Student Attitudes toward Statistics at Augsburg College

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Abstract

Macnaughton argued that the primary goal of an introductory statistics course should be to give students "a lasting appreciation for the value of statistics." Schau designed a reliable instrument for measuring changes in individual student attitudes called SATS: Survey of Attitudes Toward Statistics. It measures attitudes on four scales: difficulty, affect, cognitive competence and value. In using SATS at other schools, students saw less value in statistics after taking the course than they did before taking the course. This paper presents the results of the SATS survey at Augsburg College. Even though 61% of Augsburg students saw more value in statistics after their course than before, this difference was not statistically significant. These students had a statistically significant increase in their feeling of cognitive competence after their course even though they found it more difficult than expected.

1. Importance of Motivation and Attitudes

Schau, Macnaughton and Schield have noted the importance of attitudes.

1.1. Schau's Comments on Attitudes

Schau (2003) noted the importance of student motivation.

> 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.
>
> The accomplishment of these goals requires more from students than a good grade in a statistics course. Students who will use their statistical knowledge appropriately 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 introductory statistics course.
>
> These statements describe attitudes about statistics, the "other" important outcome in statistics education…

Schau (2003) reviewed the SATS survey: Student Attitudes toward Statistics. SATS is discussed later in this paper.

1.2. Macnaughton's Comments on Attitudes

Macnaughton (2003) posted the following on the edstat, apstat and sci.stat.edu mailing lists:

> Subject: The Most Exciting Talk at the 2003 Joint Statistical Meetings
> As I discuss in a 2002 paper, I believe a reasonable first goal of an introductory statistics course is to give students a lasting appreciation of the vital role of the field of statistics in empirical research. Under this goal, the SATS is useful because it enables us to accurately measure students' appreciation of statistics (using the Value subscale of the SATS). It is especially useful to measure each student's appreciation immediately before and immediately after a course because the difference between the two scores for a student is a precise gauge of the effect of the course on the student. It seems reasonable to say [that] the greater the average improvement in SATS Value subscale scores as a result of a course, the higher (in one reasonable sense) the quality of the course. Thus the SATS is a useful test to help us to improve statistics education.

1.3. Schield's Comments on Attitudes

Schield (2004) noted reported data on a student survey that relates to student motivation. In this survey, 47 Augsburg business students taking statistics were asked about their major, their willingness to take statistics as an elective

and their attitude toward mathematics. The two attitudes were rated on a five-point scale. Binary groups were formed from all three variables. For both ordinal scales, the two positive groups were combined into one group while neutral and the two negative were combined into a second. Thus "Like math" included "Like very much" and "Like somewhat" while "Dislike math" include "Neutral." Table 1 presents these results:

Table 1 Percentage of Business Majors Who Would Absolutely or Almost Certainly take Statistics as an Elective – Classified by Major and by Attitude toward Math

Take Statistics as Elective	ATTITUDE TOWARD MATH		
MAJOR	Like	Dislike	ALL
Acctg./Finance/Econ/MIS	38%	21%	28%
Management/Marketing	12%	0%	7%
ALL	29%	16%	22%

Those who would absolutely or likely take statistics if it were an elective are 22% among all these business majors, 16% among those who dislike mathematics, 7% among those in the less quantitative majors (marketing and management), and 0% among those who are in the less-quantitative majors and who dislike mathematics.

One reason for disliking math is not seeing value. A lack of value in statistics was evidenced when 190 students at Pomona College ranked Critical Thinking first in value among 10 core competencies but ranked Data Analysis last (Taylor, 1999). Macnaughton (2004) argues that the primary goal of an introductory statistics course should be to give students "a lasting appreciation for the value of statistics." Robert Hayden (private communication) noted, "Students will not use what they learn in a statistics course (of any kind) unless they believe they learned something usable. So we have to both provide something useful AND sell them on it."

If students in non-quantitative majors are most likely to dislike math, they might be most unlikely to elect to take a class in statistics and, if they did, they might be most unlikely to see value in that experience. Attitude is most important for students in non-quantitative majors. Schield (2008) noted that these students are 40% of college graduates and argued that these students are more likely to become judges, journalists, and social and political leaders.

