Students' Attitudes:

The "Other" Important Outcome in Statistics Education

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Abstract

Engendering positive attitudes in statistics students in an implicit objective in many introductory statistics courses. To know if we have accomplished this course objective, we need to be able to assess students' attitudes. The Survey of Attitudes Toward Statistics or SATS© was designed to measure four important components of attitudes: *Affect* (students' feelings concerning statistics), *Cognitive Competence* (students' attitudes about their intellectual knowledge and skills when applied to statistics), *Value* (students' attitudes about the usefulness, relevance, and worth of statistics in personal and professional life), and *Difficulty* (students' attitudes about the difficulty of statistics as a subject). SATS© and course achievement data were collected from undergraduate students enrolled in 11 sections of the introductory statistics course offered by a Mathematics and Statistics Department. The SATS© was administered at the beginning (pre-test) and at the end (post-test) of the course. Findings included:

1. Students' spoken attitudes were more negative than were responses to the SATS©.
2. Students attributed their attitudes to their past achievement and instructors.
3. On average, students' *Cognitive Competence* and *Value* attitudes were highest and positive. *Affect* attitudes were neutral. *Difficulty* attitudes were slightly negative. The differences between mean scores on these attitude components were large.
4. Class sections differed greatly on mean attitudes scores at the beginning of the semester, with even larger mean differences at the end.
5. Females and males, as well as Whites and Hispanics, had similar mean pre-test attitude component scores. However, males and Whites left this statistics course

with somewhat higher attitudes than females and Hispanics on some attitude components.

6. Across all students and sections, attitude changes from the beginning to the end of this course were small and negative.
7. Students' attitudes and achievement were positively related.

In addition, this paper presents a model of the structural relationships among students' attitudes and achievement. It ends with suggestions about how instructors can influence students' attitudes toward statistics.

The ultimate goal of statistics education is to produce adults who appropriately use statistical thinking. Most college students take only one statistics course, the introductory course. This course, then, is where we, as statistics instructors, do or do not motivate students to apply the statistics that they have learned in their jobs and in their lives.

Yet, Butler (1998) entitled an AmStat Forum article "On the Failure of the Widespread Use of Statistics." He suggested that, in spite of the increasing numbers of adults who complete introductory statistics courses, these adults often do not use statistical methods in their jobs and, when they do try, "the results are shambles" (p. 84).

The appropriate use of statistical understanding requires persistence. Students, of course, first need to complete their introductory statistics course successfully, rather than drop out. In their lives outside of class, they then need to be able to recognize when they require additional statistical knowledge and skills; obtain this additional statistical understanding or better yet enlist the aid of a statistician; and accurately use the skills they possess.

The accomplishment of these goals requires more from students than a good grade in a statistics course. Students who will use their statistical knowledge must:

- Think that statistics is useful in their professional and personal lives,
- Believe that they can understand and use statistics, and
- Know that they don't understand everything they might need based only on what they learned in their one introductory statistics course.

These statements describe attitudes about statistics, the "other" important outcome in statistics education (Gal, Ginsburg, & Schau, 1997; Garfield, Hogg, Schau, & Whittinghill, 2002; Schau, Stevens, Dauphinee, & Del Vecchio, 1995).

Many students express strong negative attitudes when they enter their required introductory statistics course (e.g., Schau, Stevens, Dauphinee, & Del Vecchio, 1995). These students view these courses as overwhelming learning and survival tasks that cause a great deal of stress (e.g., Onwuegbuzie & Daley, 1999). Many statistics instructors include engendering positive attitudes in their students as an implicit objective in their introductory courses; they believe that positive attitudes, along with understanding, are important course outcomes. As with any other important educational goal, such as learning, we need to be able to assess attitudes toward statistics and assess them well. In this paper, I will address these questions about students' attitudes toward statistics:

What are attitudes, especially attitudes toward statistics?

Are attitudes toward statistics important?

How do we measure attitudes toward statistics?

What do we know about students' attitudes toward statistics?

Are attitudes toward statistics and statistics course achievement causally related?

How can we influence students' attitudes toward statistics?

What Are Attitudes?

The construct of attitudes plays an important role in social psychology. In spite of this role, however, there are a variety of definitions of attitudes with no accepted consensus. Attitude theorists do agree that the defining characteristic of an attitude is its evaluative aspect. Ajzen (1989) uses a global definition that works well when considering students' attitudes toward statistics: "an attitude is an individual's disposition to respond favorably or unfavorably to … any … discriminable aspect of the individual's world" (p. 241). In our case, the "world" is anything associated with statistics.

Two students wrote the following at the beginning of their introductory statistics classes:

> "I squirmed in my chair at the mention of the [statistics] course, the 'Big M.A.' (Math Anxiety) struck again."
>
> "At elementary school I excelled in arithmetic and this gave me the confidence to tackle areas of mathematics that were more challenging."

Using Ajzen's definition, both examples convey attitudes toward statistics. The student who wrote the first example expresses an unfavorable (negative) emotional response to even the thought of being in a statistics course. The student who wrote the second expresses confidence in his/her math abilities and is favorable (positive). Notice that both examples reference math; many students think that statistics is mathematics, especially at the beginning of their statistics course.

This definition helps us think about attitudes toward statistics but we still need to measure them. Once a measure assessing students' attitudes toward statistics is created and used, we then have an operational definition of this construct, one that is useful for identifying and dealing with students' attitudes.

Are Attitudes Toward Statistics Important?

Many statistics educators and most statistics students believe that attitudes toward statistics are important. Students who hold and express negative attitudes can create an uncomfortable classroom climate (Gal, Ginsburg, & Schau, 1997). Each of us who have taught statistics have had classes that were anxiety ridden and classes that weren't. I believe that a few students with poor attitudes can dictate the climate in a class, unless the instructor or other students intervene. In addition, many of us believe that attitudes impact students' achievement, course completion, future course enrollment, and statistical thinking (or lack thereof) in their lives outside the classroom.

A variety of educational and cognitive theories propose that attitudes are important in course achievement and persistence and in the use of course-learned information outside of the classroom (see Sorge, 2001, for a brief description some of these models). Expectancy-value models of behavior are especially useful in mathematics and statistics education. Eccles and her colleagues have taken these expectancy-value models and applied them to mathematics attitudes and achievement in K-12 students (see, for example, Eccles, Adler, Futterman, Goff, Kaczala, Meece, & Midgley, 1983, and Eccles & Wigfield, 1995). We, in turn, have taken their model and applied it to statistics attitudes and achievement.

