Changes in U.S. Students' Attitudes toward Statistics across Introductory Statistics Courses

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In most disciplines, students' academic attitudes are considered extremely important. A large number of educational and cognitive models and a great deal of research exist that explore these attitudes. These models suggest and research findings support the conclusion that students' attitudes toward the discipline are important course outcomes and, in fact, are at least as important as knowledge and skills in the discipline. Unfortunately, in statistics education, attitudes are not yet considered as exerting primary impact on students' academic behaviors or as important outcomes (Gal & Ginsburg, 1994; Shaughnessy, 2007). However, when applied to statistics education, these models and findings from other disciplines suggest that students who leave their statistics courses with negative attitudes are unlikely ever to use what they have learned. That is, they will not intelligently and literately use statistics in their professional and personal lives or in any educational venture.

Many statistics instructors express the belief that, on average, students enter their introductory courses with negative attitudes and leave with positive attitudes toward statistics. However, little research exists to support or to refute these assumptions. The major goal of this project is to examine U.S. students' attitudes in their general introductory statistics courses.

In face-to-face courses, sections are composed of students and their instructors (sometimes course instructors, sometimes course and lab instructors), instructional approaches, content, and the physical location in which the section meets. Together, these create the introductory statistics course experience. To capture this experience, we used sections as the unit of analysis in this paper.

Specifically, we examined:

1. Attitudes toward statistics when introductory statistics courses begin.
2. Changes in attitudes from the beginning to the end of introductory statistics courses.

Method

1. Data Collection Instrument

The Survey of Attitudes Toward Statistics-36© (SATS-36©) contains 36 items that assess six statistics

Attitude Components. Although this survey also assesses other constructs hypothesized to be related to students' attitudes, only the Attitude Component scores are considered in this paper. For all SATS-36© pretest items, see the Scoring Guide (Schau, 2005©). Definitions of the six Components and example pretest items include:

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*."

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.*"

Students respond to each of the 36 items comprising the six Attitude Components on a 7-point Likert scale: 1 = "Strongly Disagree", 4 = "Neither Disagree nor Agree" (neutral or no attitude), and 7 = "Strongly Agree". Some items are positively-worded while some are negatively-worded. Responses to the negatively-worded items are reversed before scoring. A student who gives a higher numerical response to any item has a more positive attitude than one who gives a lower response. For each student, a score for each Attitude Component is calculated as the mean response to all items that assess that Component. A student must complete all items in a Component to receive a Component score. The meaning of positive attitudes is clear for all Components, except for *Difficulty.* Higher scores on the *Difficulty* Component indicate that students believe that statistics is easier while lower scores mean that they think it is harder.

2. Data Collection Sources and Procedures

For this paper, students' responses to the SATS-36© items were obtained from two sources: the SATS© Project and donated data. The responses from both sources were combined for this paper.

As a part of the SATS© Project, Marjorie Bond, from Monmouth College, and Candace Schau developed a web site to collect SATS© data. Although information about grades, the course, and the instructor also were collected, only student data will be reported in this paper. They invited any instructor teaching any introductory post-secondary (but not graduate-level) statistics course in the U.S. to participate at no cost. Interested instructors obtained approval from their institution's human subject review boards. Some instructors offered their students a minimal amount of extra credit for participating. Students could decide to opt out of participation without penalty. Participating instructors received a data file containing their students' responses and Attitude Component scores; these data were anonymous. The Project was approved each year by the Human Subject Review Board at Monmouth College. Data were collected during

the academic years beginning in the Fall of 2007 and ending after the Spring of 2010.

In addition, some researchers, with approval of their human subject review boards, kindly have shared their post-secondary students' SATS© responses with Candace Schau. Shared student responses again were anonymous. These data were collected during the academic years beginning in the Fall of 2006 and ending after the Spring of 2008.

Our two data sources contained responses from students who were enrolled in different kinds of statistics courses taught in various academic departments in diverse institutions. Our interest in this paper is in the attitudes of those students who were enrolled in general introductory statistics courses either with no mathematics prerequisite or an algebra prerequisite and that were taught in mathematics or statistics departments. Our data came from institutions that varied from small private and public four-year to large research institutions that award advanced-degrees. This variability allowed a wide representation of students enrolled in introductory statistics courses.

Regardless of the source, students responded to the SATS-36© items on the web during or outside of class, within a maximum time period of two weeks at the beginning and at the end of the course.

