills, and did not think that statistics was as hard, whereas females indicated that they worked harder in statistics. This pattern suggests that we need to consider multiple Student Characteristics concurrently and engage in planned consistent research across countries.

Some researchers have studied the relationships among Previous Achievement-Related Experiences (mostly commonly, statistics and mathematics experiences) and both Attitudes and Outcomes (assessed as achievement). Most of these researchers have reported positive relationships. That is, students with more previous experience or higher prior achievement in statistics and/or mathematics reported more positive attitudes on some components, especially *Affect*, *Cognitive Competence*, and *Difficulty*; they also achieved at a higher level. This pattern was consistent even though both Previous Achievement-Related Experiences and achievement have been assessed in a variety of ways.

Unfortunately, achievement is the Statistics Course Outcome that has been most frequently assessed. Most researchers who have examined the relationships among attitude components and achievement have reported positive relationships. Students with more positive *Affect, Cognitive Competence,* and *Value* achieve better in their statistics courses. As expected, these relationships were stronger when attitudes and achievement were measured closer together in time.

These studies represent a beginning in exploring the relationships among Student Characteristics, Previous Achievement-Related Experiences, Statistics Attitudes, and Statistics Course Outcomes. Their results demonstrate that some relationships consistently exist. A great deal more research is needed, including using meta-analysis to explore the sizes of the effects found in this research. To date, however, little attempt has been made to systematically examine these relationships. To be most useful, this research should be large scale, include common measures of the constructs found in the SATS-M, use one or more common research procedures, and sample using stratified techniques both within and outside of the United States.

In addition, as Eccles and others have worked on the EVT, it has evolved, as models and theories should, both in terms of where measurable components fit within super-constructs as well as with proposed relationships among super-constructs. In addition, research based on the EVT often omits some measurable components and varies the directions of the relationships among components. In spite of these differences across versions of Eccles' EVT and the research using it, EVT is useful to us in statistics education. To allow flexibility, we did not indicate the directions linking the first five attitude components in the SATS-M. A variety of possible directions exist for these links that are congruent with one or more versions of EVT and/or research based on it, yielding an interesting area for future research.

The American Statistical Association has endorsed the Guidelines for Assessment and Instruction in Statistics Education (GAISE; Franklin & Garfield, 2006). Efforts to promote and improve statistics education raise many important instructional and research questions. For example, we need to know which GAISE-consistent instructional contexts, approaches, and activities are most effective in helping students develop more positive attitudes and hence in improving their engagement in learning.

Most of the instructional innovations in statistics education are based on teachers' intuitions about what will work. Statistics educators believe that instructors can influence students' achievement, attitudes toward statistics, and other outcomes through adapting instruction accordingly, for example by developing and maintaining students' interests and by illustrating the reasons for learning statistics (e.g., Bartsch, 2006; Evans, 2007; Mills, 2004; Rhoads & Hubele, 2000). However, these instructional approaches and the activities that result from them usually are not based explicitly on educational theories or models. In addition, often the effects of these implementations are not evaluated, so little evidence exists to support their efficacy. Instructors' experiences are critical but we need solid theory-

based evidence about what does and does not work and for whom. We believe that we can improve statistics education by using models of attitudes, like the SATS-M, to guide our development and implementation of instructional interventions. We can obtain evidence of the effectiveness of these interventions and of our courses by using good measures such as the SATS-36.

People forget what they do not use. But attitudes "stick." Positive attitudes keep us using what we have learned. They also encourage us to seek opportunities to learn more. It is for these reasons that we believe that students' attitudes are the most important and influential outcome from introductory statistics courses.

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