Eccles and colleagues believe attitudes are multi-dimensional, that is, that attitudes are composed of constructs or factors that, although related, are distinct. The three expectancy-value factors of most use to us in statistics education include:

(1) Expectancies for Success - students' self-concepts regarding their ability to do statistics successfully,

(2) Task Difficulty - students' perceptions of the difficulty of statistics, and

(3) Task Value - students' perceptions of the value of doing statistics successfully.

Each of these three factors suggests an important component to attitudes toward statistics. In addition, students' perceptions of their past academic performances (in math and in statistics, if they have had previous experience in the later) influence each of these three factors.

How Do We Measure Attitudes Toward Statistics?

There are a variety of ways to measure students' attitudes toward statistics. See Gal, Ginsburg, and Schau (1997) for a description of some of these approaches.

Common Attitude Surveys

The most common approach by far, especially in post-secondary statistics courses, is to use a Likert survey. This approach is easy and quick to use. In late 1980's, there were two commonly used surveys purporting to assess post-secondary students' attitudes toward statistics. They included the

Statistics Attitude Survey (SAS) by Roberts and Bilderback (1980; see also Roberts & Saxe, 1982), and

Attitudes Toward Statistics (ATS) by Wise (1985).

A third measure, the Statistical Anxiety Rating Scale (STARS) by Cruise, Cash, and Bolton (1985), was designed to assess statistics anxiety; if attitudes toward statistics is multi-dimensional, statistics anxiety is only one part of one component of attitudes toward statistics. For a thorough description of these (and other) surveys, see Sorge (2001).

Roberts and Bilderback (1980) designed the 33-item SAS to predict students' achievement in statistics classes. Students responded on a 5-point Likert scale ranging from Strongly Agree through Neutral to Strongly Disagree. The SAS yields one global attitudes score. The single score implies that Roberts and Bilderback believed that the construct of attitudes toward statistics is one-dimensional. However, an examination of the items in the SAS suggests that that they actually assess four separate components of attitudes.

Several items could be grouped into a component that addresses students' attitudes about the value or usefulness of statistics (*Value*). An example SAS item is:

"Statistics will be useful to me in evaluating the effectiveness of my professional performance."

Another group of items could form a second component that addresses student's attitudes about their cognitive abilities related to statistics (*Cognitive Competence*). An example item is:

"I make a lot of errors when I calculate statistics problems."

A smaller set of items can be grouped into a third component that addresses students' emotional or affective attitudes toward statistics (*Affect*). An example item is:

"The thought of taking another statistics course makes me feel sick!!"

The fourth and smallest group of items forms a component that concerns students' attitudes about the difficulty of statistics as a subject (*Difficulty*). An example item is:

"Statistics is the most difficult course I have taken."

Wise (1985) needed to measure students' attitudes toward statistics as part of a larger research project. He built on Roberts and Bilderback's work, but added the concept of multi-dimensionality, when he designed the 29-item ATS to assess two components of attitudes toward statistics. Students respond to the ATS items using the same 5-point scale as that used in the SAS (although the labels are reversed). According to Wise, the "Field" component measures "attitudes of students toward the use of statistics in their field of study" (p. 402). An example item includes:

"Studying statistics is a waste of time."

Most of the items in this component assess *Value*.

Wise called his second component "Course;" he indicated that this component assesses student's attitudes toward their statistics course. An example item includes:

"The thought of being enrolled in a statistics course makes me nervous."

Most of the items in the Course component assess students' negative feelings (negative *Affect*) about statistics.

These authors essentially originated survey research into students' attitudes toward statistics. However, their measures (as well as other less frequently used measures) clearly do not present a consistent picture of students' attitudes toward statistics. The creators of these measures disagree about such fundamentals as what components and how many components comprise attitudes toward statistics. The component names are often misleading and simply incorrect in some of the surveys. The items themselves suffer from a number of problems. The most fundamental is that some items appear to be misplaced in regard to the component they are supposed to be measuring.

The Survey of Attitudes Toward Statistics© (SATS©)

Development. I believe that attitudes are multi-dimensional and wanted to develop a Likert survey measuring students' attitudes toward statistics that exhibits the following characteristics:

(1) A set of scales that tap the most important components of attitudes toward statistics,

(2) Components that are consistent with educational and cognitive theories that propose the multi-dimensionality of attitudes.

(3) Applicability in most, if not all, departments offering introductory statistics courses,

(4) Applicability anytime during a statistics course (at the beginning, during, and at the end of courses), and

(5) Content partly based on students' and instructors' input.

My graduate students and I developed the SATS© using a 5-step approach. Our extensive development approach 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 attitudes generated and sorted into a consensus component structure by introductory statistics' students and instructors,
4. Pilot testing and subsequent revision of items written from these phrases to assess their components, and
5. Validation of its four-component structure using Confirmatory Factor Analysis techniques.

The current version of the SATS© consists of 28 items measuring four components of students' attitudes toward statistics. These components and example items from the pretest version of each 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."

"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."

The four components in the SATS© are consistent with our application of Eccles and colleagues' three expectancy-value factors to statistics education. These same components also are found in a variety of other theories concerned with the multi-dimensionality of attitudes.

Although Eccles and colleagues included affective perceptions within their factor called Task Value, we included *Affect* as a separate attitude component for three reasons. First, conceptually, students' affective feelings toward statistics are not the same as their attitudes about the value of statistics. In fact, Eccles and Wigfield (1995) indicated that students' affect influenced their perceptions of task value. Second, measures of attitudes toward statistics historically have included this component (often in the form of statistics anxiety). Third, the statistics instructors and students who assisted in the development of the SATS believed that students' affect toward statistics.

The second SATS© component, *Cognitive Competence*, represents the expectancy-value factor called Expectancies for Success in statistics. The third component, *Value*, represents the factor of task value: students' attitudes about the value of statistics. The fourth component, *Difficulty*, represents the factor of task difficulty. Eccles and colleagues assessed task difficulty as the student's perception of the difficulty of math for that specific student; we, however, asked for students' attitudes about the difficulty of the domain of statistics for most people.

