The Effect of Conceptualization and Content Perception on Affect and Difficulty Subscales of the Survey of Attitudes Toward Statistics

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Abstract
In this mixed-methods study, we look at the relationship between students' perception and attitudes toward statistics. Perception is quantified into Content and Concept while the Survey of Attitudes Toward Statistics (SATS) is used to quantify attitudes. We will explore the relationship between Content knowledge and Difficulty SATS subscale as well Concept knowledge and Affect SATS subscale.

Key Words: Students' perception, attitudes, SATS©, statistics education

1. Introduction

The purpose of this study is to examine the relationship between students' perception and attitudes toward statistics. Existing research in statistics education has focused on students' learning and conceptual understanding of statistics, but there is very little research on students' perception of statistics. We use the term perception as a way of describing the overlap between cognitive (understanding and/or defining statistics) and non-cognitive (attitude or motivation) factors. The cognitive factors were measured using a Perception survey, which looks at the following components: students' content knowledge of statistics and students' conceptualization of statistics. The non-cognitive factors were measured using the Survey of Attitudes Toward Statistics (SATS-36; Copyright © C. Schau, 1996, 2003). Both surveys were administered at the beginning of the semester (Pre-course) and at the end of the semester (Post-course).

This study was designed with the following research hypothesis:
1. For pre-course data, there is a relationship between content knowledge and difficulty. Students who have less content knowledge about statistics will have a significantly lower mean difficulty score.
2. For pre-course data, there is a relationship between conceptualization and affect. Students who have higher concept knowledge about statistics will have a significantly higher mean affect score.

Findings from this study add to our understanding of students' perceptions of statistics at the beginning and toward the end of the semester. The present study is one of the only few studies to date that examines student perceptions of statistics.

2. Literature Review

Very few studies have examined students' perceptions and definitions of statistics. Reid and Petocz (2002) interviewed 20 statistics students to understand how the students defined statistics. They found that students' definition can be categorized into one of the following three major themes or six levels:

By focusing on techniques: (Gathering – Extrinsic Techinical)
(1) Statistics is individual numerical activities
(2) Statistics is using individual statistical techniques
(3) Statistics a collection of statistical techniques

By focusing on data: (Applying – Extrinsic Meaning)
(4) Statistics is the analysis and interpretation of data
(5) Statistics is a way of understanding real-life using different statistical models.

By focusing on meaning: (Creating – Intrinsic Meaning)
(6) Statistics is an inclusive tool used to make sense of the world and develop personal meanings.

In a similar study, Gordon (2004) developed five categories or themes from her study of students' definition of statistics. These were: (1) no meaning; (2) process or algorithms; (3) mastery of statistical concepts and methods; (4) tool for getting results in real life; and (5) critical thinking. However, both studies only focused on the cognitive components, and did not examine students' attitudes.

Evans (2007) developed a survey instrument called *Student Attitudes and Conceptions in Statistics* (STACS), in order to examine the relationship between students' attitudes and conceptual understanding of statistics. Evans found a significant correlation between positive attitudes and accurate conceptions of statistics. However, this study had limitations because it failed to capture the multidimensional nature of attitudes and conceptions.

Bond, Perkins and Ramirez (2012) conducted a mixed-methods study to explore the relationships between students' attitudes, conceptualizations and content knowledge of statistics. They collected written responses on students' perception of statistics, and used the categories developed by Reid and Petocz (2002) in examining the students' conceptualizations of statistics. Students' content knowledge of statistics were also examined and they categorized these into six major themes: (1) no understanding; (2) probability only; (3) descriptive statistics only (e.g., mean, median, mode); (4) descriptive statistics with emphasis in variability; (5) descriptive statistics and probability; and (6) inferential statistics. They also used the *Survey of Attitudes Toward Statistics* (SATS) because of its validated psychometric properties on the six attitude components: affect; cognitive competence; value; difficulty; interest; and effort. Results of this study showed no significant difference in the mean SATS pre-scores among groups in the content categories, as well as in the conceptualization levels. Similar results were obtained for the SATS post-scores. However, they found a significant correlation between pre-content and pre-concept, suggesting that students' content knowledge of statistics was related to how they conceptualized statistics at the beginning of the course.

