

A Quantitative Analysis of Confidence Levels of Statistics Students

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Abstract

Within education, student confidence is determined by a person's belief in their ability to experience success. Research on student self-efficacy points to the idea that students' higher or lower confidence levels can directly affect overall achievement. With this knowledge, the following study assesses two classes of Carroll College Introduction to Statistics students on their perceived self-efficacy, disposition toward statistics, relationship with the course professor, ability levels in statistics, and overall personal feelings about math to observe whether any of these areas directly correlate to the final grades of the students. In this case, achievement is measured using students' final grades within the course. Using analysis of variance (ANOVA) and chi-squared tests for independence, it was found that a strong, positive correlation existed between each area of the study and the student's final grades. Therefore, a correlation may exist between higher grades and positive perceptions of each area within a mathematics classroom.

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1 Introduction

Throughout education, building students' confidence in themselves and their school work is an increasingly important aspect of a teacher's job. Within mathematics, a subject considered one of the most challenging for students, individual confidence levels tend to drop significantly when walking into the classroom. A common belief among the general population may be that "there are math people, and there are non-math people" or that "people either get math or they don't." With this in mind, the question arises about whether or not these preconceived notions affect students' achievement. Suppose a correlation between those preconceived notions and student achievement exists. In that case, educators must address the question, "How can teachers change this preconceived notion from a fixed mindset to a growth mindset to increase their students' achievement?"

For this paper, self-efficacy, which is defined as "students' confidence in their ability to master new skills and tasks," and students' own perceived abilities and dispositions will all be measures of students' confidence levels (Friedel, Cortina, Turner, Midgley, 2010, p. 102). This research suggests that student self-efficacy can change based on classroom environments, assessment strategies, and how the material is presented. As students transition to higher-level mathematics courses, these negative perceptions of their ability levels can negatively influence their educational achievement. Having this knowledge should inspire educators to pay attention to the dispositions of their students, instead of spending time and effort focusing on teaching curriculum content. Spending a limited time addressing student confidence through their self-efficacy may be beneficial. While it is unreasonable to believe that educators can address the

dispositions of all their students constantly, becoming knowledgeable in this topic can provide basic guidelines for how educators can incorporate small opportunities within their classrooms to build student confidence. Therefore, understanding the depth of how students' self-efficacy and dispositions change and mold their learning can serve as a guide to current and future educators.

2 Literature Review

The topic of this research paper explores the effects of student overall confidence and self-efficacy on academic performance and achievement within a mathematics classroom. The information referenced in this study examines varying levels of self-efficacy across elementary, middle school, high school, and college students. The literature provides explanations for why student self-efficacy declines and how the students' anxieties, relationships, attitudes, engagement, motivation, and perceptions of their abilities affect their achievement in the classroom. Ideas for improving, building, and positively influencing student self-efficacy are also a topic of concern within the literature. Educators need to understand the intricacies of student self-efficacy and how it relates to student's academic success to be effective teachers. Having the ability to influence student learning and success is an important skill set to develop within the role of an educator.

One important aspect of this paper is identifying what factors cause an increase in academic achievement. Friedel et al. (2010) discussed the differences in classroom environment, home environment, and teacher evaluations of learning between elementary and middle school classrooms, and how these factors affect self-efficacy. Along with this, Midgley, Feldlaufer, and Eccles (1989) specifically stated that teacher self-efficacy may

influence student self-efficacy. Both articles are concerned with the effects on students as they transition to higher-level math. Furthermore, Waples (2016) suggested that anxiety related to math is the cause of decreased self-efficacy while Pietsch, Walker, and Chapman (2003) pointed to how student competency and affect highly relate to self-efficacy. These researchers focused on the idea that a decline in students' attitudes towards mathematics may contribute to lower self-efficacy rather than outside factors in students' classroom experiences causing the decline.