2. The SATS: Instrument and Results at Other Schools

This section presents the SATS instrument and SATS data from other institutions.

2.1. The SATS Instrument

Schau (1999) created, validated and copyrighted a survey instrument known as SATS-28©: Survey of Attitudes Toward Statistics-28. This instrument has two distinguishing characteristics. First, it is an attitude survey; it does not attempt to measure competence or to predict performance. Second, it is a longitudinal survey at the individual level; it compares measurements after the course with those before for the same individual. Measuring attitudes and changes in attitudes – for a given individual – make the SATS an extremely powerful instrument.

The original version of the SATS, SATS-28©, was developed using pretest data from a sample of undergraduate students. The results of this pretest supported a four-component structure: Affect, Cognitive Competence, Value, and Difficulty. See Schau et al., (1995). The 28 items use a 7-point Likert response scale to assess these four components of students' attitudes toward statistics. Scores range from 1 to 7 (4 is neutral). Higher scores correspond to positive attitudes. The survey also asks questions about demographic and academic background.

The four scales of the SATS-28 are:

- **DIFFICULTY (Do-ability)**: Statistics is easy (hard) for me
- **AFFECT**: I like (dislike) statistics
- **COGNITIVE COMPETENCE:** I can (can not) learn how to do statistics
- **VALUE**: Statistics is useful (not useful) both professionally and personally

While Affect, Cognitive Competence and Value are positive (more is good), Difficulty is a negative. Thus students with higher scores believe statistics is easier; students with lower scores believe statistics is more difficult.

A newer version, the SATS-36©, contains 36 items that assess six components, the original four plus two more, Interest and Effort. The SATS-36 also contains several single global attitude items in both the pretest and posttest versions, as well as a global Effort item in the posttest version only.

2.2. Schau's Results

Schau (2003) presented the results for 287 students who took both the pre and post test. 'Difficulty' is replaced with 'Easy' so it flows in the same direction as the three other scales. The standard deviation is shown in parenthesis beneath the associated mean score (where 4.0 is neutral).

Table 2: Schau's Results

	"Easy"	Affect	Value	Competence
Pre-test	3.62	4.12	4.96	5.01
	(0.78)	(1.13)	(0.97)	(1.09)
Post-test	3.49	3.95	4.57	4.84
	(1.15)	(1.45)	(1.21)	(1.27)

In the Pre-test, these students felt most positively about their COMPETENCE (5.01 > 4) despite their agreement that it would not be EASY (3.62 < 4) and they attributed considerable VALUE to statistics (4.95 > 4) and they were nearly neutral (4.12 ~4) on affect – on whether they liked or disliked statistics. Since Schau (2003) did not provide paired results, the unpaired data was analyzed as follows:

Table 3: Analysis of Schau's Unpaired Results

	"Easy"	Affect	Value	Competence
Change (Post-Pre)	-0.13	-0.17	-0.39	-0.17
Pooled Std. Dev.	1.39	1.84	1.55	1.67
Effect Size	-0.09	-0.09	-0.25	-0.10
T-score (unpaired)	-1.58	-1.57	-4.26	-1.72

In analyzing this data, Schau (2003) concluded:

> *Value* exhibited the largest change; *Value* mean scores decreased by almost twice as much as mean scores on the other three components (0.4 points which is a decrease of about 7% on the scale).

Even though all the changes were negative, some were larger than others. To be statistically significant for a sample size of 287, a t-score must be at least 1.97. In analyzing this data, Schield (2004) concluded:

> After completing a traditional course, student's attitudes were more polarized (increased standard deviations) than before and there was a statistically significant 8 percent decrease in the value they perceived in the subject.

Statistical educators identified several plausible explanations for the negative change in VALUE:

- Students may not recognize the value in studying statistics until much later
- The post test is given close to the final; this is a time when students are highly stressed.

Nevertheless, having a negative change in VALUE is not a desirable outcome.

