Examining Introductory Students' Attitudes in a Randomization-Based Curriculum

A Senior Project

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By

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Abstract

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Student attitudes regarding introductory statistics courses are not always the most positive. The purpose of this research is to utilize the Survey of Attitudes Toward Statistics to evaluate introductory statistics students' attitudes pre- and post course. Furthermore, comparisons of attitudes within different introductory course curricula across institutions will be made. Various components within the survey, such as difficulty, value, and interest, will be assessed in order to determine where students' attitudes are affected the most and how they are correlated with other variables such as current GPA and curriculum taught. The outcomes for these models look at demographic predictors that have a significant effect on the difference between Pretest and Posttest attitude component scores.

Acknowledgements

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Introduction

When assessing the effectiveness of curricula there are two main focuses: a student's understanding and a student's attitudes toward the subject. The later tends to take the back seat when evaluating what makes a curriculum successful. However, students' attitudes about courses are recognized as extremely important and play a significant role in course outcomes, and are comparable in significance to the students' understanding of the subject matter (Schau and Emm□oğlu 2012). These attitudes also affect the way students view the usefulness and application of statistics to their lives (Gal, Ginsburg, and Schau, 1997). By examining student attitude it allows for a well--rounded evaluation of the curriculum being used.

Specifically in this study we wanted to compare and contrast the attitudes of students within different introductory statistics course curricula across institutions. The first curriculum evaluated was a more traditional approach, which focuses on individual concepts and less on statistical inference until the end of the course. The second curriculum is a newer approach, often referred to as Randomization-Based curriculum, which focuses on statistical inference throughout the course, integrating technology, and working through the whole "statistics problem" instead of working on each individual concept one at a time. The Randomization-Based curriculum has proposed advantages of improving student understanding of the logic and scope of statistical inference, as well as offering students experience integrating technology for statistical methods that are becoming more commonly used.

Using Schau and Emm□oğlu's national study done in 2012 as a baseline comparison, we reviewed our results to compare similarities. Their study included 101 sections and around 2200 students from institutions across the United States. Their findings exhibited that students' experience an impartial or positive attitude toward statistics at the beginning of the course, and at the end they tended to experience abatement in their positive attitudes toward statistics.

For our smaller study we focused on individual student scores, opposed to section mean scores. The student means are comparable to that of the section medians, with the main difference coming from the score variability which is higher for student scores than section scores (Schau and Emm□oğlu, 2012).

Ideally we would prefer to see a positive change between pretest and posttest scores, but this is not always the case. If we could identify influential factors that helped maximize the increase or at least minimize the decrease in attitude component score differences, then we could compare how well curriculums perform while accounting for other factors. To do this, demographic questions, such as grade point average (GPA), gender, confidence level, and so on are used as predictors for the difference in individual attitude component from pre to post.

Data Collection

To evaluate students' attitudes in their introductory statistics courses the *Survey of Attitudes Toward Statistics (SATS-36)* (Schau, Stevens, Dauphinee, and Del Vecchio, 1995) was implemented. The survey consists of 36 items that are split into six attitude components: Affect, Cognitive Competence, Value, Difficulty, Interest, and Effort. By examining the six individual components the survey allows for a comprehensive assessment of a student's attitude concerning statistics (Schau and Emm□oğlu 2012).

- **Affect (6):** Students' feeling concerning statistics.
  i.e. "I am scared of statistics."
- **Cognitive Competence (6):** Students' attitudes about their intellectual knowledge and skills when applied to statistics.
  i.e. "I will understand statistics equations."
- **Value (9):** Students' attitudes about the usefulness, relevance, and worth of statistics in personal and professional life.
  i.e. "Statistics is irrelevant in my life."
- **Difficulty (7):** Students' attitudes about the difficulty of statistics as a subject.
  i.e. "Statistics is highly technical."
- **Interest (4):** Students' level of individual interest in statistics.
  i.e. "I am interested in using statistics."
- **Effort (4):** Amount of work the student expends to learn statistics.
  i.e. "I plan to attend every statistics class session."

