Investigating the Validity of the Survey of Attitudes Toward Statistics

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The Survey of Attitudes Toward Statistics (SATS) is a tool widely used by statistics educators to help gain insight into students' attitudes and how they impact teaching and learning in introductory statistics courses. Three instructors at Winona State University have been administering this survey to students both at the beginning and end of several semesters since 2011. This study involved an analysis of the data collected in these courses to investigate students' attitudes towards statistics and how they change throughout the semester. The results were also compared to national norms. Finally, an exploratory factor analysis was conducted using the data collected from Winona State University courses to investigate the construct validity of the SATS tool. It was found that this national survey might not actually be measuring what the creators of the survey intended.

Introduction:

Introductory statistics courses are frequently viewed as the "worst course taken in college" or "the most despised of college courses" (Schau, Stevens, Dauhinee, Del Vecchio, 1995). Even though many students dislike statistics, mathematics, and numbers in general, it is required for most major fields of study, for example, psychology, biology, and marketing. Students with negative attitudes are more likely to academically perform worse, resulting in uncertainty when solving statistical problems (Nolan, Beran, & Hecker, 2012). To assess students' attitudes towards their introductory courses and how they affect teaching and learning, Candace Schau created the Survey of Attitudes Toward Statistics (SATS) (Schau, Stevens, Dauhinee, Del Vecchio, 1995).

The first version of the survey, SATS-28, used twenty-eight items to measure four core components: *Affect, Cognitive Competence, Value,* and *Difficulty.* Later, a six factor model, SATS-36, was created. This updated version has thirty-six items to measure six components. The first four were from the original survey with the addition of *Interest* and *Effort.*

Affect: measures students' feelings regarding statistics (6 items)
Cognitive Competence: measures students' attitudes about their skills when applied to statistics (6 items)
Value: measures students' attitudes about the usefulness and relevance of statistics in their lives (9 items)
Difficulty: measures students' attitudes about the difficulty of statistics (7 items)
Interest: measures students' level of interest in statistics (4 items)
Effort: measures students' attitudes toward the amount of time they will put into their statistics course (4 items) (Bond, 2007)

Each question is measured on a 7-point Likert scale, with higher responses corresponding to more positive attitudes (Bond, 2007). A list of the questions can be found in **Figure 2** on page 5.

The SATS is intended to be given to students at the beginning and end of the semester to measure how their attitudes changed over time. It is desirable to see positive differences to show that students' attitudes increased after taking an introductory statistics course. Educators can use the results to assess which type of attitude is lacking and where to improve their teaching style. For example, if students have an overall decrease in the *Value* component, educators can use new ways to show the importance of statistics in the work place.

Not only does this survey have the thirty-six items to measure the six components, but it also has additional questions asking about the student's demographic and academic background. Some examples are shown below:

What is your major?
How well did you do in your high school mathematics course?
What grade do you expect to receive in this course?
Your sex: Male or Female
Your citizenship: U.S. citizen or Foreign student
Your age (Bond, 2007)

These questions could be used to further the analysis of a study. For example, it may be interesting to see differences between males and females or differences between majors. It may also be interesting to see the correlation between the grade the student expects to receive and their attitudes.

In this study, Winona State University data was analyzed to look at where students' attitudes started, ended, and the differences to see increases or decreases. This data was also used in an exploratory factor analysis to investigate the validity of the SATS tool. It was of interest to see if this survey is actually measuring what Schau intended: thirty-six items used to measure six different attitude components.

Methods:

Three educators at Winona State University have administered the SATS to their introductory statistics courses at the beginning and end of several semesters. The data was compiled by matching the pre and post data for each student identification number. After the pre and post data was matched, the negatively worded item responses had to be reversed, so the results could be properly analyzed. This was done by changing 1 and 7, 2 and 6, and 3 and 5, while 4 stayed the same. After all responses were on the same scale, averages and standard deviations were found for the pre-scores, post-scores, and mean differences for all six components.