Furthermore, Bond and her colleagues have developed a framework or model that is designed to explain students' perception of statistics, in particular, the relationship between student beliefs (consisting of their content knowledge and conceptual understanding) and their attitudes. They posit that students' beliefs impact students' attitudes, however, they acknowledged that further research should be done to examine the relationship.

3. Methodology

This project used a mixed methods approach. Qualitative data were used to allow the participants to give their own ideas. Quantitative data gathered on the SATS-36 provided more standardized information that could be easily compared with other studies. The specific mixed methods approach used was a concurrent, embedded approach (Creswell, 2009) in which the quantitative and qualitative data were collected at the same time and the quantitative data took precedence over the qualitative data. The priority of the quantitative data was seen in two aspects of the study. First, the qualitative data were coded into numerical codes and then treated as quantitative data. Second, the research questions are centered on quantitative data and could not have been answered using qualitative data alone.

3.1. INSTRUMENTS

Survey of Attitudes Toward Statistics (SATS-36) The 36 items on the most recent version of the Survey of Attitudes Toward Statistics measure six subscales that collectively report student attitudes toward statistics (Shau, 2003). The survey was designed for use by undergraduate students in post-secondary education. The subscales measure the following:

1. *Affect* This subscale, which is comprised of 6 items, measures participants' feelings toward statistics and addresses both positive and negative feelings.
2. *Cognitive Competence* Six items make up the cognitive competence subscale, which assesses participants' attitudes about whether they think they can understand statistics.
3. *Value* The focus of this subscale is the usefulness and importance of statistics and it has 6 items.
4. *Difficulty* This scale measures how easy the participant perceives statistics to be and is measured by 7 items.
5. *Interest* The 4 items on this subscale assess how interested the student is in the subject of statistics.
6. *Effort* Participants' expectations of the work required to learn statistics is assessed by the 4 items on this subscale.

Both pre-test and post-test versions of the SATS-36 are protected by copyright. More information about the SATS-36, the instruments, and the instructions for scoring can be accessed at this site: http://www.evaluationandstatistics.com.

Perception of Statistics The online survey titled *Perception of Statistics* uses short-answer questions to ask undergraduate students about their understanding of the term "statistics." Like the SATS-36, the Perception of Statistics instrument has both pre- and post-test versions, which are intended to be administered prior to and after the participant takes an undergraduate statistics course. The survey link is typically provided to the student at the time of solicitation and takes approximately 5-12 minutes to complete. The pre-course version of *Perception of Statistics* asks about a participants' previous statistics instruction and includes four additional questions which inquire about the participants' understanding of statistics. The post-course version of *Perception of Statistics* includes six open-ended questions; four of these questions are repeated from the pre-course version and two additional questions as about the participants' expectation of the course. The survey content and development was described in Bond, Perkins, & Ramirez (2012).

3.2. SAMPLE

Data were solicited from two classes with the same instructor at a private university in Fall of 2012. There were 80 students in the data set. Seventy-eight students took the Pre-surveys only while 65 students took the Post-surveys. There were 63 students who took both the Pre- and Post-surveys. At the beginning of the semester, 83 students were registered and could have taken the surveys, so we have a 94% response rate. In the two sections, 10 students total withdrew from the courses and were therefore unavailable for the second data collection. Therefore, 73 students could have taken the Post-surveys, and we have an 89% response rate.

Several of the students had taken statistics courses previously, as described in Table 1.