Each attitude component has a certain number of questions categorized to them, indicated by the number next to the component name above. Every question is answered on a Likert scale from 1 to 7. Additionally some questions are negatively worded; therefore for negatively worded questions the scores were inversed so that they would be on the same scale as a positive worded question (i.e. a negative score of 1 would be a positive score of 7 and vice versa). For every attitude component their respective question scores (assuming 7 = most positive) were summed and then divided by the number of questions in that component to find the mean component score, as recommended in the SATS Scoring Guide (www.evaluationandstatistics.com). These means scores were then used for further comparisons between pretest and posttest scores.

The sample was taken across five different universities: Appalachian State University, California Polytechnic State University, Drodt College, Hollins University, and Hope College. The universities also ranged from California (Cal Poly) to Virginia (Hollins), and also some of the universities were public and some were private. The students at Cal Poly were emailed individual five-digit identification number, in order to keep their names confidential, at the beginning of the course, and were asked to take the pre version of the Survey of Attitudes Towards Statistics before the end of the first week of the classes. A student could complete the survey in two ways, by either declining to continue when asked, after some demographic questions, or choosing to continue the survey. The week before finals week students were again emailed asking them to finish the post version of the survey by the beginning of finals week. Students were also advised to respond if they had lost their identification number. Similar processes took place at the other four institutions, with some start and end date differences.

The response rate for those students that took both the pre and post parts of the SATS-36 was 61.67% (354 out of 574 possible). Pre and Post response rates individually were much higher, around 85% (486 out of 574 possible) and 73% (419 out of 574 possible) respectively.

Cronbach's Alpha

Internal consistency is an important part of psychometric testing and to measure it we used Cronbach's alpha. Any alpha above 0.70 was considered acceptable meaning internal consistency is upheld (Carlson, 2011). Expected intervals were given by Schau in the SATS-36 Scoring Guide (see Table 1), but they were not provided for the Interest and Effort components (www.evaluationandstatistics.com). Effort had the lowest alpha in both pretest and posttest.

Table 1: Pretest and Posttest Cronbach's Alphas with Expected Intervals

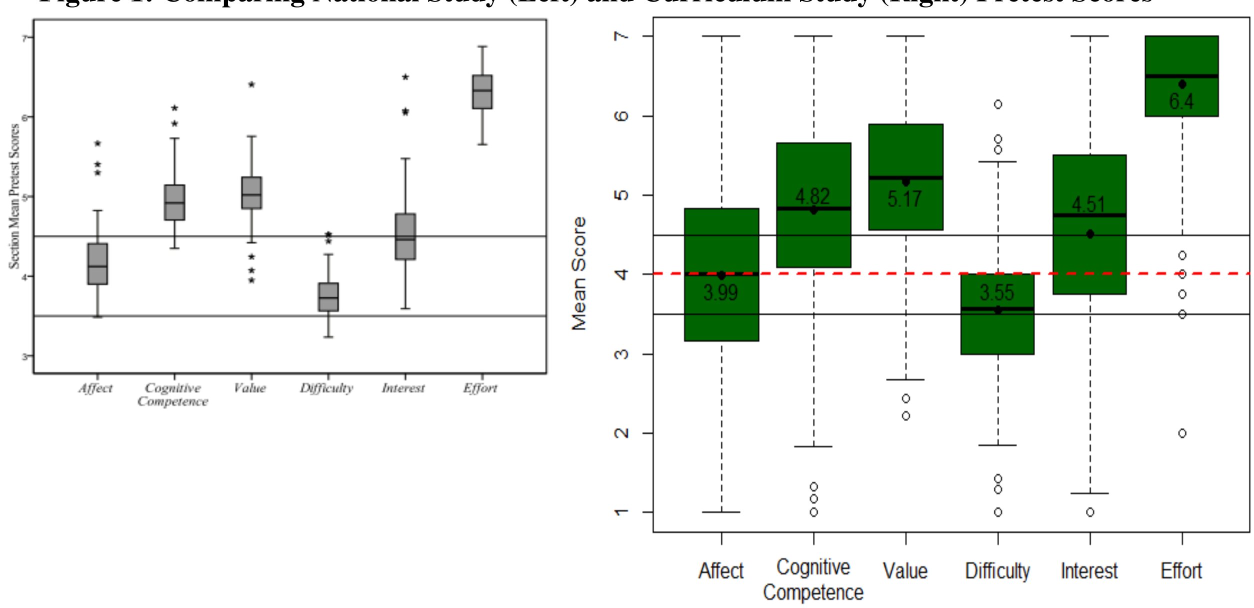
Components	Pretest	Posttest	Expected Interval*
Affect	0.83	0.89	.80 to .89
Cognitive Competence	0.86	0.90	.77 to .88
Value	0.88	0.91	.74 to .90
Difficulty	0.73	0.81	.64 to .81
Interest	0.88	0.93	*
Effort	0.76	0.73	*