Every item in the first two components, *Affect* and *Cognitive Competence*, contains the word "I." That is, each item in these two components asks students about themselves. The third component, *Value*, contains some items that ask students about themselves and others that ask about the value of statistics in general. Also, this component contains some items about the value of statistics in professional life and other items about its value in personal life (as the two example items given earlier demonstrate). The items in the fourth component, *Difficulty*, are not specific to each student but rather are general.

Three additional items on the SATS© assess students' global attitudes. They were included primarily for use in assessing the concurrent validity of three of the four SATS component scores. These global items include:

Math Cognitive Competence

"How good at mathematics are you?"

Career Value

"In the field in which you hope to be employed when you finish school, how much will you use statistics?"

Statistics Cognitive Competence

"How confident are that you can master introductory statistics material?"

All of the items in the four components, as well as the three global items, use a 7-point Likert response scale (1 = Strongly Disagree, 4 = Neither Disagree nor Agree, 7 = Strongly Agree). Although some of the items are written negatively, responses are reversed before scoring so higher responses always mean more positive attitudes. Positive attitudes are self-explanatory for all items and components, except for the *Difficulty* component. Higher scores on the *Difficulty* component mean that students think that statistics is easier while lower scores mean that they think it is harder.

An additional five items assess different aspects of students' academic backgrounds including prior mathematics course experience, self-judged prior mathematics achievement, progress toward their degree as assessed by earned credit hours, global post-secondary achievement as measured by their GPA, and prior statistics course experience. The SATS© also asks students for a variety of demographic information (e.g., gender, age). In addition, students are asked to indicate the grade they expect to receive in their statistics course. The SATS© is available for viewing on the web at:

http://www.evaluationandstatistics.com

Students, on average, spend about ten minutes responding to the items on the SATS© administered in a paper-and-pencil or a Web format. The SATS© is easy to administer in either format.

Psychometric evidence. Before using any kind of measure, it is important to examine the measurement quality of its scores. Usually, both score reliability and validity are examined. For surveys, reliability usually is assessed as the internal consistency of the items composing each scale, that is, the degree of interrelationship among students' responses to the scale's items. Cronbach's coefficient alpha often is used for this assessment. The SATS© component scores generally exhibit reasonably high alpha values indicating good internal consistencies. These values show a consistent picture within each attitude component across studies that vary in terms of students' educational level (undergraduate or graduate), gender, and ethnicity (White, Hispanic, African American, unknown); time of administration (beginning, middle, or end of the course); and course and instructor characteristics (Cashin & Elmore, 2000; Faghihi & Rakow, 1995; Hilton, Schau, & Olsen, in press; Mayer, 1999; Mills, 2002; Schau, 2003; Schau, Dauphinee, & Del Vecchio, 1992; Schau, Dauphinee, & Del Vecchio, 1993; Schau, Stevens, Dauphinee, & Del Vecchio, 1995; Schutz, Drogosz, White, & Distefano, 1999; Watson, Lang, & Kromrey, 2002; Wisenbacker & Scott, 1995). The range of alpha values by component includes:

Affect (17 values from 9 studies) - .80 to .89

Cognitive Competence (16 values from 8 studies) - .77 to .88

Value (17 values from 9 studies) - .74 to .90

Difficulty (16 values from 8 studies) - .64 to .81

The *Difficulty* component tends to exhibit the lowest level of internal consistency, but that level is considered at least adequate.

Two kinds of score validity information are available for the SATS©. The first kind concerns the score validity of the four-component structure. Two sets of confirmatory factor analyses indicate that the four-component structure fits responses to the SATS© well and that the items fit into their hypothesized components. This four-component structure fits responses from White undergraduate males and females at both pre-test and post-test administrations with only minor differences (Dauphinee, Schau, & Stevens, 1997; Hilton, Schau, & Olsen, in press; Schau, Stevens, Dauphinee, & Del Vecchio, 1995). These findings imply that scores from the SATS© have the same meaning for both genders at both administration times, at least for undergraduates who self-identify as Whites; that is, mean scores can be compared. Unfortunately, no one has tested this structure for other ethnic groups.

The second kind of score validity information is often called concurrent validity. Scores have concurrent validity if they interrelate as expected with other measures of similar constructs. There is evidence of concurrent validity for the SATS© component scores of *Affect*, *Cognitive Competence*, and *Value*. SATS© *Affect* scores correlated strongly with scores from Wise's ATS Course scale (which also measures students' affective feelings about statistics) at both pre-test (Cashin & Elmore, 2000; Schau, Stevens, Dauphinee, & Del Vecchio, 1995) and post-test (Cashin & Elmore, 2000) administrations. Scores from the SATS© *Value* component correlated strongly with scores from the ATS Field scale (which also measures students' attitudes about the value of statistics), again at both pre-test (Cashin & Elmore, 2000; Schau, Stevens, Dauphinee, & Del Vecchio, 1995) and post-test (Cashin & Elmore, 2000) administrations.

In addition, the expected relationships between the single global SATS© items and the corresponding construct scores were found. Correlation values greater than +. 5 were found between students' pre-test *Cognitive Competence* component scores and their pre-test responses to the single global *Cognitive Competence* item, as well as between their pre-test *Value* component scores and their pre-test responses to the single global *Career Value* item. These correlations are quite high considering that the global item in each correlation is a single item with a 7-point scale.

What Do We Know About Students' Attitudes Toward Statistics?

There is not much research on students' attitudes toward statistics. Researchers in education have conducted most of the research that does exist. They usually study the students in their own courses; many of their students are education majors and may be advanced undergraduate or graduate students. Much of this research has been presented at conferences and has not been published. It often is difficult to obtain and may not include all of the information we need. We know little about the attitudes of undergraduates who are enrolled in introductory statistics courses and even less about students in these statistics courses offered by mathematics or statistics departments.

In this paper, I emphasize findings from a subsample of the students who participated in the development and testing of the SATS©. These findings come from data collected from undergraduates who were enrolled in the introductory statistics course offered by the Mathematics and Statistics Department of a major Southwestern research university. The Psychology, Sociology, Engineering, and Business Departments at this University offered their own introductory statistics courses so students with these majors are not well represented in these findings. We collected SATS© attitudes and course achievement data in a total of 11 sections of this introductory statistics course across two consecutive semesters.