Table 1: Previous statistics courses

Category	Count	Percentage (n = 78)	Course (if given)
No statistics courses in either High School or College	51	65%	N/A
Statistics course – High School Only	22	28%	AP Statistics (10); Introduction to Statistics (6); Math Studies (1)
Statistics course – College Only	4	5%	Retaking this course (2)
Statistics course – High School and College	1	1%	IB Statistics SL (1)

3.3. SOLICITATION AND DATA COLLECTION

The research project was approved by the university's IRB prior to data collection. During the first two weeks of the statistics courses, the instructor informed the students about the research project and offered a minimal amount of extra credit for students who participated by providing information. The survey link was provided in class and was also posted on the course management site. The instructor also sent an email announcement with the survey link through the course management system. The same procedure was followed during the final two weeks of the course, during which the students were asked to participate in the post-course data collection. The final solicitation in class was given during the lecture before the final exam. Because of the timing of the course, students did not know their final course grade when the participated in the post-course survey. Students were not penalized for choosing not to participate.

3.4. ANALYSIS

Qualitative The qualitative data analysis followed the procedure detailed in Bond, Perkins, & Ramirez, 2012. Please refer to this article for specific explanations. The researchers used a "tight data analysis" approach (Miles & Huberman, 1994) in all qualitative the data analysis. In a "tight" approach, the coding scheme is decided prior to analyzing the data. This allows researchers to clearly build on previous research and also enables researchers to collect information about participants' views in participants' own words without necessarily needing to collect the breadth and depth of information needed to study a phenomenon.

The qualitative data were analyzed from two perspectives. The first perspective considered participants' understanding of the content of the term "statistics;" that is, how accurate was the participant's definition? The researchers used a coding scheme which used the following ranking:

0 = no understanding,
1 = probability only or sports statistics,
2 = descriptive statistics only,
3 = descriptive statistics with the concept of variability added,
4 = descriptive statistics with the concept of probability added, and
5 = inferential statistics and/or hypothesis testing (Bond, Perkins, Ramirez, 2012).

The second perspective of data analysis looked for the participants' conceptualization of statistics; that is, how well do students grasp the usefulness of statistics for everyday life? For this coding scheme, the researchers used the codes developed by Reid and Petocz (2002) as they are presented in the literature review of this article.

Two of the researchers independently coded the qualitative data, then the three researchers discussed any initial disagreement in the coding. This allowed the two researchers, who work in different disciplines, to explain their reasoning for the codes. Most of the time, the two researchers noted explanations and agreed that one code was the best fit for the data. When an agreement was not clearly met, the third researcher considered the data and decided on the final code for that participant. The rate of agreement for the content codes was 93.6% and the rate of agreement for the conceptualization codes was 95.4%.

Quantitative The quantitative data analysis centered on two groups of data. First, the SATS-36 data were collected quantitatively, which allowed for immediate quantitative analysis. Second, the data from the *Perception of Statistics* survey were collected as qualitative data, but then were coded and converted to quantitative data using the procedures outlined above. This data transformation resulted in two variables: 1. Content, and 2. Conceptualization. Both of these variables were treated as ordinal data because the range was quite limited and because the assumptions of scale data were not met, specifically, there was no absolute zero point and intervals between numbers could not be assumed to be equal.

Participants' responses on the SATS items were reverse coded when appropriate and averaged to create subscale scores. Subscale scores were then used in quantitative analyses. One-way ANOVA's were used to examine the two research hypotheses at $\alpha = 0.05$. Descriptive statistics, graphs, and Chi-square goodness-of-fit test at $\alpha = 0.05$ were used to examine Concept and Content variables. We used ANOVA to examine whether there were significant differences in means of SATS scores across groups of participants with different Pre-Content scores and then with different Pre-Concept scores. These ANOVA involve 10 tests (we already tested 1 SATS subscale each), so to ensure an overall significance level of at most 0.05, we use a Bonferroni correction and require a significance level of $\alpha = 0.05/10 = 0.005$ for each individual test.