Pretest Scores

For our study we used a ½ point difference in student mean scores as a substantial difference because in order for a score to change by a ½ point the student must answer at least two questions with higher or lower scores to see an increase or decrease as large as ½ a point (Schau and Emm□oğlu 2012).

Pretest boxplots of individual components, as expected, are comparable to the national study with the exception of the larger spread found in the student mean scores. In our study the only component that started off close to negative (~ ½ point below 4) was the Difficulty component; Cognitive Competence, Value, and Effort all started positive. This implies that students' attitudes expect statistics to be moderately difficult.

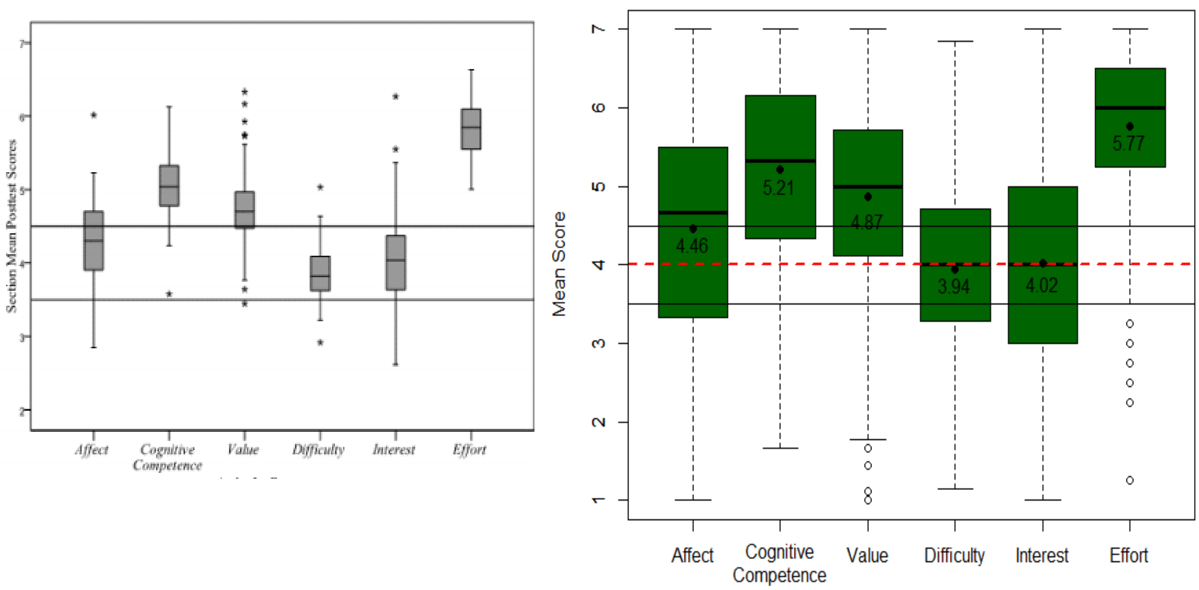
Figure 1: Comparing National Study (Left) and Curriculum Study (Right) Pretest Scores



Posttest Scores

Similarly with the Pretest scores, the student medians are very close to the national study's section medians, and again as expected the variability in students' mean scores is much larger. There are definite changes from the Pretest scores; Affect, Cognitive Competence, Value, and Effort are all positive median scores, whereas the medians for Difficulty and Interest are almost perfectly neutral. With the Effort component having the highest median this can be interpreted as students put a good amount of work into their statistics course outside of class.