Five hundred eighty-one students completed the SATS© within the first two weeks of the beginning of their course (the pre-test administration); 288 of these students also completed it within the last two weeks (the post-test administration). Only one student took the SATS© during the post-test administration but not during the pre-test administration; that student's data are not included in the analyses.

Of the 293 students who took the pre-test but not the post-test, 201 (69%) did not receive a letter grade (A through F); since they had withdrawn from the course, they could not have participated in the post-test data collection. Their mean pre-test attitude scores were lower than those of the students who took the pre- and the post-tests by .1 point or less (less than 2% differences on this scale); clearly these differences were small. Participation rates were high; usually, every student present on the day of SATS© data collection participated, with the occasional exception of one or two students. Thus, it is likely that most of the 92 students who received a letter grade but did not take the post-test SATS© were absent the day we collected the post-test data. Unfortunately, these students could not afford to miss class. On average, the students who took the pre-test but not the post-test received grades of about C+ (2.45) while those who took both received grades of about B (2.88), a difference of .4 point on the usual 4-point grading scale. Whenever possible, pre-test analyses were conducted on both sets of students: all 580 students who took the pre-test and the 287 students from this group who took both the pre- and post-tests.

My analyses yielded seven findings of interest. These findings included:

1. Students' spoken attitudes were more negative than were responses to the SATS©.
2. Students attributed their attitudes to their past achievement and instructors.
3. On average, students' *Cognitive Competence* and *Value* attitudes were highest and positive. *Affect* attitudes were neutral. *Difficulty* attitudes were slightly negative. The differences between mean scores on these attitude components were large.
4. Class sections differed greatly on mean attitudes scores at the beginning of the semester, with even larger mean differences at the end.
5. Females and males, as well as Whites and Hispanics, had similar mean pre-test attitude component scores. However, males and Whites left this statistics course with somewhat higher attitudes than females and Hispanics on some attitude components.
6. Across all students and sections, attitude changes from the beginning to the end of this course were small and negative.
7. Students' attitudes and achievement were positively related.

Students' Spoken Attitudes were More Negative than were Responses to the SATS©

As mentioned previously, part of the SATS© development process utilized a small focus group of introductory statistics students and instructors. These participants were asked to individually generate an exhaustive list of words and phrases that, in their views, represented introductory students' attitudes toward statistics. The group generated 92 unique words and phrases. Of these, almost 80% were negative and many of these were emotionally charged (e.g., dread, despair, crying); these are the kinds of responses that create negative climates in statistics classrooms. The positive responses were much less emotional (e.g., interesting, new way of thinking).

It was difficult to create good items that expressed attitudes using positive terms (e.g., enjoy) rather than negating negative terms (e.g., not scared). Our pilot set of items contained about 50% positive and 50% negative items. When we eliminated items based on our pilot study analyses, many more positive than negative items were eliminated.

Because of the predominance of strong negative words and phrases created during the development phase, we thought students' responses to the SATS© survey would be at least somewhat negative too. Thus, the SATS© results were unexpected. For both sets of pre-test analyses and the post-test analyses, average *Cognitive Competence* scores were somewhat positive (about 1 point above neutral), as was the mean *Value* score at the pre-test administration. The mean post-test *Value* score was slightly positive, about ½ point above neutral. The *Difficulty* scale was the only scale to yield mean negative attitudes, and these means were only slightly negative for both pre- and post-tests (about half a point below neutral). See Table 1. These means generally are similar to those found in research using the SATS with other samples of students (e.g., Cashin & Elmore, 2000; Faghihi & Rakow, 1995; Hilton, Schau, & Olsen, in press; Mayer, 1999; Mills, 2002; Schau, 2003; Schau, Dauphinee, & Del Vecchio, 1992; Schau, Dauphinee, & Del Vecchio, 1993; Schau, Stevens, Dauphinee, & Del Vecchio, 1995; Schutz, Drogosz, White, & Distefano, 1999; Watson, Lang, & Kromrey, 2002; Wisenbacker & Scott, 1995).

It appears that spoken attitudes are more negative than those recorded on a survey. Perhaps students who hold negative attitudes are more verbal than those who hold neutral and positive ones.

Students Attributed their Attitudes to their Achievement and to Instructors

Students in two sections of a required introductory graduate-level statistics course taught in a College of Education were given an extra-credit opportunity to write brief statements about their attitudes and the sources for these attitudes regarding mathematics and statistics and courses in these disciplines. Although they cited a variety of sources for their feelings, they most often mentioned two general themes: their achievement and teacher (and class) characteristics. At the beginning of the classes, these students attributed positive attitudes to good math achievement that created positive math self-concepts. For example, students wrote:

> "My overall feeling about math is good, and I enjoy taking math classes. I think that the reason I feel this way is due to my having successfully completed several math classes…"
>
> "I have always enjoyed math and I usually had no difficulty with math classes. Math and sciences have always been my best subjects and enjoyable for me…"

Students attributed negative attitudes at the beginning of classes to poor teaching that led to poor mathematics self-concept and poor achievement. For example, students wrote:

> "I have little confidence regarding my mathematics ability. I struggled with geometry in 9th grade and almost failed Algebra I. … In algebra, I found the teacher impossible to understand and eventually gave up."

"The [statistics] teacher I had did not care whether the students understood the materials or not - she had to teach to get her masters degree. She stated that this was the only reason she was teaching the course."

"[My] instructor for Algebra I and II and geometry used to rearrange the class seating after each test according to performance on exams, i.e., those who did well sat in the front, those who did poorly sat in the very back. This ritual was conducted with great ridicule for those who did poorly."

Many students also attributed positive change in their attitudes across their statistics course (as well as high achievement) to teacher characteristics. For example, some of them wrote:

"... the instructor's enthusiastic and supportive style helped translate [my] anxiety and work into a sense of accomplishment."

"... the instructor not only knew the material but ... showed a real interest in each one of the students and their progress in her class."

As one student wrote, "Instructors make a large difference." See the chapter by Gal, Ginsburg, and Schau (1997) and papers by Onwuegbuzie, Da Ros, and Ryan (1997) and Watson, Kromrey, Lang, Hess, Hogarty, and Dedrick (2003) for additional discussion of this important topic.

Mean Attitudes Vary

Attitudes varied, depending primarily on the component being measured and the section in which the student was enrolled. Mean gender and ethnic attitude differences were small, when they existed at all. Similarly, attitudes did not change much from the beginning to the end of the course.