We examined students' pretest scores and their change scores on each Attitude Component by course section. To interpret the importance of findings, rather than just their statistical significance, authors usually recommend that researchers select values based on reasonable assumptions about the size of findings needed for importance in the field under study, given the measure being used (e.g., Cohen, 1988). Using this approach, we considered differences of about ½ point or more as important (Sorge, 2001). That value represents a change of about 8% of the possible range in the Likert scale.

In a pretest-posttest design like this, it is common to have a number of students who complete only the pretest as well as some that complete only the posttest. Students who complete only the pretest often have dropped out of the course or have instructors who did not give them adequate time at the end of the term to complete the posttest. Students who complete only the posttest often added the course too late to participate in the pretest. To examine attitude change across course sections, we examined responses from students who completed both the pretest and the posttest. To provide a reasonably representative picture of students' attitudes in a section, we used data from sections that provided a minimum of 15 matched students' pretest and posttest Component scores.

In addition, we wanted to use scores that exhibited at least adequate internal consistency. We analyzed Component scores from students in sections whose pretest responses and whose posttest responses exhibited Cronbach's alpha values of at least .60.

Between the section size and alpha value limits, some sections contributed scores from all Attitude Components while some contributed scores from only some Components. Table 1 presents this information.

Table 1

Number of Participating Course Sections from Four-Year and Research Institutions and Number of Participating Students by Attitude Component

Attitude Component	Number of Sections from		Number of Students
	Four-year institutions	Research institutions	
Affect	39	34	1870
Cognitive Competence	40	34	1899
Value	38	34	1861
Difficulty	31	32	1678
Interest	39	34	1902
Effort	30	23	1454

As Table 1 shows, about equal numbers of course sections came from four-year and research institutions. The Components of *Difficulty* and *Effort* yielded the fewest number of sections. These Components usually yield the lowest alpha values and so the greatest numbers of sections were eliminated from their analyses.

Results

1. Pretest Results

It is important to examine students' attitudes at the beginning of the statistics course. Figure 1 presents a box plot of the section mean pretest scores from each Attitude Component. Table 2 presents corresponding descriptive statistics.