4. Results

4.1. RELATIONSHIP BETWEEN CONTENT AND DIFFICULTY AND BETWEEN CONCEPT AND AFFECT

Bond, Perkins, and Ramirez (2012) suggested that there could be a relationship between Pre-Content knowledge and Difficulty with students having a low content knowledge believing that the course would be more difficult than those with a high content knowledge. Additionally, Bond, Perkins, and Ramirez hypothesized that students with high Concept scores would also have high Affect scores. However, for the Pre-surveys, we did not find a significant relationship between Difficulty and Content ($F(5,68) = 1.57$, $P = 0.180$). Likewise, there was not a significant relationship between Affect and Concept ($F(5,69) = 1.09$, $P = 0.375$).

4.2. STUDENT CONTENT AND CONCEPTUALIZATIONS OF STATISTICS

Table 2 and Figures 1 and 2 contain the descriptive results of the variables Content and Concept. It is obvious that there is a difference in the Content distribution from Pre- to Post. Students move from a lower level of content knowledge to a higher level of content knowledge as the course progressed. This is similar to the results of Bond, Perkins, and Ramirez (2012); however, when looking at Concept, there does not appear to be a change in the distribution from Pre- to Post. This differs from the Bond, Perkins, and Ramirez data. We performed a Chi-square Goodness-of-Fit test using the Pre-Concept percentages as the hypothesized percentages. There was not a significant difference in the distributions between the Pre-Concept and Post-Concept ($X^2 = 7.03$, $P = 0.218$).

Table 2: Report of participants content knowledge and conceptualizations of statistics

Content Knowledge (Identify topics about statistics)	Pre (n = 78)		Post (n = 65)	
	Count	Percentage	Count	Percentage
No understanding	6	8%	0	0%
Probability only; sports statistics	12	15%	0	0%
Descriptive statistics only (mean, median, mode, etc)	29	37%	4	6%
Descriptive statistics with emphasis in variability	1	1%	3	5%
Descriptive statistics and probability	15	19%	13	20%
Inferential statistics	15	19%	45	69%
Conceptualizations (Statistics is about . . .)	**Pre (n = 78)**		**Post (n = 64)**	
	Count	Percentage	Count	Percentage
TECHNIQUES				
Equations	3	4%	1	2%
Using individual techniques	10	13%	7	11%
Using a collection of techniques	13	17%	11	17%
USEFULNESS				
Analysis and interpretation of data	28	36%	32	50%
Understanding real-life using different statistical models	19	24%	11	17%
MEANINGFULNESS				
Making sense of the world and developing personal meanings	5	6%	2	3%

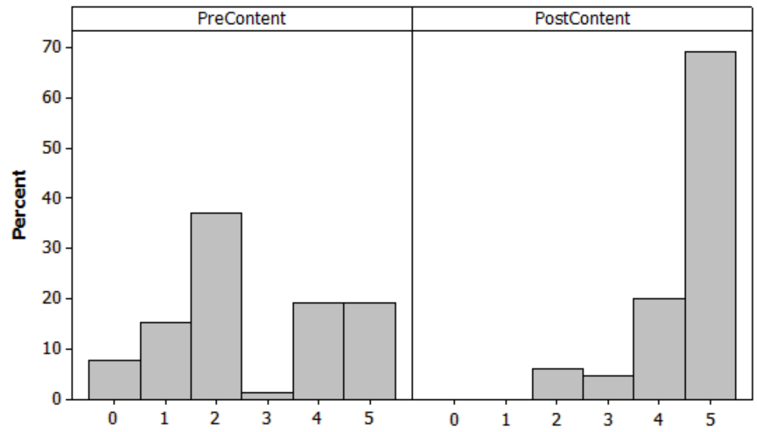

Figure 1:.Histogram of Content (Pre and Post)