Differences by attitude component. As mentioned previously, at the pre-test administration of the SATS©, students' mean *Cognitive Competence* and *Value* attitudes were highest and somewhat positive. These means were almost one point (on the 7-point scale) or about 17% higher than those for *Affect*. The pre-test mean for *Affect* was neutral and about 1/2 point (about 8%) higher than the mean for *Difficulty*, which was slightly negative. See Table 1.

At the post-test administration of the SATS©, the mean for *Cognitive Competence* remained somewhat positive and was now higher then the *Value* mean by about ¼ point (about 4%). The *Value* mean was slightly positive and about ½ point (about 8%) above the *Affect* mean which remained neutral. The *Affect* mean remained about ½ point (about 8%) higher than the *Difficulty* mean, which remained slightly negative.

Course section differences. Class sections differed greatly on mean attitudes scores at the beginning of the semester, with even larger mean differences at the end. For students in the 11 sections who took the pre-test, section 3 students, as a group, exhibited the lowest pre-test *Affect* and *Cognitive Competence* attitudes. Section 2 students exhibited the highest pre-test *Affect* and *Value* attitudes. The mean pre-test differences between the highest and lowest section scores for this group ranged from about ½ point for *Difficulty* (about an 8% difference between the low and high section mean *Difficulty* scores) to about .8 point for *Affect* (about a 14% difference between the low and high section scores). See Table 2.

For students who took both the pre- and post-tests, the sections containing the students who exhibited the lowest attitudes showed the same pattern as that for all students who took the pre-test. The mean values also remained about the same. The sections exhibiting the most positive attitudes, however, changed. Section 4 students responded with the highest mean attitudes for *Affect*, *Cognitive Competence*, and *Difficulty*. The pre-test differences between the highest and lowest mean section scores for this group were somewhat larger than the comparable mean differences from all pre-test students, ranging from about 2/3 point for *Difficulty* (about an 11% difference) to .9 point for *Affect* (about a 15% difference). See Table 2.

At the post-test, the sections exhibiting the lowest and highest mean attitude scores changed completely. Section 10 students exhibited the lowest mean scores on all attitude components except *Difficulty*. Section 8 students responded with the most positive mean attitudes on all components except *Value*. The differences between mean post-test scores in the sections with the highest and lowest means were large for all four components, much larger than they were at pre-test. As occurred at the pre-test, mean *Affect* scores showed the largest section differences. The mean post-test difference for this component was almost 2 points (about 32%), over twice as large as the mean pre-test difference. The smallest mean post-test difference was for *Value* while *Difficulty* had shown the smallest mean difference at pre-test. This post-test mean difference in *Value* was over one point (about 20%), almost twice as large as the *Value* difference that occurred at the pre-test. See Table 3 for the highest and lowest raw mean section scores.

These results suggest that the section in which the student was enrolled is important in regard to their attitudes. To explore the contribution of section to post-test attitude score variability, analysis of covariance was used to adjust component post-test responses for corresponding pre-test responses; section was the independent variable.

Section 10 continued to have the worst mean post-test attitudes on the components of *Affect* and *Cognitive Competence*. Section 2 continued to exhibit the worst mean post-test attitudes on *Difficulty*. Although Section 10 students exhibited the worst mean post-test attitudes on *Value* using raw scores, Section 6 students' adjusted *Value* mean post-test scores were worst. The same sections remained highest. See Table 3 for these adjusted mean post-test attitude component scores.

Pre-test attitude scores were important in post-test score variability. Pre-test scores shared from 11% (*Affect*) to 22% (*Cognitive Competence* and *Value*) of the variance in post-test scores, depending on the attitude component being studied. See Table 4.

Section, controlling for pre-test scores, was also an important factor in students' post-test attitudes for all four components. Section shared from 11% (*Value*) to 21% (*Affect*) of the variance in post-test scores, depending on the attitude component being studied. See Table 4. For *Affect*, section was twice as important as pre-test scores in post-test variability. For *Value*, pre-test scores were twice as important as section. For *Cognitive Competence* and *Difficulty*, both were about equally important. These findings support the idea of the importance of the class experience involving the course instructor and the group of students in regard to students' attitudes, as well as the importance of the attitudes students bring to this course.

Gender and ethnic similarities and differences in attitudes. Overall, mean gender differences were small; when they occurred at all, they favored males. Gender differences were larger at the end than at the beginning of the course, but they still tended to be small.

The largest mean pre-test gender differences occurred for *Affect* and *Cognitive Competence*. In both cases, the males' mean scores were about ¼ point (or about 4%) higher than the corresponding mean scores for females. These mean pre-test gender differences were smaller for *Affect* and no longer existed for *Cognitive Competence* when those students who completed both the pre- and post-tests were considered. See Table 5.

Mean gender differences were larger (although still small) on two of the attitude components at the post-test. Males' mean scores were about 1/3 point (about 6%) higher than females' on both *Affect* and *Cognitive Competence*. They differed by less than .2 point on the other two components.

Other research studies that have examined gender differences used different student samples. In agreement with my findings, some of these studies reported small mean gender differences favoring males (e.g., Auzmendi, 1991; Cashin & Elmore, 2000; Roberts & Bilderback, 1980; Roberts & Saxe, 1982; Waters, Martelli, Zakrajsek, & Popovich, 1988). The remainder of the studies either found no mean gender differences on any type of attitude (e.g., Cherian & Glencross, 1997; Faghihi & Rakow, 1995; Sutarso, 1992; Schau, Dauphinee, & Del Vecchio, 1992; Schutz, Drogosz, White, & Distefano, 1999; Tomazic & Katz, 1988; Wisenbaker & Scott, 1997), or very occasionally reported a higher mean score for women (Rhoads & Hubele, 2000; Zeidner, 1991).

Only the White and Hispanic American ethnic groups in this sample were large enough to compare. I could find no other research that compares these two ethnic groups.

Mean ethnic group differences on the attitude component scores were very small at the beginning of the course, with some favoring Whites and others favoring Hispanics. They were larger, and favored White Americans, at the end of the course.