Figure 1

Box Plot of Section Mean Pretest Scores by Attitude Component

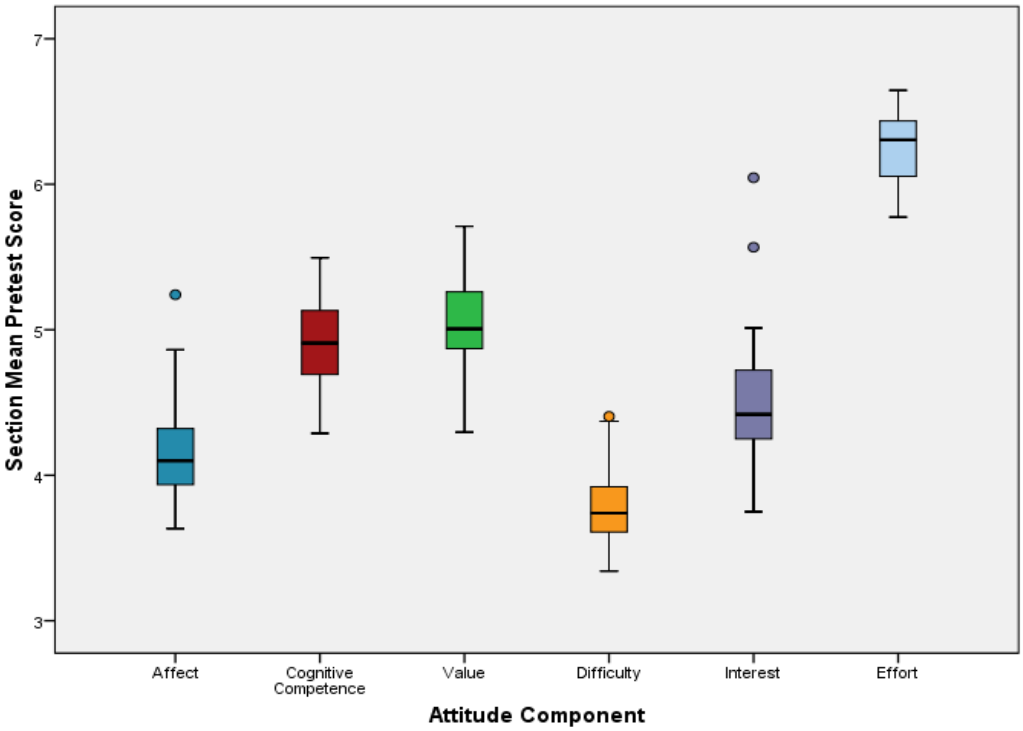

Table 2

Descriptive Statistics for Section Mean Pretest Scores by Attitude Component

Attitude Component	*M*	*SD*	*Min.*	*Max.*
Affect	4.14	.29	3.63	5.24
Cognitive Competence	4.93	.26	4.29	5.49
Value	5.04	.27	4.30	5.71
Difficulty	3.77	.25	3.34	4.40
Interest	4.48	.38	3.75	6.04
Effort	6.26	.24	5.78	6.65

The average section scores from two Attitude Components were essentially neutral, within ½ point of 4

(*Affect* and *Difficulty*). The average section score for *Interest* was about ½ point above neutral while those for *Cognitive Competence* and *Value* were about one point above neutral, all important differences. The average section score for *Effort* was over two points above neutral, again an important difference. Although some section averages were below neutral on three components (*Affect*, *Difficulty*, and *Interest*), the section minimum average score always was less than one point below. In addition, all 4 outlying section means were at the positive ends of the distributions.

2. Attitude Changes

To examine attitude changes in sections, the pretest score on each Component was subtracted from the posttest score for each student. These Component change scores then were averaged into section mean change scores.

Figure 2 presents a box plot of the section mean change scores from each Attitude Component. Table 3 presents corresponding descriptive statistics.

Figure 2

Box Plot of Section Mean Change Scores by Attitude Component

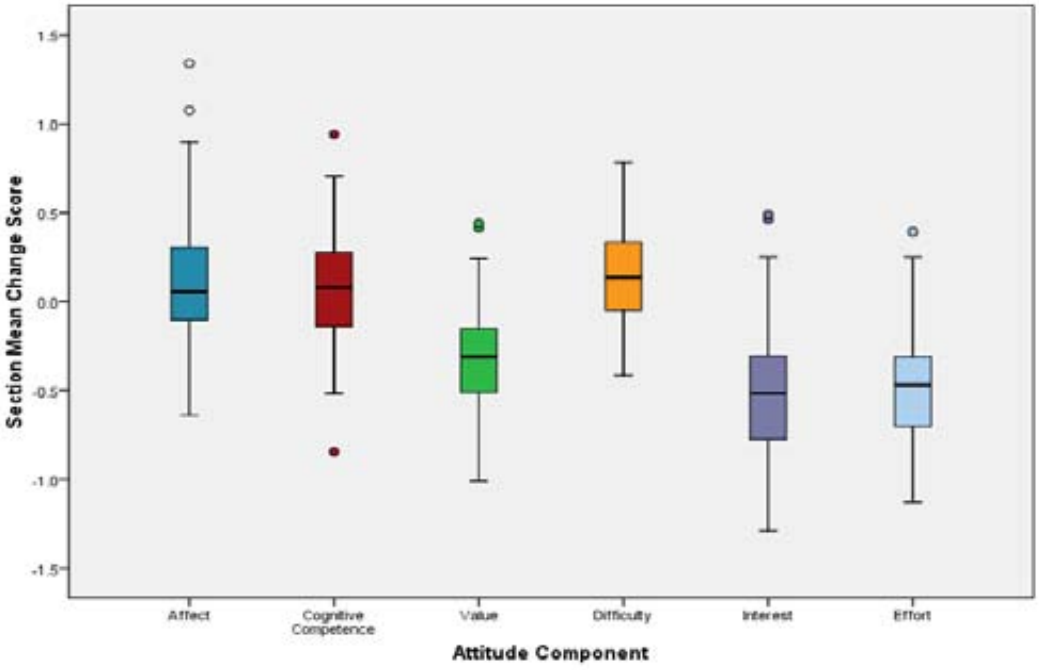

Table 3

Descriptive Statistics for Section Mean Change Scores by Attitude Component

Attitude Component	*M*	*SD*	*Min.*	*Max.*	*95% Confidence Interval*
Affect	.13	.42	-.64	1.34	.028 to .223
Cognitive Competence	.10	.33	-.84	.94	.021 to .172
Value	-.34	.29	-1.01	.44	-.409 to -.272
Difficulty	.15	.25	-.42	.78	.086 to .212
Interest	-.53	.36	-1.29	.49	-.616 to -.446
Effort	-.47	.31	-1.13	.39	-.555 to -.387