There were a total of 707 surveys taken that were used for the pre-data results while only 488 surveys were used for the post-data results, and 486 surveys were used to calculate the mean differences. This is due to the fact that many of the post-surveys didn't have a student ID number, making it impossible to match to a pre-survey. Another reason is that students dropped the course in the middle of the semester. It was also found that two surveys had post-data but no corresponding pre-data. This could be due to the fact that the student added the course later or

was absent the day the survey was administered. It could also be that the student ID was entered wrong, so the computer program could not match the pre- and post-data.

Using a statistical program, JMP, paired t-tests were run to determine whether a significant changed occurred in any of the six components throughout the semester. 95% confidence intervals were also obtained for each of the six mean differences. A change was considered significant if a p-value of less than 0.05 was found or if the confidence interval did not include 0. Using this analysis, Winona State educators can understand their students' different attitude types toward statistics.

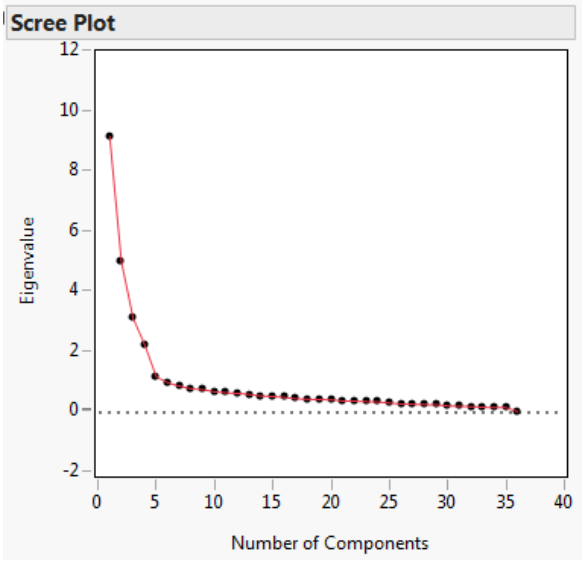
The Winona State University data was also used in an exploratory factor analysis to assess the validity of the Survey of Attitudes Toward Statistics. First, a six factor analysis was performed because of the structure of the SATS-36 version. After looking at the amount of variability explained, the scree plot, and the factor loadings, it was determined that a four factor model seemed to be optimal for this data. **Table 1**, below, displays the amount of variability that is explained as each factor is added to the model. The first factor explains 45.44% of the variance in the model; the second explains 69.56%, and so on. It can be seen that by adding the fifth factor, only about 3% more of the variability is explained. For this reason, four factors was chosen as the optimal number of factors for the analysis.

Table 1: Variability Explained by Each Additional Factor

Factor	Variability Explained
1	45.44
2	69.56
3	83.91
4	93.58
5	96.95

This can also be seen graphically on the scree plot, shown in **Figure 1**. The "elbow" of the graph appears to be at four factors. This is because the fifth factor isn't adding a large enough amount of variability, so the line becomes more horizontal, creating an elbow shape.

Figure 1: Scree Plot



Results & Discussions:

To understand the changes in attitudes toward statistics in Winona State University students, it is important to understand where students started, ended, and how much they changed. **Table 2**, below, displays the Winona State data. It can be seen that students start an introductory statistics course with average attitudes toward statistics because most of components' averages are right around 4, the middle of the Likert scale. *Effort* has the highest average of all six components. This means students believed they would spend a great amount of time working on the homework and studying for tests. When looking at the post-data, the averages seem very similar. Most of them are in the 4-5 range while *Effort* still has the highest.

Table 2: Averages and Standard Deviations for Pre Scores, Post Scores, and Mean Differences

	Pre-test (n=707)		Post-test (n=488)		Mean Difference (n=486)		95% CI for Mean Difference	
Component	M	SD	M	SD	M	SD		p-value
Affect	4.20	1.09	4.55	1.22	0.38	1.29	(0.26, 1.49)	< 0.0001
Cog Com	4.78	1.03	5.00	1.16	0.26	1.17	(0.15, 0.36)	< 0.0001
Value	4.96	0.99	4.83	1.07	-0.07	0.97	(-0.12, 0.02)	0.1364
Difficulty	3.71	0.73	4.04	0.84	0.35	0.89	(0.27, 0.43)	< 0.0001
Interest	4.61	1.13	4.23	1.24	-0.30	1.23	(-0.42, -0.19)	< 0.0001
Effort	6.44	1.04	6.13	1.00	-0.32	1.30	(-0.44, -0.20)	< 0.0001