These two ethnic groups entered their statistics course with very similar attitudes; most pre-test mean differences were 1/10 point or less. Unlike gender differences, the size of these mean pre-test differences did not depend on whether the students had taken the post-test. However, on the post-test, Hispanic mean attitudes tended to decrease. Their mean post-test scores on *Cognitive Competence* and *Value* were .4 point (about 7%) lower than those of Whites; they were ¼ point (about 4%) lower on *Affect*. See Table 6.

In this sample, females and Hispanics, two groups that traditionally are considered at-risk in mathematics courses, entered their statistics course with similar attitudes but left with less positive attitudes on some attitude components. However, both the gender and the ethnic differences were small compared to those associated with section and attitude type.

Changes across the course. When overall mean student attitudes changed from the beginning to the end of this introductory statistics courses, these changes tended to be small and negative. Although the mean values on all four components decreased from pre- to post-test, only the means for *Value* decreased by more than .2 point (3%); its decrease was about .4 point (about 7%). Like the gender and ethnic differences, the differences associated with overall mean changes across the course are small compared to those associated with attitude component and section.

At first consideration, we might think that we always want positive change in attitudes with exposure to statistics education. Many of us believe that statistics education should help students see and be able to evaluate the use of statistics in their lives and to understand their own statistical skills. Attitude component scores would naturally decrease if students enter statistics courses with unrealistically positive attitudes. The students in this sample entered their statistics course with somewhat positive attitudes about the value of statistics. Perhaps they knew so little about statistics at the beginning of the course that they believed statistics could do more for them than is realistic. Or the instructors may not have used examples that were realistic enough to show students how statistics could work for them. In any case, students' attitudes about the usefulness of statistics decreased after having a semester of statistics instruction. However, on average, it still remained at least slightly above neutral. It would be informative to examine the direction and amount of attitude change by component for individual students within the context of what we, as instructors, know about them. Possible section differences in attitude change would be useful to explore.

Other researchers that have examined attitude change across introductory statistics courses used courses that were not taught in mathematics or statistics departments. Most of them concluded that at least some components of attitudes became more positive across these courses (e.g., Harlow, Burkholder, & Morrow, 2002; Katz & Tomazic, 1998; Perney & Ravid, 1990; Roberts & Sax, 1982; Sorge, Schau, Hubele, & Kennedy, 2000; Waters, et al., 1988) while others reported no change (Green, 1993; Rhoads & Hubele, 2000; Shultz & Koshino, 1998). Schau (2000) reported an increase in one attitude component and decreases in two others. When larger positive changes occurred, they often came from students in new innovative courses taught by enthusiastic instructors (e.g., Harlow, Burkholder, & Morrow, 2002).

Students' attitudes were positively related to their achievement. Like many others, I believe that statistics attitudes and achievement are positively related; that is, students whose attitudes are more positive tend to achieve better in class. However, research evidence supporting this belief is not yet well established. Until recently, studies exploring attitudes toward statistics have focused on a small part of the complex relationships between attitudes and achievement. These studies often have explored these relationships by correlating attitude and achievement scores. See Sorge (2001) for a summary of this research. Like much of this research, I found small to moderate correlations among attitudes and course achievement, with larger relationships among post-test attitudes and final achievement than among pre-test attitudes and achievement.

The only achievement variable available for my sample was letter grade; it was converted to the usual 4-point numerical scale and standardized within section due to differences in instructors' grading standards across sections. Attitude component scores also were standardized within section. Table 7 presents correlations from this sample; these correlations provide only limited support for my belief. The pre-test attitude component relationships with course grade were small, .20 or below. They were smaller when using only the pre-test scores from those students who took both the pre- and post-tests. Pre-test *Cognitive Competence* shared the most variation with grade (4% or less). The post-test relationships were higher. *Cognitive Competence* and *Affect* each shared about 12% of the variance in grade. *Value* shared about 9%. Consistent with some other research findings, and with expectations, post-course attitude scores were more strongly related to achievement than were the pre-course scores (e.g., Wisenbaker & Scott, 1997).

A hierarchical regression, entering the four standardized pre-test attitude component scores in the first block and the four standardized post-test component scores in the second block, was used to predict standardized grade. The pre-test block shared only 3% of the variance in grade. The post-test block, controlling for the pre-test block, shared 16% of the variance in grade. Together, they shared 20%.

These relationships, although adequate, were not strong. There are at least three reasons these relationships were not stronger. First, letter grade is not the best measure of course achievement to use in analyses due to its limited number of possible values. Total course points would be a better measure. Second, students who didn't participate in the post-test, on average, received lower grades than those who did participate, thus likely restricting the possible size of the relationships. Third, simple correlations and regressions are unlikely to represent the complexity of the interrelationships among attitudes and achievement.

Are Attitudes Toward Statistics and Statistics Course Achievement Causally Related?

I believe that attitudes toward statistics and course achievement causally impact each other, and that these relationships can be represented in a model. I have used four primary sources of information in developing the current version of my model:

- My extensive experience teaching introductory statistics courses,
- Discussions about possible models with my past graduate students who are now my colleagues,
- The small amount of research literature available on this topic, and

- Eccles and colleagues' expectancy-value model (e.g., Eccles & Wigfield, 1995).

Models often contain constructs that are internal to the model (endogenous constructs) and constructs that are external to the model (exogenous constructs). These models represent the researcher's idea about the causal relationships among the endogenous constructs while taking the exogenous constructs as "givens."

In my model, the four endogenous attitudes constructs match the four components of the SATS©. The direction of the impacts among the attitude components is based on Eccles and Wigfield (1995). They described five directional impacts among their three expectancy-value factors (i.e., *Affect* impacts *Value*, *Cognitive Competence* impacts *Affect* and *Value*, and *Difficulty* impacts *Cognitive Competence* and *Value*). We then filled in the remaining path from *Difficulty* to *Affect* to create the part of our model that interrelates the four attitude components. This part of the larger model is represented in the box in Figure 1. Prior Achievement and Prior Attitudes were added as exogenous constructs. Achievement was added with attitudes and achievement impacting each other, and Prior Achievement and Prior Attitudes impacting both. See Figure 1 on the following page.

This model is untested. Structural equation modeling (SEM) techniques can be used to determine if student data fit a more detailed version of this model. However, SEM techniques require attitude and achievement data from at least 200 students, collected at least twice during the semester. I do not have access to such a data set. However, using data from engineering undergraduates in a required introductory engineering statistics course, my colleague Carmen Sorge and I were able to test a part of this model. With some modifications, the data fit the model adequately. The post-test attitude components together accounted for about 1/3 of the variation in course achievement. Prior achievement accounted for the remaining 2/3. I believe that these variance percentages associated with course achievement (1/3 with attitudes and 2/3 with prior achievement) will generalize to other samples. See Sorge (2001).

