# HOW DO ATTITUDES CHANGE FROM ONE STATS COURSE TO THE NEXT?

Anne Michele Millar[1] and Bethany J. G. White[2]
[1]Mount Saint Vincent University, Halifax, Nova Scotia, Canada
[2]The University of Western Ontario, London, Ontario, Canada
Michele.Millar@msvu.ca

*Are attitudes sustained across the term break? We usually measure attitudes at the beginning and end of a course. However, at the end of the course students are suffering from end of term stress and exam anxiety, and these may be reflected in their attitude scores. We would hope that positive attitudes are sustained, while negative attitudes improve during the break. Sustaining positive attitudes leads to sustained student engagement. We consider data for two introductory statistics courses taught over two semesters at a mid-size primarily undergraduate university.*

## INTRODUCTION

Statistics and quantitative research methods are essential in many disciplines but students often enter required statistics courses with some level of apprehension. According to Onwuegbuzie and Wilson (2003), uncomfortable levels of statistics anxiety are prevalent among students and this anxiety may be a contributor to the negative reputation of statistics courses. Statistics educators face a considerable challenge when it comes to engaging, inspiring and facilitating learning for their students in light of these impressions. As educators, we hope that what we do in our courses helps improve our students' attitudes toward statistics over the term. Students with positive attitudes towards statistics have a healthier view of statistics as a discipline and may be more likely to engage in behaviors such as pursuing further studies in statistics, using statistics in their future academic and professional activities and consulting statistics experts when necessary (Ramirez, Schau, & Emmioglu, 2012). Therefore, the change in students' attitudes toward statistics is an important outcome to consider when conducting evaluations and research in statistics education.

In order to assess the change in attitudes we need an instrument to measure attitudes. The Survey of Attitudes Toward Statistics-36 (SATS, copyright C. Schau, 1996; 2003), consists of 36 items that assess six attitude components along with items that address a variety of demographic variables. The attitude components include *Affect*, *Cognitive Competence*, *Difficulty*, *Value*, *Interest* and *Effort*. A Likert scale ranging from 1 ("Strongly disagree") to 7 ("Strongly agree") is used for each of the 36 attitude items. Attitude component scores are calculated by averaging the scores of the relevant items, after reversing responses to any negatively-worded items. Complete information about the SATS can be found on the SATS website (Schau, 2005). The survey typically is administered at the beginning and end of the term, and gain scores (post-scores – pre-scores) are calculated for each component.

Results for over 2000 students across the United States have been assessed by Schau and Emmioglu (2013). They found slight mean increases in *Affect*, *Cognitive Competence*, and *Difficulty*, some mean decrease for *Value*, and mean decreases of around 0.5 points for *Interest* and *Effort*, the latter two being large enough to be considered practically significant. Since students typically are anxious and stressed at this point in the term, our study investigates how attitudes change from post-survey over the break between terms, after the students have had some time to recover from end-of-term stressors.

## BRIEF SYNOPSIS OF STUDY

### *Background*

Our data were collected from students at a primarily undergraduate Canadian University. The algebra-based introductory statistics course studied is taught over two semesters - Introduction to Statistics I, and Introduction to Statistics II. Most students take both courses in the same academic year, so we were able to obtain attitude scores in September, December, January and April for 150 students. The surveys were administered in the fall term of 2010 and the winter term of 2011, during the statistics tutorials. All but two students who attended the tutorials completed the surveys. Results for the fall term were similar to those reported by Schau and Emmioglu

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(2012). Our primary interest was in the *Affect* component, as we wanted to assess students' feelings about statistics; we really want them to enjoy their statistics experience. Our secondary interest was in the *Effort* component, as we were concerned about the drop in the mean scores over the first term. The following information is quoted from the SATS Scoring page (Schau, 2003). The *Affect* component is measured as the mean of six items (e.g. "I will enjoy taking a statistics course" and "I am scared by statistics", the latter is reverse scored). The *Effort* component is the mean of the four items (e.g. "I plan to complete all of my statistics assignments" and "I plan to study hard for every statistics test") that assess the "amount of work the student expends to learn statistics".