2.3. SATS Results at Ball State

Pierce (2006) administered the SATS-36 to students at Ball State University. SATS survey data was collected from three introductory statistics courses based, respectively, on college algebra, college calculus and high school AP statistics. According to Pierce,

> For the pretest, students across all the courses were the most positive with regard to the effort component, least positive about the difficulty component, slightly positive about both the cognitive competence and value component, and about equally neutral about the affect and interest components. On the three global attitudes scores students across all courses were slightly positive about their math and statistics cognitive competence, but more neutral about career value.
>
> Considering the average differences on the six components and the three global attitude scores, there was only very slight movement after participating in each course. Three of the components, affect, cognitive competence, and difficulty, showed very minor positive differences; while the remaining three, value, in-

terest, and effort, showed minor negative average change. For the three global attitude scores, math cognitive competence showed no difference but career value and statistics cognitive competence both showed minor negative differences.

In subsequent correspondence, Dr. Pierce provided paired information on the change in VALUE shown in the first three rows and first four columns of Table 4:

Table 4: Analysis of Pierce's Paired Results for VALUE

Statistics Course	Mean Difference	St. Dev. (paired)	Number Students		t-value (paired)	t* (5% cutoff)	Effect Size
Algebra-based	-0.55	1.10	40		-3.20	2.02	-0.50
Calculus-based	-0.13	0.84	40		-0.98	2.02	-0.15
AP high school	0.06	0.54	9		0.33	2.26	0.11
Weighted Ave.	-0.30	0.94	89		-2.99	1.99	-0.32

The analysis of Pierce's data is shown in the bottom row and in the right three columns. Note that the overall decrease and the algebra-based decrease are statistically significant. The effect sizes (mean difference over pooled standard deviation) were -0.5, -0.15, +0.11 and -0.32 for the three different groups.

When asked what the negative change in Values was associated with, Dr. Pierce replied,

> I did not find the negative change to be strongly associated with any specific criteria for which I had data. All correlations were much less than .5. However, the correlation with average difference in interest scores was 0.5.

3. Student Attitudes at Augsburg

SATS-26 surveys were conducted in 2003-4 at Augsburg College, a small comprehensive college in Minneapolis.

It is interesting to know what students expect in a statistics course. In the pre survey, students were asked about their GPA and what grade they expected in their statistics course. Figure 1 shows the results:

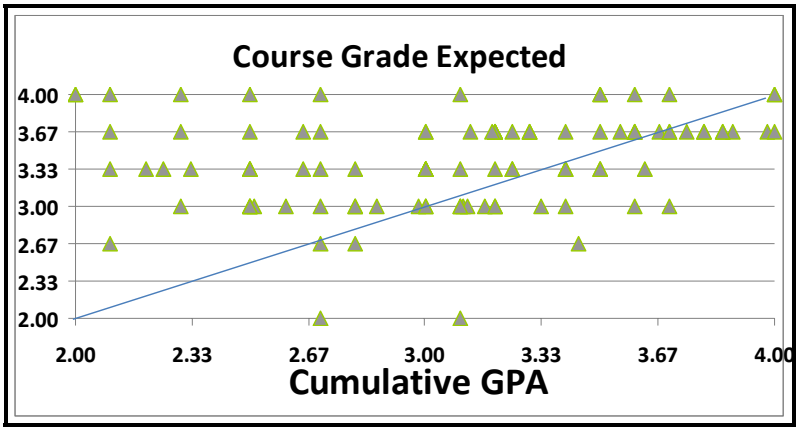

Figure 1. Grade expected versus student GPA

The diagonal line is not a least-squares regression 'best fit.' This line is where a student's expected or predicted grade is the same as that student's GPA.

Most Augsburg students expect a better grade in this course than seems warranted by their cumulative GPA. Many of these students may be disappointed with their actual grade.

This result provides another explanation for the negative change in VALUE noted by Schau and Pierce. If students expect too much of a course, they are more likely to be disappointed with the outcome. If this over-optimism is used to explain the lack of a positive increase in VALUE for statistics, then we might predict a decrease in perceived VALUE for other quantitative courses such as Math for Liberal Arts or Accounting/Finance. If we don't find such a decrease in these other courses, then using over-optimism to explain the decrease in VALUE for statistics may not be warranted.