Figure 2: Comparing National Study (Left) and Curriculum Study (Right) Posttest Scores



Pretest and Posttest Comparisons

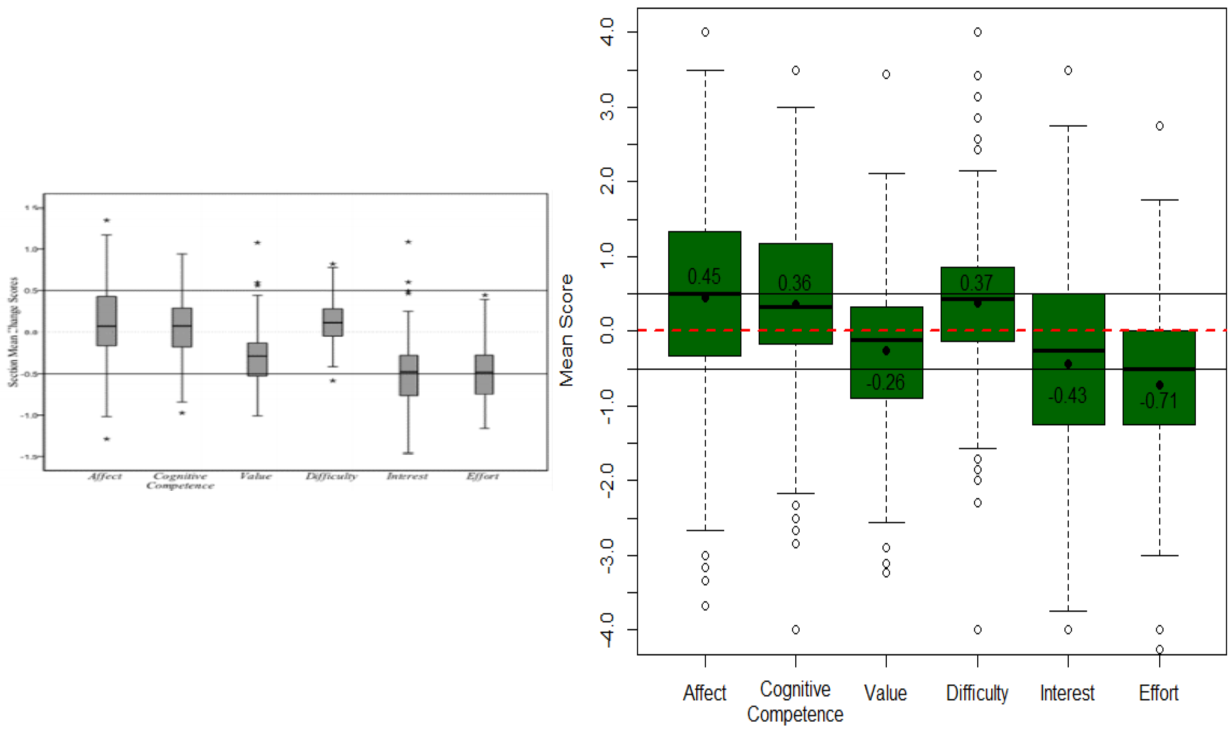
When comparing Pretest and Posttest scores for our study, it is recommended by Schau that only those students that completed both Pretest and Posttest be compared with each other. Changes from Pretest to Posttest varied by component, as we would expect. Our positive changes were larger than the national study, and our negative changes were smaller than those of the national study. Table 2 gives the means and standard deviations of the differences from Pretest to Posttest for each attitude component.