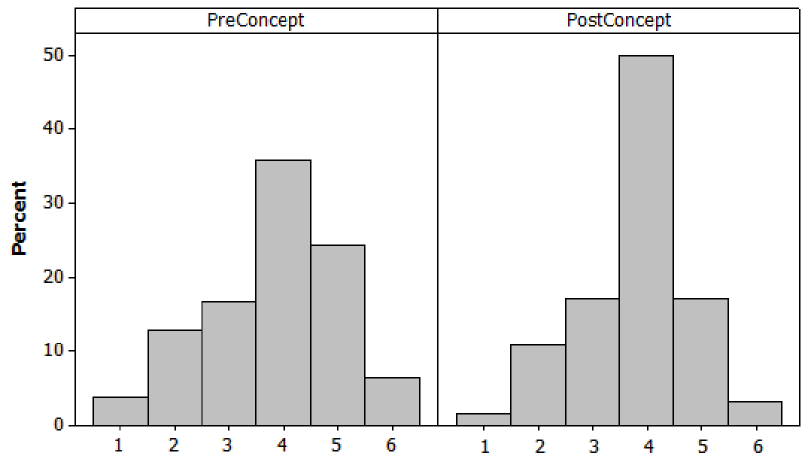

Figure 2: Histogram of Concept (Pre and Post)

4.3. RELATIONSHIPS BETWEEN SATS, CONTENT, AND CONCEPTS

Table 3 contains the Cronbach's alpha values for each of the six SATS-36 attitude components. The alpha values are in the acceptable range, with a minimum of 0.66 for the Pre-SATS and a minimum of 0.82 from the Post-SATS. Difficulty may have a lower internal consistency on the pre-test due to the lack of variability in the responses (Bond, Perkins, & Ramirez, 2012).

Table 3: Cronbach's alpha values for the SATS-36 attitude components

	Pre-SATS		Post-SATS	
Component (Number of items)	Cronbach's α	n	Cronbach's α	n
Affect (6)	0.73	75	0.83	63
Cognitive Competence (6)	0.80	75	0.84	63
Value (9)	0.90	76	0.82	63
Difficulty (7)	0.66	74	0.83	61
Interest (4)	0.86	75	0.85	60
Effort (4)	0.86	78	0.84	63

Table 4: SATS Subscales

	Affect	Cognitive Competence	Value	Difficulty	Interest	Effort
Pre-Scores						
Mean	4.26	4.95	4.90	3.74	4.70	6.37
SD	1.06	0.99	1.11	0.75	1.16	1.09
n	75	75	76	74	75	78
Post-Scores						
Mean	3.96	4.62	4.41	3.75	3.69	5.94
SD	1.31	1.25	0.96	1.05	1.34	1.13
n	63	63	63	61	60	63
Mean Change	0.30	0.33	0.49	-0.01	1.01	0.43

Table 4 shows the Pre- and Post-subscores for the SATS-36 attitude components. The SATS scores represent averages from a 7 – point Likert scale, with mean scores around 4 as neutral. With the exception of the Difficulty subscale, all five subscores have mean values above 4 on the Pre-SATS. The Difficulty subscale can be thought of as perceived easiness, and thus, lower values should be interpreted as "statistics is a difficult subject" whereas higher values mean "statistics is easy." There was a drop in almost all of the subscales with Interest having the largest drop of 1.01 units.

Using $\alpha = 0.005$ (for an overall $\alpha = 05$), none of the SATS subscales were significant when compared to the Pre-Content groupings and to the Pre-Concept groupings. This is consistent with the results of Bond, Perkins and Ramirez (2012).

5. Discussion

Through the research hypotheses as well as an overall check of all SATS subscales, we saw no significant difference in any of the SATS subscale mean scores across the Pre-Content categories and the pre-Concept categories. This is consistent with the results from Bond, Perkins, and Ramirez. These two research projects support the theory that students' perception of statistics does not influence the SATS-36 subscales. Therefore, any drop in attitude is not due to student's Pre-perception of statistics.

The class had a project-based assignment where the students developed their own data collection instrument, gathered data, analyzed data, and interpreted the data. We wonder if the lack of improvement on the conceptualization scores may be due to the participants' focus on project work in class. It may have been a situation of "not seeing the forest for the trees" in that the tasks involved in creating their own survey and collecting, analyzing, and interpreting the data may have moved participants' understanding of statistics from a big-picture, conceptual understanding of statistics to the details involved in crunching data.

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