Further research also provided insight into specific ways achievement and performance are affected by self-efficacy. Namely, performance and achievement vary depending on the cooperative versus competitive types of classroom structure, parental involvement, and how relevant the student perceives the information. This idea is echoed by Enkosa, Weldemeskel, and Berhanu (2023) and Al-Hija and Araidy (2023). The psychological aspect of self-efficacy and how these factors directly influence achievement is studied. This situation is negated by Oppong-Gyebi, Dissou, William, Maanu, Francis, and Adu-Obeng (2023) who presented that student's thoughts and attitudes about their studies do not influence achievement and performance within the class.

Except for Oppong-Gyebi et al. (2023), most research pointed to the fact that students' self-efficacy and motivation within the classroom correlated to their achievement within the class. There are many reasons for self-efficacy to be affected negatively; therefore, it is important to identify ways in which self-efficacy could increase. This research paper will include ideas from Schunk (1981, 1982, and 1993) that describe how attributional feedback, or feedback that teachers provide that focus on

student strengths to help them improve, is an effective way to build student self-efficacy. Schunk (1985) suggested that students' peers may also dictate levels of self-efficacy in students. Moreover, Joët, Usher, and Bressoux (2011) and Joseph, Korkor, Yarhands, and Obeng (2022) argued that social interactions between students and peers or students and teachers along with environmental factors in the classroom were more effective ways to improve students' self-efficacy.

While this research points to the existence of strong, positive trends in favor of student self-efficacy affecting their academic performance and achievement in mathematics, there is much variation in the reasons for what caused students to have strong or weak self-efficacy and how this translates to achievement and performance, and in what ways efficacy can be increased. This study seeks to determine if the strong, positive correlation between student confidence and achievement in the class holds firm when observed in a college-level statistics course.

3 Methodology

Participants

The participants of this study initially consisted solely of 41 Carroll College Fall 2024 Introduction to Statistics students who were 18 years of age or older; however, two students dropped the class during the semester. Thus, 39 students were included in the convenience sample for final consideration in this study. There were no other exclusions of any groups, and no vulnerable groups were targeted. The purpose of this study was to determine if there is a correlation between math students' disposition toward statistics, personal self-efficacy, relationship with the course professor, personal feelings about math, and perceived ability level for statistics and the final grades they received. The

course instructor for Introduction to Statistics provided students with the necessary consent form and the pre and post-questionnaires for the study. All participation in this study is anonymous and optional.

Considering primary and secondary sources used for research, reported experimental results of studies on elementary, secondary, and college-level students were consulted. These experiments identified many aspects concerning how self-efficacy affects achievement and performance in mathematics. Subjects of interest were not limited to a specific geographical area. Instead, students from different countries were considered by the authors of these sources.

Materials

Before this study began, a draft of the research proposal, including the consent form, the questionnaire used for data collection, and all procedure descriptions were submitted to the Carroll College Institutional Review Board (IRB) for approval. The consent form informed participants of the research overview, participant requirements, benefits, and risks. A statement of their consent to release their final grades in the course was also included. The questionnaire, created by the Principal Investigator and adapted from an existing questionnaire by Joseph, Yarhands, Francis, and Akweitley (2023), measured students' feelings about their self-efficacy, relationship with the professor, personal feelings about math, ability levels in statistics, and disposition toward statistics. Four statements are provided: two are positively associated and two are negatively associated. Thus, if one statement uses a positive phrase, such as "I feel confident in..." then that topic must also include a negative statement that uses a phrase such as "It is impossible for..." Students were asked to rank their agreement with the statement on a

scale of 1-5 where 1 would mean the student strongly disagrees with the statement and 5 would mean the student strongly agrees with the statement. Students were also asked to self-report the anticipated grade they believed they would earn in the course.

Professionals in mathematics and education were consulted to ensure the questionnaire was valid and reliable.