Table 2: Means and Standard Dev. for Pretest and Posttest Differences (Curriculum & Nat. Study)

Component	Mean	SD	Mean(National)	SD(National)
Affect	0.45	1.33	0.13	1.23
Cognitive Comp.	0.36	1.12	0.10	1.06
Value	-0.26	1.01	-0.32	0.96
Difficulty	0.37	0.95	0.15	0.84
Interest	-0.43	1.31	-0.50	1.25
Effort	-0.71	1.00	-0.48	1.14

Figure 3 shows that the changes between Pretest and Posttest are again similar between the two studies, except for the larger variability in our study coming from student-based means. The Effort component was the only one with a substantial difference between Pretest and Posttest (median = -0.71). A decrease on this scale seems understandable because students' scores on the Pretest for Effort are predicting how much effort they will put into the course, whereas the Posttest scores are a reflection that should be more realistic (lower). The other attitude components did not have a substantial difference (at least ½ point difference), which was expected from the national study results.

Figure 3: Comparing National Study (Left) and Curriculum Study (Right) Change Scores



When looking at the change in attitude components it is valuable to understand what the changes mean in context of student attitudes. For an increase or decrease in the Affect component, students' feelings concerning statistics become more positive or negative, respectively. When Cognitive Competence component scores increase students feel more secure in their knowledge and skills in statistics, and vice versa for a decrease. As Value component scores increase students are more positive about the usefulness and relevance of statistics in their daily lives. As Difficulty component scores become more positive, this implies that students find statistics easier. The Difficulty component is the only one that has a somewhat reversed order, where lower scores mean that the student felt statistics was difficult. For an increase in the Interest component students' interest in statistics has increase, and the opposite for a decrease. When Effort component scores decrease, which is more likely to happen, students did less work or studying for statistics as they reported in the pre version of the survey.

Attitude Comparison Models

Multiple linear regression was used to create six models that predict the difference between pretest and posttest attitude components scores. The focus for these models is a teaching style the Randomization-Based curriculum. There were three categories: taught using the traditional curriculum, first or second time using the randomization-based curriculum, and those who had taught the randomization-based curriculum multiple times and are thought to be comfortable with it. There were five total predictors: gender, confidence, study time, current GPA, and teaching style. Confidence was found from a global question asked on the pre version of the Survey of Attitudes Toward Statistics, which says "How confident are you that you can master introductory statistics material?" Study time was another demographic question used that asked "In a usual week, how many hours did you spend outside of class studying statistics?"

The significance of the predictors varied between attitude components. However gender and current GPA were not significant in any model, but were kept in so they were accounted for. For the categorical variables: teachers who had taught the Randomization-Based curriculum multiple times were used as the reference group, and males were used as the reference for gender. Multicolinearity was also checked using VIFs found using R 2.14.1 for each model, and there were no multicolinearity found. Residuals were plotted against fitted values, no apparent patterns were seen. The residuals for the six models did not violate any assumptions. Furthermore, an alpha of 0.05 was used to interpret significance of the models.

Table 4: Multiple Linear Regression Output: *Affect* Component

Coefficients	Estimate	Std. Error	t	P-Value
Intercept	1.595	0.385	4.145	< 0.0001
Gender(Female)	0.150	0.152	0.972	0.3319
Confidence	-0.146	0.057	-2.561	0.0109
Current GPA	-0.006	0.004	-1.500	0.1345
Teaching Style(Trad.)	-0.434	0.204	-2.132	0.0337
Teaching Style(R-B New)	-0.231	0.160	-1.449	0.1483
Study Time	-0.057	0.032	-1.810	0.0712

Using the Affect model as an example, confidence and teaching using a traditional curriculum were significant predictors for the difference in Affect from Pre to Post. Study time is also moderately significant. Because teaching using a traditional curriculum had a negative coefficient, it can be interpreted as if a student was taught using a Traditional curriculum their difference in Affect scores were 0.434 lower on average than a student who had a teacher who had taught the Randomization-Based curriculum multiple times, accounting for all other variables in the model. For each one point score increase in confidence there is an average decrease of 0.146 in the difference in Affect scores. If students feel more confident, they are less likely to gain more appreciation of statistics in the course. Additionally, for each hour increase in study time there is an average decrease of 0.057 in the difference in Affect scores; students who study more tend to not learn to appreciate statistics at the same level as students who study less.