The most important results of interest were the significance of the mean differences. Because the differences were found by subtracting the pre-scores from the post-scores, a positive difference is desired to show that the students' attitude scores have increased. Small p-values (<0.0001) were found for five of the six components, meaning there were significant changes in students' attitudes. *Value* was the only component with a change that was not significant (p-value = 0.1364). It can also be seen that *Value* is the only component with a 95% confidence interval that includes 0; this is another way to know that there has not been a significant change. To interpret the confidence interval for the *Affect* component, it can be said that we are 95% confident that the mean difference between the pre- and post-scores is between a 0.26 and a 1.49 increase in students' attitudes.

Affect, *Cognitive Competence*, and *Difficulty* all have significant, positive increases. The increase in *Affect* means students' feeling regarding statistics improved. Educators would be happy to see this because it shows that students enjoyed the introductory statistics course more than they thought they would. Students' attitudes about their knowledge when applied to statistics also increased, shown by a positive mean difference for *Cognitive Competence.* This means that students think their skills and ability to learn statistics have increased. An increase in *Difficulty* actually means that students believe statistics is easier after taking a course than when they first started. This is because a positively worded question with a high score in the *Difficulty* component means the student thought the class would be easy.

Unfortunately, *Interest* and *Effort* resulted in significant decreases in students' attitudes toward statistics. A decrease in *Interest* is something educators don't want to see. This means that students were less interested in statistics after completing their introductory course. Students also spent less time than they thought they would, shown by a significant decrease in *Effort.* Even though *Value* decreased, it was not significant, meaning students' attitudes toward the

relevance and usefulness of statistics remained about the same at the beginning and end of the semester.

After understanding students' attitudes at Winona State, it was of interest to assess the validity of the tool used. To do this, an exploratory factor analysis was conducted using the pre-data. **Figure 2** shows the original SATS tool and the four factor model. On the left-hand side, the thirty-six items are listed and color coded to match their corresponding component. For example, items 6, 8, 22, 24, 30, 34, and 36 (in purple) are part of the *Difficulty* component.

Figure 2: Exploratory Factor Analysis Results

	Original SATS						Factors			
Question	Affect	Cog Comp	Value	Difficulty	Interest	Effort	1	2	3	4
1 - I plan to complete all of my statistics assignments.										
2 - I plan to work hard in my statistics courses.										
3 - I will like statistics.										
4 - I will feel insecure when I have to do statistics problems.										
5 - I will have trouble understanding statistics because of how I think.										
6 - Statistics formulas are easy to understand.										
7 - Statistics is worthless.										
8 - Statistics is a complicated subject.										
9 - Statistics should be a required part of my professional training.										
10 - Statistical skills will make me more employable.										
11 - I will have no idea what's going on in this statistics course.										
12 - I am interested in being able to communicate statistical information to others.										
13 - Statistics is not useful to the typical professional.										
14 - I plan to study hard for every statistics test.										
15 - I will get frustrated going over statistics tests in class.										
16 - Statistical thinking is not applicable in my life outside my job.										
17 - I use statistics in my everyday life.										
18 - I will be under stress during statistics courses.										
19 - I will enjoy taking statistics courses.										
20 - I am interested in using statistics.										
21 - Statistics conclusions are rarely presented in everyday life.										
22 - Statistics is a subject quickly learned by most people.										
23 - I am interested in understanding statistical information.										
24 - Learning statistics requires a great deal of discipline.										
25 - I will have no application for statistics in my profession.										
26 - I will make a lot of math errors in statistics.										
27 - I plan to attend every statistics class section.										
28 - I am scared by statistics.										
29 - I am interested in learning statistics.										
30 - Statistics involves massive computations.										
31 - I can learn statistics.										
32 - I will understand statistics equations.										
33 - Statistics is irrrelevant in my life.										
34 - Statistics is highly technical.										
35 - I will find it difficult to understand statistical concepts.										
36 - Most people have to learn a new way of thinking to do statistics.										