During the fall term, although individual students' scores varied greatly, the mean *Affect* score was essentially unchanged from pre to post, exhibiting a slight increase, well below 0.5 points (Millar & Schau, 2010). The mean *Effort* score decreased by over 0.5 points. Why the significant drop? There are several possible reasons, apart from any actual decrease in the students' attitudes. First, the mean pre-score was 6.58, with 75% of students scoring 6.5 or higher, and over 25% with 7.0, the highest score possible. In any Likert-type scoring system, higher scores have a greater potential to decrease, while lower scores have a greater potential to decrease. The *Effort* score has the highest mean of any attitude component, and thus, the greatest potential to decrease. Second, some of the items in the post-survey differ from the pre-survey:

- Pre-survey item - "I plan to complete all of my statistics assignments"
- Post-survey item - "I tried to complete all of my statistics assignments"
- Pre-survey item - "I plan to study hard for every statistics test"
- Post-survey item - "I tried to complete all of my statistics assignments"

The post-survey tends to measure how much effort the students think they succeeded in putting into the course; whereas, the pre survey measures how much effort they intend or hope to put into the course. Last, and this applies to all the component scores, when the post-survey was administered at the end of the semester in December, most students reported that they were experiencing a high level of stress (as assessed by one of the additional questions included on the post-survey). Individuals suffering from stress and anxiety will tend to have more negative attitudes towards life in general, not just towards statistics.

At the start of the second term, the students have completed their final exam, received their grades, and had several weeks to recover. Therefore, we expected to find that all attitude component scores would be somewhat more positive, on average, in January than December, and that we would see a marked improvement in *Effort* scores since the students would be describing the effort they intended to put into the course for the new term, rather than assessing the effort they had actually invested during the previous term.

*Results*

Not all students who had completed the post-survey in the first semester continued on to the second course the next semester. The results shown below are based on the 156 students who completed both the December post-survey and the January survey (the pre-survey for the second term). As expected, we found some increase on all components (see Table 1).

Table 1. Gains in Component Scores and Absolute Gains from December to January (n=156)

| | Gain | | Change =\|gain\| | |
|---|---|---|---|---|
| Component | mean | St. dev. | mean | St. dev. |
| Affect | 0.04 | 0.90 | 0.66 | 0.62 |
| Cognitive Competence | 0.11 | 0.68 | 0.51 | 0.46 |
| Value | 0.05 | 0.63 | 0.50 | 0.40 |
| Difficulty | 0.04 | 0.65 | 0.50 | 0.42 |
| Interest | 0.06 | 0.95 | 0.69 | 0.65 |
| Effort | 0.35 | 0.76 | 0.56 | 0.62 |

Although some of the mean gains are negligible, the individual increases and decreases (the magnitudes of the absolute values of gain scores) are relatively large. The mean of the absolute values of the gain scores for *Affect* is 0.66, although the increase in the mean is only 0.04. The

*Effort* component has a mean gain of 0.35, which is statistically significant (t = 5.74, p < 0.0015 using a Bonferroni correction to allow for testing all six components), and is of particular interest when compared to the September scores for this group of students. The mean decrease in *Effort* between September and December was 0.60, giving a mean decrease between September and January of only 0.25. Thus, the decrease in *Effort* from the beginning of Introduction to Statistics I to the beginning of the next term, when the course is truly completed, is well below the 0.5 considered to be of practical significance.

We investigated the *Affect* scores further as well. The mean gain is virtually zero, but again, individual students changed considerably (either positively or negatively). The students with higher scores in December had greater potential to decrease whereas students with low scores had a greater potential to increase. Thus we expected the gain to be related to the December score. A simple linear regression of gain scores versus December scores shows a significant negative relationship: *Affect Gain* = 1.240 - 0.2662 *Affect December* (t = -5.18, p < 0.00025). See Figure 1.

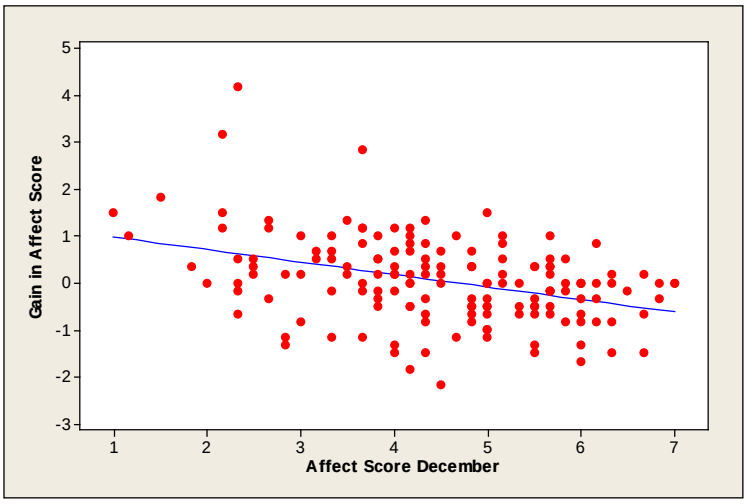


Figure 1. *Affect* Gain scores versus December scores with regression line

However, as in all survey data, we have measurement error. If a student writes the survey twice, the score will vary slightly even without an intervention. Students' attitudes would be best represented by their expected scores, but we are analyzing their observed scores from a single administration of the survey (i.e., their expected scores with additional measurement error). This measurement error results in the phenomenon known as regression-to-the-mean, whereby the observed gains will be negatively related to the December scores even if there were no linear relationship between the true or expected gain for each student and their expected December score. We can compensate for regression to the mean, by adjusting the values of the coefficients (Millar, White & Romo, 2013).