The Cognitive Competence model had two significant predictors: confidence and the traditional curriculum teaching style. For each one point increase in confidence there is an average decrease of 0.172 in the difference in Cognitive Competence scores. Meaning students who have more confidence tended to feel less confident in their knowledge and skills in statistics. A student who was taught using a traditional curriculum had on average a decrease of 0.587 in the difference in Cognitive Competence scores, compared to those taught in a Randomization-Based curriculum by a teacher who has taught it multiple times.

The Value model had two moderately ($0.05< \alpha <0.1$) significant predictors: study time and Randomization-Based curriculum being taught for the first or second time. For each hour increase in study time there is an average decrease of 0.04 in the difference in Value scores. Implying that students who study more tend not to learn the usefulness and relevance as students who study less. A student who is taught by a teacher who is new to the Randomization-Based curriculum have on average a decrease of 0.213 in the difference in Value scores, compared to those taught in a Randomization-Based curriculum by a teacher who has taught it multiple times.

For the Difficulty model study time was statistically significant and the traditional curriculum teaching style was moderately significant. For each hour increase in study time there is an average decrease of 0.056 in the difference in Difficulty scores. This entails that students who study more tend to find statistics more difficult than those who study less, which is expected because a student who finds statistics not that difficult might study less. A student who was taught using a traditional curriculum had on average a decrease of 0.267 in the difference in Difficulty scores, compared to those taught in a Randomization-Based curriculum by a teacher who has taught it multiple times.

For the Interest model, study time was moderately significant and Randomization-Based curriculum being taught for the first or second time was statistically significant. For each hour increase in study time there is an average decrease of 0.058 in the difference in Interest scores. Students who study more tend to lose interest in statistics compared to those who study less. This is understandable because if a student has to spend more time studying they might become annoyed with the subject and lose interest. A student who is taught by a teacher who is new to the Randomization-Based curriculum have on average an increase of 0.378 in the difference in Interest scores, compared to those taught in a Randomization-Based curriculum by a teacher who has taught it multiple times.

For the Effort model confidence, the traditional curriculum teaching style, study time, and the Randomization-Based curriculum being taught for the first or second time. For each one point increase in confidence there is an average decrease of 0.079 in the difference in Effort scores. Meaning students who have higher confidence tend to not put as much work in their statistics course outside of class compared to students with lower confidence. A student who was taught using a traditional curriculum had on average a decrease of 0.509 in the difference in Effort scores, compared to those taught in a Randomization-Based curriculum by a teacher who has taught it multiple times. For each hour increase in study time there is an average increase of 0.072 in the difference in Effort scores. Entailing those students who study more their amount of work outside the class increases; this is what we would expect to be true, hopefully. A student who is taught by a teacher who is new to the Randomization-Based curriculum have on average an increase of 0.5 in the difference in Effort scores, compared to those taught in a Randomization-Based curriculum by a teacher who has taught it multiple times.

Results Summary

Pretest and Posttest attitude component scores were extremely similar to those of the national study done by Schau and Emm□oğlu. From our study we found that the differences between Pretest and Posttest attitude components were overall more positive and less negative, compared to the national study. When looking at the differences in attitude components between Pretest and Posttest, personal confidence and study time for the course are significant for most attitude components. Some of the significant effects were not expected, such as the decrease in the Value component as confidence rises. Furthermore, compared to those taught in a Randomization-Based curriculum by a teacher who has taught it multiple times, students taught with a traditional curriculum had significantly smaller differences in attitude components, except for Value and Interest. Value scores changed the least form Pre to Post, and Effort had the largest drop in scores from Pre to Post.

From the results found in the this study it seems that a Randomization-Based curriculum that has been taught multiple times results in more positive attitudes toward introductory statistics, compared to a traditional curriculum or a Randomization-Based curriculum being taught for the first or second time.