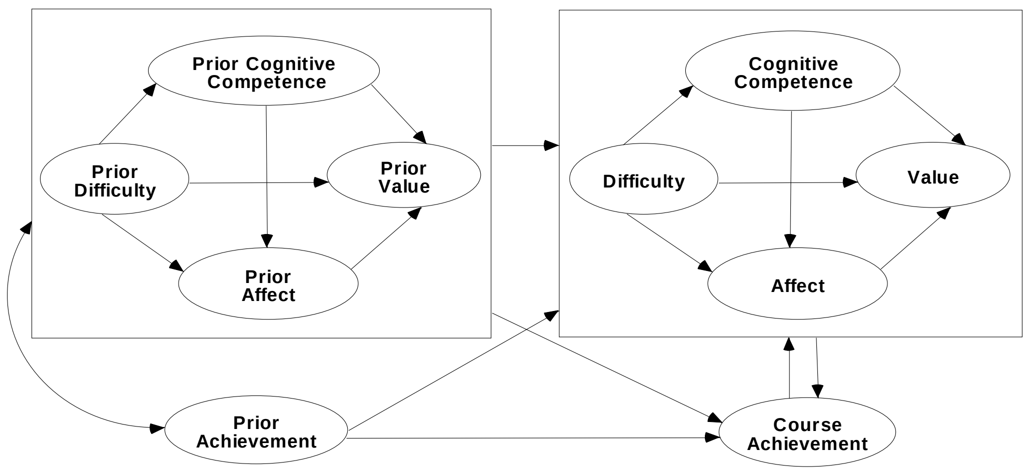

Figure1 (corrected). Model interrelating students' attitudes toward statistics and course achievement.

This model isn't the only reasonable model relating statistics attitudes and achievement. The literature contains a few other SEM models. Harlow, Burkholder, and Morrow (2002) studied students enrolled in a reform-based quantitative methods course in psychology. Their model included two exogenous correlated constructs: pre-test mathematics skills and pre-test attitudes. Course performance, post-test attitudes, and post-test ratings of the course's learning activities constituted the endogenous outcome constructs. The standardized structural path coefficient relating the pre-test attitude construct to the course performance construct was moderately sized and positive (.38).

Wisenbaker and colleagues (e.g.,Wisenbaker and Scott 1997; Wisenbaker, Scott, & Nasser, 1999; Wisenbaker, Scott, & Nasser, 2000)) also created, tested, and modified a series of structural models of statistics achievement. In their models, the structure interrelating the attitude components differed depending on time of measurement. In general, Wisenbaker and his colleagues reported that attitude components measured at the end of the course predicted final course achievement; those measured at the beginning of the course did not. This latter finding is not consistent with the finding reported above by Harlow, Burkholder, and Morrow (2002).

The attitude components assessed by the SATS©, coupled with students' past achievement, are not all of the important student inputs into their work in statistics courses. We currently are adding two other components to the SATS©. These include:

- *Interest* – students' self-reported level of individual interest in statistics, and
- *Effort* – amount of work students say they expend to learn statistics.

It is not clear, however, if these two constructs are components of attitudes. Other important inputs and outcomes include students' goals for studying statistics and the metacognitive approaches they use in doing so.

How Can We Influence Students' Attitudes Toward Statistics?

There are many things that we as instructors can do to try to influence our students' attitudes and to help them at least complete our courses. Unfortunately, there is little research available on the effectiveness of these approaches. My suggestions, which aren't exhaustive, are based on educational and cognitive theories, what I've tried, and others' suggestions that sound reasonable to try. Whatever you choose to do, however, must be comfortable for you and fit into your vision of yourself as an introductory statistics course instructor. See also Harris and Schau (1999).

First, encourage students with debilitating anxiety or lack of self-confidence to see a counselor at your institution. Most of us aren't equipped to deal with excessively negative emotions.

Second, stress that your statistics course is not a math course (unless, of course, it is). Indicate what math skills students need as prerequisites (e.g., basic algebra skills) and that you can't teach them those skills in a statistics course.

Third, bring positive attitudes to your course. If you don't believe that teaching statistics is valuable and that your students can learn statistics, they won't believe it either.

Fourth, if you believe that students' attitudes are important, acknowledge their importance both in and out of class. Be sympathetic, supportive, and encouraging. Acknowledge that it takes time and energy to understand statistics.

Fifth, if engendering positive attitudes is one of your learning goals, you need to assess your students' attitudes at the beginning and at the end of your course to evaluate your success in meeting this goal. You need to do this assessment anonymously, using an identification system that masks student names but allows you to match pre- and post-test responses. Carefully select your attitudes measure. Although each measure's creator has named the measure and its scales, there often is no psychometric evidence to show that scores from that measure actually assess what the names of the scales imply. Carefully examine the item content to determine what is being assessed and the measure's psychometric characteristics to be certain that the measure is of good quality.

Sixth, use activities that will help students identify and acknowledge their attitudes. I believe that administering an attitude survey helps students make explicit and verbalize their own attitudes and that this process helps them. You can suggest that your students write about their own or others' attitudes and the reasons for them. You can hold class discussions about attitudes, although that is difficult to do before your students have learned to trust you. Use of any of these, and many other, activities also lets your students know that you think attitudes are important.

Seventh, provide a great deal of structure in your course. Be organized. An organizing handout on the first day helps.

Eighth, use humor but not sarcasm. Laughter helps people, even introductory statistics students and instructors, feel better.

Ninth, let students know that it is very likely that both you and they will make mistakes sometime during the course. Indicate that everyone makes mistakes, but that it is more important to try than to always be right. Acknowledge the mistakes you make during class and use them as "teaching moments," for content, process, and attitudes.

Tenth, allow students to use so-called "cheat sheets" on exams. The process of creating these sheets is an excellent study technique, and their existence will help students be calm at least at the beginning of your tests.

Eleventh, if possible, use more than in-class tests for assigning grades. Tests, especially timed tests with no supporting material allowed, make many students anxious (e.g., Onwuegbuzie, 2000).