3.1. Augsburg Pre and Post Data (Unpaired) Summaries

The pretest was taken by 112 students and the posttest by 71 but only 62 took both. Those 62 are the basis for the data presented here. Of these 62, 14 students were taking formal/traditional statistical inference [BUS 379] while 58 students were taking a news-based Statistical Literacy course [GST 200]: a course designed specifically for students in non-quantitative majors.

Table 5 presents the SATS pre-scores obtained by Schau and Schield. Standard deviations are in parenthesis.

Table 5: Pre scores: Schau and Schield

SATS	"Doable" Easy	Affect (I like)	Thinking (I can do it)	Value (Useful)
Schau	3.62	4.12	5.01	4.96
	(0.78)	(1.13)	(1.09)	(0.97)
Schield (Augsburg)	3.72	3.95	4.61	5.14
	(1.16)	(1.0)	(1.21)	(1.25)

For DIFFICULTY (Doability), Schau's students thought it would more difficult than did the Augsburg students. But most Augsburg students knew they were taking a General Studies course, GST200, called "Quantitative Reasoning (Statistical Literacy)" whereas all of Schau's students knew they were taking a traditional statistics class. Thus, the Augsburg students may have felt their course should be easier than a regular statistics course.

For AFFECT, Augsburg students had a slightly negative attitude whereas Schau's students were slightly positive. This difference might be due to the fact that most of the Augsburg students were in non-quantitative majors.

For COGNITIVE COMPETENCE (thinking), both groups of students were positive, but the Augsburg students were less positive than Schau's students. Again, this may reflect a higher percentage of non-quantitative majors.

For VALUE, both groups of students were positive, but Augsburg students were slightly more positive than Schau's.

Notice that Augsburg students ranked VALUE above COGNITIVE COMPETENCE whereas Schau's students ranked them in the opposite order. This may reflect a higher math readiness by Schau's students.

Table 6 presents the pre and post SATS results for Augsburg students for each scale. Standard deviations of pre and post student means (unpaired) are in parenthesis.

Table 6: Augsburg Pre and Post Results (unpaired)

SATS	"Doable" Easy	Affect (I like)	Thinking (I can do it)	Value (Useful)
Pre-course	3.72	3.95	4.61	5.14
	(0.50)	(0.96)	(0.98)	(0.77)
Post-course	3.50	3.98	4.96	5.16
	(0.77)	(1.33)	(1.08)	(1.19)
Change	-0.22	0.03	0.35	0.02
% change	-5.9%	0.8%	7.6%	0.4%
Pooled SD	(0.65)	(1.16)	(1.03)	(1.00)
Effect Size	-0.34	0.03	0.34	0.02
T-score	-2.67	0.20	2.67	0.16

First compare the pre and post means using the unpaired standard deviations. Augsburg students had

- statistically significant increases in DIFFICULTY and in their COGNITVE COMPETENCE
- a very slight (statistically insignificant) increase in AFFECT and VALUE

Now compare the pre and post standard deviations (unpaired):

- variation increased slightly for COGNITIVE COMPETENCE and AFFECT
- variation increased considerably for VALUE and DIFFICULTY.

3.2. Augsburg Pre and Post Data: Plots by Individual

To see what is happening at the individual level, consider these four pre-versus-post plots: one for each scale.