It can be seen from the right-hand side of **Figure 2** which items grouped together based on the factor analysis. For example, item 20, originally intended to measure *Interest*, loaded on

Factor 2. Items 1, 2, 14, and 27 loaded on Factor 4. Because these four items were originally intended to measure *Effort* and they all loaded on the same factor, it can be inferred that they are actually measuring students' attitudes toward the amount of effort they put into their class. Item 31, I can learn statistics, also loaded on Factor 4. Intuitively, this makes sense. If students are willing to put in the effort, they may believe they can learn statistics. If they are not willing, they will probably not learn statistics. Factor 3 consists of eight of the nine *Value items.* Again, because this factor consists of the original *Value* items, it is safe to say that they are actually being measured by the SATS. Factors 1 and 2 are a combination of *Affect, Cognitive Competence, Difficulty,* and *Interest.* By looking at the wording of the items, it seems that these four components could be combined to measure both interest and different aspects of how a student feels he or she will perform in a statistics course. For example, item 3, I will like statistics, intended to measure *Affect* may seem like an *Interest* item. This item and the original four *Interest* items loaded on same factor. It can also be noted that Factor 1 includes all of the negatively worded questions, while the positively worded questions loaded on Factor 2.

The results of this factor analysis were similar to those of Nolan, Beran, and Hecker (2012) and Vanhoof, Kuppens, Castro Sotos, Verschaffel, and Onghena (2011). Both groups found that *Affect, Cognitive Competence,* and *Difficulty* loaded on a single factor. This is similar in that each of these three components didn't load on a single, unique factor but rather loaded together. Like this study, they also found that *Value* was a unique component because it loaded on its own factor. Neither one of these two studies mentions the two newest components, *Interest* and *Effort,* in great detail.

Implications and Further Research:

After understanding the results of Winona State University students, it was of interest to compare them to the national norms to determine if they were similar. The creators of the SATS revealed the survey's national norms in a personal communication with the professors involved in this study. *Value, Interest,* and *Effort,* the three components that showed a decrease from the beginning of the semester to the end, are inline with what is typically observed nationally. After taking an introductory statistics course, Winona State students have significantly higher attitude scores relating to *Affect, Cognitive Competence,* and *Difficulty.* This, however, is not typically observed nationally. *Difficulty* usually tends to decrease, while *Affect* and *Cognitive Competence* stay about the same. Because *Difficulty* increased at the Winona State level and, on average, decreased at the national level, the professors in Winona are possibly teaching statistics better, since students think statistics was easier after taking the course than when they had first started.

In the future, it would be interesting to explore the differences in students based on the questions they had to answer at the end of the survey. There may be differences between males and females or differences among majors. It would also be interesting to look at differences between the three professors who administered the surveys and taught the courses. This could be helpful in finding out their strengths and weaknesses to increase students' attitudes toward statistics. For example, if one professor had a higher attitude score for *Interest,* they may share the types of examples they use or the way they teach to engage students and interest them in statistics.

After investigating the SATS by running a factor analysis using the Winona State data, it can be said that the SATS may not actually be measuring six unique components as the authors claim it is measuring. Currently, it is only measuring two of the original components, *Value* and

Effort, because the corresponding items load on two distinct factors. Educators using this tool should consider only measuring *Value* and *Effort* attitudes and combine the other components, *Affect, Cognitive Competence, Difficult,* and *Interest,* into only two factors to measure how confident students are in their ability to learn statistics.

Further research should be done to investigate the relationships between the components, especially the four that were not unique. It would also be of interest to conduct a confirmatory factor analysis to dig deeper into the validity of the survey. The SATS is a great tool for educators to use to assess their students' attitudes, however, is should be used with caution. The administrators of the survey should look into all of the items that loaded on Factors 1 and 2 to determine if attitudes increased or decreased, rather than focusing on the original components.

References:

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