There are at least two additional sources of help. Freda Watson, for her doctoral dissertation at the University of South Florida-Tampa, is creating a multi-media program called EncStat to identify students with poor attitudes toward statistics and to help them develop more positive attitudes. A second phase of the project (EncStat – Professor) will provide statistics instructors with information about statistics anxiety and how to help students cope with it (Watson, Kromrey, & Hess, 2002). In addition, Anthony Onwuegbuzie does a prodigious amount of research on the correlates of statistics anxiety, one part of the *Affect* component of attitudes toward statistics.

Conclusion

I began this paper by indicating that many of us want our students to be intelligent users of statistics in their lives. This outcome may have little to do with course achievement and everything to do with their attitudes toward statistics. The SATS© is a simple measure that assesses these attitudes. It is easy to use, score, and explain.

We need to better understand students’ attitudes toward statistics and their interrelationships with achievement and eventual use in life, and we need to find more methods for promoting positive attitudes. I believe that assessing our students’ attitudes and creating, considering, and testing models such as the one I’ve presented here will help us understand the nature of students’ attitudes toward statistics as well as their statistics learning.

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Table 1. SATS© Attitude Component Mean Scores (Standard Deviations) at Pre- and Post-Test

	Affect	Cognitive Competence	Value	Difficulty
Pre-test* (n=580)	4.03 (1.14)	4.91 (1.09)	4.86 (1.01)	3.62 (0.76)
Pre-test ** (n=287)	4.12 (1.13)	5.01 (1.09)	4.96 (0.97)	3.62 (0.78)
Post-test (n=287)	3.95 (1.45)	4.84 (1.27)	4.57 (1.21)	3.49 (1.15)

*Pre-test scores for students who took the pre-test.
** Pre-test scores for students who took the post-test also.

Table 2. Lowest and Highest SATS© Pre-test Component Mean Scores by Section (Section Number)

	Students Who Took Pre-test			Students Who Took Pre- & Post-test		
	Lowest	Highest	Difference	Lowest	Highest	Difference
Affect	3.57 (3)	4.41 (2)	0.84	3.60 (3)	4.50 (4)	0.90
Cognitive Competence	4.58 (3)	5.21 (6)	0.63	4.65 (3)	5.34 (4)	0.69
Value	4.60 (8)	5.27 (2)	0.67	4.60 (8)	5.33 (6)	0.73
Difficulty	3.31 (9)	3.78 (4)	0.47	3.31 (9)	3.96 (4)	0.65

Table 3. Lowest and Highest Raw and Adjusted SATS© Post-test Component Mean Scores by Section (Section Number)

	Raw			Adjusted		
	Lowest	Highest	Difference	Lowest	Highest	Difference
Affect	2.85 (10)	4.74 (8)	1.89	2.90 (10)	4.77 (8)	1.87
Cognitive Competence	3.79 (10)	5.53 (8)	1.74	3.90 (10)	5.49 (8)	1.59
Value	4.09 (10)	5.26 (5)	1.17	3.96 (6)	5.29 (5)	1.33
Difficulty	2.67 (2)	4.05 (8)	1.38	2.69 (2)	4.05 (8)	1.36

Table 4. Percent Variance in Post-test Attitude Scores Associated with Pre-test Attitude Scores and with Section Membership by attitude component

Attitude Component	Pre-test	Section	Total
Affect	11%	21%	32%
Cognitive Competence	22%	18%	40%
Value	22%	11%	33%
Difficulty	14%	14%	28%

Table 5. SATS© Attitude Component Mean Scores (Standard Deviation) at Pre- and Post-Test by Gender

	Affect			Cognitive Competence			Value			Difficulty		
	Male	Female	Difference	Male	Female	Difference	Male	Female	Difference	Male	Female	Difference
Pre-test*	4.22 (1.10)	3.93 (1.15)	0.29	5.07 (1.13)	4.84 (1.06)	0.23	4.90 (0.97)	4.84 (1.02)	0.06	3.67 (0.74)	3.59 (0.78)	0.08
Pre-test**	4.24 (1.11)	4.04 (1.15)	0.20	5.07 (1.15)	4.98 (1.07)	0.09	4.96 (0.92)	4.96 (0.97)	0.00	3.64 (0.70)	3.60 (0.82)	0.04
Post-test**	4.17 (1.36)	3.85 (1.48)	0.32	5.06 (1.24)	4.75 (1.28)	0.31	4.59 (1.13)	4.56 (1.25)	0.03	3.61 (1.11)	3.45 (1.16)	0.16

*196 males and 368 females took the pre-test.
**98 males and 183 females took both the pre- and the post-tests.

Table 6. SATS© Attitude Component Mean (and Standard Deviation) Scores at Pre- and Post-Test by Ethnicity

	Affect			Cognitive Competence			Value			Difficulty		
	White	Hispanic	Difference	White	Hispanic	Difference	White	Hispanic	Difference	White	Hispanic	Difference
Pre-test*	4.03 (1.17)	4.02 (1.00)	0.01	4.94 (1.11)	4.84 (0.97)	0.10	4.89 (1.02)	4.78 (0.95)	0.11	3.62 (0.75)	3.65 (0.78)	-0.03
Pre-test**	4.10 (1.16)	4.13 (0.98)	-0.03	5.03 (1.07)	4.97 (1.07)	0.06	4.97 (0.99)	4.86 (0.82)	0.11	3.60 (0.74)	3.75 (0.76)	-0.15
Post-test**	4.08 (1.47)	3.82 (1.43)	0.26	5.01 (1.30)	4.61 (1.22)	0.40	4.68 (1.18)	4.27 (1.28)	0.41	3.52 (1.18)	3.56 (1.11)	-0.04

*373 White Americans and 118 Hispanic Americans took the pre-test.
**188 White Americans and 58 Hispanic Americans took both the pre- and post-tests.

Table 7. Correlations among SATS© Attitude Component Scores and Grades*

	Affect	Cognitive Competence	Value	Difficulty
Pre-test (n=360)	.12	.20	.08	.09
Pre-test** (n=268)	.04	.14	.06	.03
Post-test*** (n=268)	.35	.36	.30	.17

*Attitude scores and grades were standardized within section.
**Pre-test scores for students who took the pre-test.
*** Pre-test scores for students who took the post-test also.