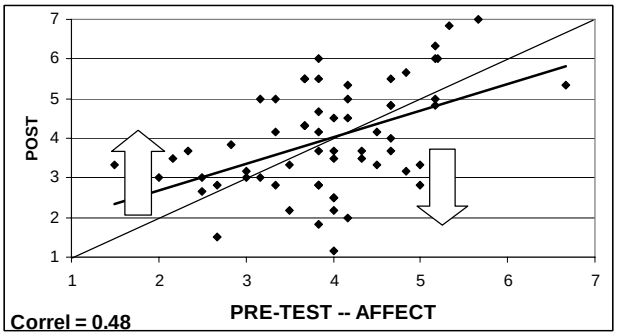

Figure 2. AFFECT Scores: Pre versus Post

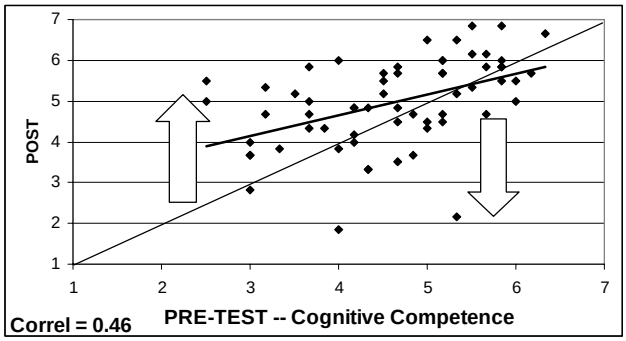

Figure 3. Cognitive Competence: Pre versus Post

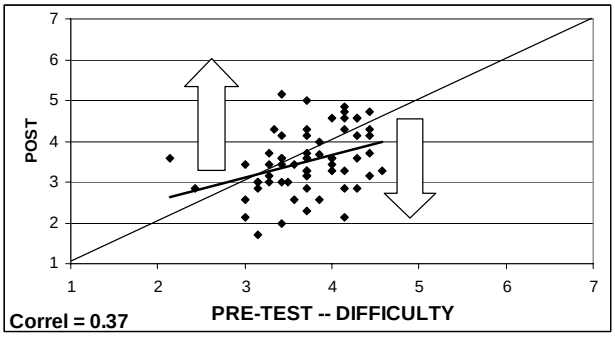

Figure 4. DIFFICULTY Scores: Pre versus Post

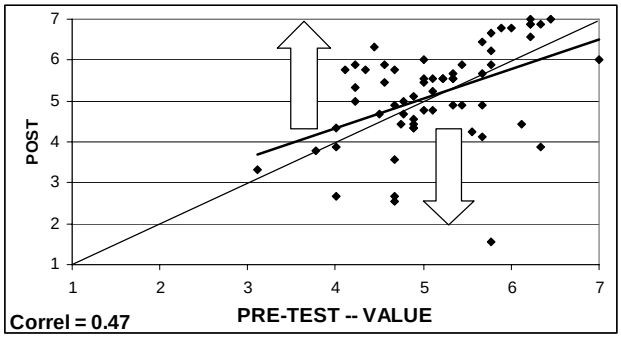

Figure 5. VALUE Scores: Pre versus Post

In each plot, the long diagonal line is not a best fit regression line. It is the line where pre and post scores are equal. The short diagonal line is the best-fit regression line.

First notice the outliers: they are most pronounced for AFFECT and VALUE; least obvious for DIFFICULTY and COGNITIVE COMPETENCE. Consider those scoring below three (very negative) on the VALUE scale. There were none on the pre-test; four on the post-test. Had these four students been excluded, the post-test score for VALUE would have been a 5.36 with a statistically significant improvement of 0.24 (%) and an effect size of 0.2.

Looking at Figure 5 it appears that more students had a greater VALUE post than pre – there are more dots above the diagonal equal-value line than below. But this appearance may not reflect the underlying reality. Although the diamonds indicate individual students, there may be more than one student associated with a particular diamond. Using the individual data, we find that VALUE was higher for post than pre for 61% of these students; 61% saw increased VALUE. However if we compare this 61% observed with a 50% expected due just to chance, we find that this difference is not statistically significant for this small sample size (n=62).

3.3. Augsburg Pre and Post Data (Paired) Summary

Now compare the paired results for Augsburg students with those obtained by Pierce.