Future Steps

For further analysis, past SATS-36 data and conceptual understanding scores will be added to better fit the attitude models. In addition, we will be looking at the post attitude component scores as the response, and adding in the pre attitude component scores as a covariate. Section-based effects will also be investigated and compared to the student-based effects found in this study.

References

Carlson, K., and Winquist, J. (2011)."Evaluating an Active Learning Approach to Teaching Introductory Statistics: A Classroom Workbook Approach." *Journal of Statistics Education*, 9(1).

Gal, I., Ginsburg, L., and Schau, C. (1997). "Monitoring Attitudes and Beliefs in Statistics Education," in *The assessment challenge in statistics education*, Eds. I. Gal, and J. B. Garfield, Netherlands: IOS Press, 37-51.

Schau, C., Stevens, J., Dauphinee, T. L., and Del Vecchio, A. (1995), "The Development And Validation Of The Survey of Attitudes Toward Statistics," *Educational and Psychological Measurement*, 868-875.

Schau, C., and Emm□oğlu, E. (2012). "Do Introductory Statistics Courses In The United States Improves Students' Attitudes?" *Statistics Education Research Journal*, 11(2): 86-94.

Appendix

Model Output:

Table 5: Multiple Linear Regression Output: *Cognitive Competence* Component

Coefficients	Estimate	Std. Error	t	P-Value
Intercept	1.531	0.316	4.850	< 0.0001
Gender(Female)	0.096	0.125	0.769	0.4422
Confidence	-0.172	0.047	-3.667	0.0003
Current GPA	-0.003	0.003	-0.897	0.3706
Teaching Style(Trad.)	-0.587	0.167	-3.493	0.0005
Teaching Style(R-B New)	-0.117	0.131	-0.891	0.3737
Study Time	-0.030	0.026	-1.153	0.2498

Table 6: Multiple Linear Regression Output: *Value* Component

Coefficients	Estimate	Std. Error	t	P-Value
Intercept	0.044	0.276	0.160	0.8731
Gender(Female)	-0.014	0.109	-0.125	0.9009
Confidence	-0.003	0.041	-0.078	0.9377
Current GPA	-0.002	0.003	-0.701	0.4839
Teaching Style(Trad.)	-0.140	0.146	-0.956	0.3397
Teaching Style(R-B New)	-0.213	0.115	-1.855	0.0645
Study Time	-0.040	0.023	-1.778	0.0764

Table 7: Multiple Linear Regression Output: *Difficulty* Component

Coefficients	Estimate	Std. Error	t	P-Value
Intercept	0.727	0.269	2.704	0.0072
Gender(Female)	0.072	0.106	0.681	0.4963
Confidence	-0.021	0.040	-0.525	0.5997
Current GPA	-0.003	0.003	-1.320	0.1878
Teaching Style(Trad.)	-0.265	0.142	-1.860	0.0637
Teaching Style(R-B New)	0.026	0.112	0.230	0.8179
Study Time	-0.056	0.022	-2.514	0.0124

Table 8: Multiple Linear Regression Output: *Interest* Component

Coefficients	Estimate	Std. Error	t	P-Value
Intercept	0.272	0.374	0.728	0.4669
Gender(Female)	0.200	0.148	1.354	0.1767
Confidence	-0.066	0.055	-1.189	0.2354
Current GPA	-0.003	0.004	-0.804	0.4220
Teaching Style(Trad.)	-0.288	0.198	-1.457	0.1461
Teaching Style(R-B New)	-0.377	0.155	-2.428	0.0157
Study Time	-0.058	0.031	-1.876	0.0616

Table 9: Multiple Linear Regression Output: *Effort* Component

Coefficients	Estimate	Std. Error	t	P-Value
Intercept	-0.383	0.261	-1.465	0.1439
Gender(Female)	0.191	0.103	1.846	0.1209
Confidence	-0.078	0.039	-2.023	0.0439
Current GPA	0.0003	0.003	0.114	0.9091
Teaching Style(Trad.)	-0.505	0.138	-3.650	0.0003
Teaching Style(R-B New)	-0.497	0.109	-4.577	< 0.0001
Study Time	0.072	0.022	3.329	0.0010