The slope for the regression of the January scores on the December scores is adjusted using the error in variables (EIV) method (Fuller, 1987) by dividing by an estimate (Rxx =0.87) of the test-retest coefficient for *Affect* scores, and the intercept for the gain is the EIV adjusted intercept for the January score. We denote these EIV adjusted coefficients by $\alpha_0$ and $\alpha_1$:

$$\hat{\alpha}_{1gain} = \frac{\hat{\beta}_{1Jan}}{Rxx} - 1 = \frac{0.734}{0.89} - 1 = -0.173$$

$$\hat{\alpha}_{0gain} = mean(Jan) - mean(Dec)\frac{\hat{\beta}_{1Jan}}{Rxx} = 5.536 - 5.491\left(\frac{0.734}{0.89}\right) = 0.823$$

The EIV adjusted line, *Affect Gain* = 0.823 - 0.1731 *Affect December*, is shown in Figure 2.

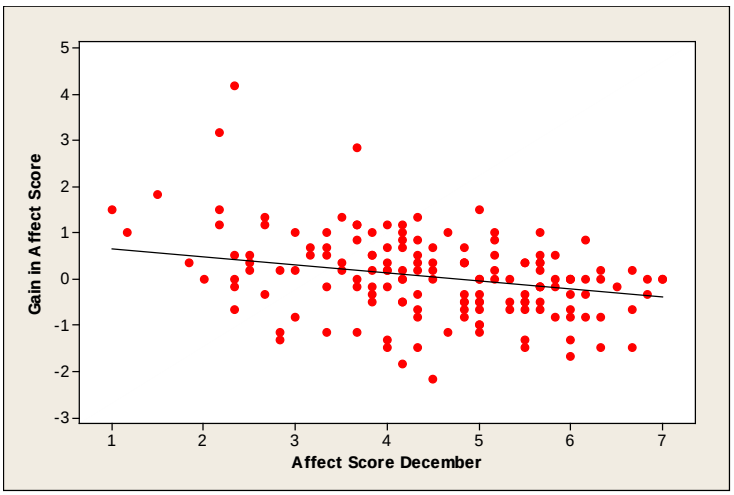


Figure 2. *Affect* gain scores versus December scores with EIV adjusted regression line

The magnitude of the slope is smaller than that of the ordinary least squares regression (OLS) line. The 95% confidence interval of (-0.275,-0.072) shows that the relationship is still significantly negative so it does not appear that the negative estimate of the ordinary least squares slope is entirely due to regression-to-the-mean. We show the fitted values for the gains (the estimated conditional mean given the December score) for a selection of December scores, using both the OLS regression coefficients and the EIV adjusted regression coefficients in Table 2. Using the EIV adjusted scores, we estimate that students with expected low scores (1.5) will increase on average by over 0.5 points (an increase with practical significance), while those with expected high scores (6.5) decrease on average by 0.3 points (i.e., less than the 0.5 required for practical significance). These results also suggest that the January scores for those with low December *Affect* scores tend to increase more, on average, than those with similarly extreme high December *Affect* scores decrease.

Table 2. Fitted values for gains in *Affect* score

| December *Affect* Score | EIV Adjusted Fitted Gain | OLS Regression Fitted Gain |
|---|---|---|
| 1 | 0.65 | 0.97 |
| 1.5 | 0.56 | 0.84 |
| 2 | 0.48 | 0.71 |
| 3 | 0.3 | 0.44 |
| 4 | 0.13 | 0.18 |
| 5 | -0.04 | -0.09 |
| 6 | -0.22 | -0.36 |
| 6.5 | -0.30 | -0.49 |
| 7 | -0.39 | -0.62 |

## CONCLUSION

Even after adjusting for attenuation in the slope parameter due to regression-to-the-mean, we still observed practically significant changes in mean *Affect* scores from post-survey in December to pre-survey in January conditional on low December scores. As there was negligible gain in the overall mean score, this reinforces the importance of taking into consideration the previous score when assessing gains. For the *Effort* component we found a significant gain from December to January, compensating to large extent for the decrease between September and December. There was wide variation in individual student gains, both positive and negative for each of these components, demonstrating the need for continued research in this area. These results suggest that a post-survey administered at the end of the term, but before final exams, may not

reflect the true change in student attitudes towards statistics over the course. The effects of the course, or any interventions on attitudes, may be confounded with student stress and workload because of the timing of the post-survey. This finding highlights the importance of post-survey timing when assessing student attitudes.

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