Table 7: Comparison of Paired Results

Statistics Course	Mean Difference	St. Dev. (paired)	Number Students		t-value (paired)	t* (5% cutoff)	Effect Size
Augsburg DIFFICULT	-0.22	0.75	62		-2.31	2.00	-0.29
Augsburg AFFECT	0.03	1.21	62		0.20	2.00	0.02
Augsburg THINK	0.35	1.08	62		2.55	2.00	0.32
Augsburg VALUE	0.02	1.07	62		0.15	2.00	0.02
Pierce VALUE	-0.30	0.94	89		-2.99	1.99	-0.32

Generally the paired standard deviations are smaller than unpaired for the same data. But this is not necessarily the case. The paired standard deviations are larger than the unpaired for all four scales: Difficulty (0.75 vs. 0.65), Affect (1.21 vs. 1.16), Cognitive competence (1.08 vs. 1.03) and Value (1.07 vs. 1.00).

Given the outliers noted in the post-test for Value, one wonders why the post-test value wasn't much larger than the pre-test. Presumably the appearance of outliers was offset by the expected decrease from using paired data.

Using paired data, two changes were statistically significant: the negative change in Difficulty (it was harder than anticipated) and the positive change in Cognitive Competence.

This combination is promising. Had the increase in Cognitive Competence been accompanied by a increase in difficulty (an increase in Easiness), one might wonder if the two were connected. But when students feel a stronger sense of Cognitive Competence despite finding the course more difficult than expected, then it may be that students have actually learned something useful.

Table 8 illustrates an unexpected result in perceptions that appeared when the pre and post scores were compared.

Table 8: Who do you think has better skills in statistics?

Survey	Gender	Men worse	Equal	Men better
PRE	Men	5%	66%	29%
	Women	4%	66%	31%
POST	Men	0%	80%	20%
	Women	0%	69%	31%

Note the 14 point increase in "equal" among men offsetting the 9 point decrease in "men better" and the 5 point decrease in "men worse,"

4. Analysis

The following points arose during this exercise.

1. What did the students understand when asked questions about their attitudes toward "statistics"? In the pre-survey, few if any of the students had studied statistics before. Did they have any idea of what it was going to involve? Did they hope they might study sports scores or financial forecasts? Did they think they might improve their results in gambling or in playing cards? Second, when they thought of "statistics" were they thinking of the course they were taking or of the numbers they had encountered in everyday life? Statistics – like economics – is very different if you have never encountered it before. One wonders if students were even thinking of the same construct in the post survey as in the pre-survey.
2. In the post-course survey, students in non-quantitative majors (English, history, music, art, etc.) may see more personal value in everyday statistics; less professional value in a regular STATISTICS course. Students in highly quantitative majors (Math, Economics, Finance, Accounting, etc.) may see the reverse: more professional value in a STATISTICS course; less personal value in studying everyday statistics. Majors in management, marketing, psychology, sociology, journalism and political scientists may be in between.

5. Conclusion

Augsburg students had slightly different results on the SATS survey than did those surveyed by Schau or Pierce.

- Augsburg students did not have a negative change in attitude involving VALUE
- Augsburg students had a statistically significant increase in their feeling of cognitive competence.
- Over 60% of the Augsburg students saw more value in statistics after the course than before
- Some saw much less value after than before so the net increase in VALUE was not statistically significant.

While the lack of increase in VALUE is a negative, the lack of decrease is a positive. The most positive results are the statistically-significant increase in student's feeling of Cognitive Competence along with a statistically significant increase in the difficulty of the course.

This data gives some support for claiming that the Augsburg Statistical Literacy course is indeed helping students to improve their attitude toward their cognitive competence in dealing with quantitative data.

6. Recommendations

This data was obtained in 2003-4. New data should be obtained for a larger numbers of students. Students should be asked about their major (whether their major requires a quantitative course), their attitude toward mathematics and how likely they would be to take the course as an elective. Students taking traditional statistics should be separated from those taking statistical literacy. Thought needs to be given on what to do with outliers on the Post survey that were not present on the Pre survey. Finally, the results of the SATS survey might be compared with those obtained on the Dartmouth survey. See Haines and Jordan (2006).

Those reporting SATS scores should report the pre and post with unpaired standard deviations, the paired difference with paired standard deviations, and the detail scatter plots with correlations for each of the four scales. Differences in changes may be explained by differences in pre-test values. In this way we can better understand how different groups of students relate to different summary results.

Acknowledgments

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