Procedure

Students, 18 years and older, were provided with a consent form by their course instructor before the beginning of the course. The course instructor then provided the questionnaire to consenting participants at the beginning of the course. Students were asked to repeat the survey at the end of the course. The course instructor collected the consent forms and results to protect students' identifying information. The course instructor provided the Principal Investigator with pre and post-course questionnaire answers which were stripped of identifying information. Final course grades were obtained through the course instructor and given to the Principal Investigator without identifying information.

Once data was collected, rated scores provided by each student in response to the questions were transformed into ratings of positive and negative feelings associated with each area the question fell under. That is, if a student gave a rating of five, showing that they agreed with a negative statement, then their score became one to show that their feelings disagreed with the positive statement this question asked. If a student gave a rating of five for a positive statement, their score remained a five. The higher the score, the more positively the student feels about the subject. These scores were totaled and sorted by which area the questions pertained to. For example, the scores associated with

questions about students' personal feelings about math were kept separate from the scores questions about remaining areas. These totaled scores were categorized by the student's final course grade.

Analysis of Variance (ANOVA) tests were used to examine the mean value of scores associated with final grades to determine if there is a statistical significance in the difference of the mean scores for each final grade. This was done for each area studied: self-efficacy, relationship with the professor, personal feelings about math, ability level in statistics, and disposition toward statistics.

The chi-squared test for independence was also utilized to determine whether the scores reflecting students' positive or negative feelings about the area were independent of the grades they felt they would receive.

4 Results

The totaled scores for each student within each area of the study are shown in Table 1 below with the student's respective final grade.

Self Efficacy	Relationship with Professor	Personal Feelings about Math	Ability Levels for Statistics	Disposition Toward Statistics	Final Letter Grade
16	15	17	10	16	F
12	11	10	14	12	B
16	19	17	19	16	B
10	17	9	13	10	C
5	10	8	5	5	D
19	17	19	20	19	A
18	19	18	16	18	A
11	13	11	14	11	C
16	16	17	18	16	A
14	18	14	15	14	B
14	19	15	16	14	A
17	19	17	15	17	B

16	16	13	15	16	A
10	15	9	7	10	C
14	19	9	14	14	A
18	19	15	19	18	A
16	16	10	12	16	C
19	18	18	19	19	B
16	18	15	17	16	B
20	19	15	17	20	B
20	20	18	17	20	A
14	14	14	10	14	B
15	17	14	13	15	B
15	14	16	14	15	C
16	19	17	17	16	A
16	17	16	15	16	B
9	17	8	13	9	C
10	18	9	13	10	C
16	19	17	16	16	A
5	9	5	4	5	F
11	15	11	10	11	B
19	18	17	17	19	A
10	18	11	13	10	B
4	18	4	5	4	C
9	18	11	12	9	B
9	20	10	6	9	D
14	17	11	15	14	B
10	18	12	9	10	D
8	16	11	8	8	D

Table 1: Sum of individual students' scores responding to each of the areas studied.

4.1 ANOVA Results

Figure 1 shows a boxplot of the perceived ability level scores within each final grade.

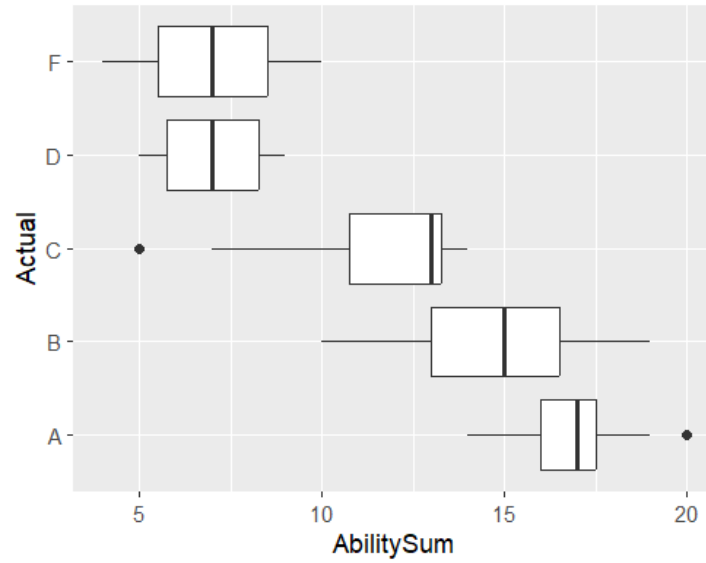


Figure 1: Boxplot of perceived ability level scores categorized by final grades.