Each Component's section mean change score was statistically different from 0 at an alpha level of .05. However, the statistically significant positive changes were too small to be important (less than ½ point). That is, section mean Component scores, on average, did not clearly improve for any Component. Three section mean Component scores stayed about the same from pretest to posttest (*Affect*, *Cognitive Competence*, and *Difficulty*). The remaining three section mean Component scores decreased: *Value* by ⅓ point and *Interest* and *Effort* by about ½ point. The latter two decreases are important.

Cognitive Competence exhibited one outlying section mean score that was at the negative end of the scale. However, the other 8 outliers were at the positive ends of distributions of their Components.

Discussion

We examined students' attitudes toward statistics when they first entered their introductory statistics courses, as well as changes in those attitudes from the beginning to the end of the courses. Students enrolled in face-to-face courses experience their courses in sections. Thus, we examined mean attitudes from sections of students. We explored six related but distinct Attitude Components.

At the beginning of their introductory courses, in general, sections of students neither liked nor disliked statistics; they believed that statistics wasn't going to be easy, but it wasn't going to be difficult either. They tended to value statistics somewhat and believed that they likely would be able to learn statistics. They were slightly more interested than disinterested in statistics. They reported that they expected to expend a great deal of effort to learn statistics. Instructors are not correct in their belief that, in general, attitudes toward statistics are negative at the beginning of their terms; instead, they are somewhat positive or neutral depending on the Attitude Component being examined.

How did attitudes change by section from the beginning to the end of statistics courses? In general, sections of students neither liked nor disliked statistics any more at the end than at the beginning of their courses. They still believed that they likely could learn statistics (but to no greater extent than their beliefs at the beginning of the term) and that statistics wasn't easy, but it also wasn't difficult. Unfortunately, they tended to value statistics less than they had at the beginning of the course, they were less interested in statistics, and they put in less effort than they had intended. On average, instructors are not correct in their belief that attitudes in the sections that they teach are more positive overall at the end of the term than they are at the beginning.

We believe that the three most important Attitude Components are *Value*, *Cognitive Competence*, and *Interest*. Students won't employ statistics in life, in their work, or in their other courses unless they believe it is useful. They will use statistics if they believe that they indeed can do statistics. People engage in tasks they find interesting. We want students to at least maintain, or preferably to improve, their attitudes in these Components. The impacts of the Components of *Effort*, *Difficulty*, and *Affect* are less clear. People must believe that the effort they expend to engage is statistical thinking and tasks is reasonable; if they believe that it will require too much effprt, it is likely that they will not do statistics. If they believe that statistics is too difficult, again it is likely that they will not even try. Perhaps we want attitudes about these two Components to be neutral. Although it is nice to like the tasks in which we engage, it is not a requirement. Everyone does things that are necessary but that they don't really like. So perhaps we want neutral or positive attitudes in regard to this Component.

The section means at the beginning of these courses tended to display the above general pattern. That is, sections of students were at least somewhat positive in terms of *Value*, *Cognitive Competence*, and *Interest* while they were neutral regarding *Difficulty* and *Affect.* However, they indicated that statistics would take a great deal of *Effort*, perhaps too much to be reasonable.

Affect and *Difficulty* means remained neutral by the end of the course. *Cognitive Competence* means remained slightly positive so hadn't increased. However, *Value* and *Interest* decreased, as did *Effort*. We did not see the pattern that we hoped to see in some of these Attitude Components.

As is the case in all research on humans, the participants in this study were volunteers. Because these instructors were interested in their students' attitudes, we believe that they want to be good teachers and want students to have positive experiences in their statistics courses. As these instructors generally did not obtain the desired attitude changes in their students, then it is our contention that other instructors who do not consider attitudes to be of importance are unlikely to do so.

This study showed that general introductory statistics courses are not enough to increase (or often even maintain) students' attitudes toward statistics. If these attitudes are important to us as statistics educators, we need to identify student, instructor, instructional, and course characteristics that are related to desired attitude outcomes. We then need to design our courses to build on these characteristics and evaluate their effects on course outcomes. And we need to evaluate all of our instruction for its impact on students' attitudes toward statistics.

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