The mean value of the A grade is much higher than the mean scores of the remaining grades. This suggests that higher perceived ability levels may be correlated with higher grades.

Figure 2 presents the boxplot of disposition scores within final grades.

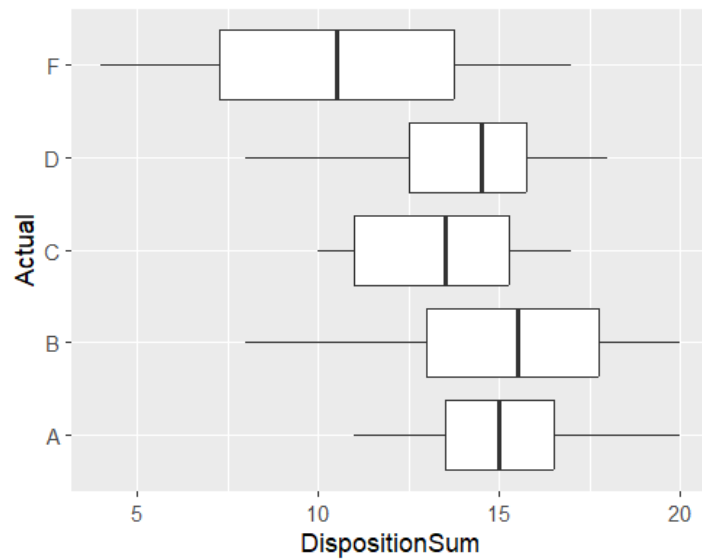


Figure 2: Boxplot of disposition scores categorized by final grades.

There does not appear to be a large discrepancy between the disposition scores of each grade. This suggests that disposition may not be strongly correlated to higher grades received in the class.

Figures 3 and 4 show the boxplots of efficacy scores and personal feelings scores, respectively, within final grades.

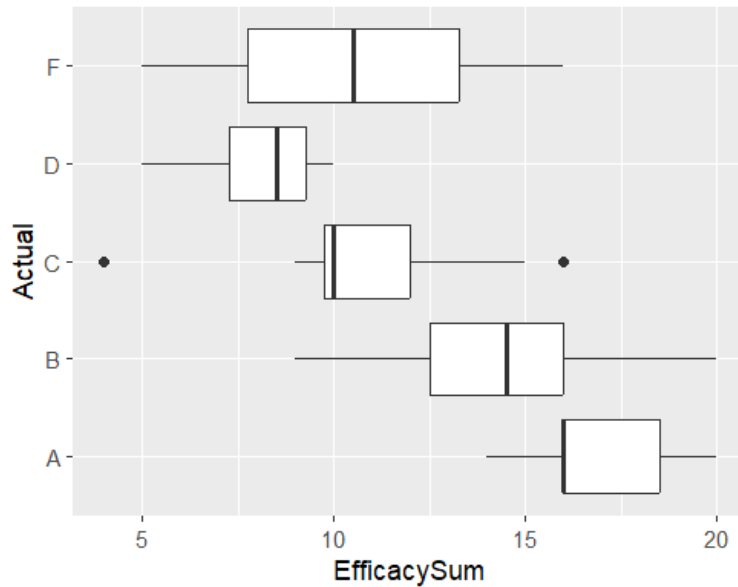


Figure 3: Boxplot of efficacy scores categorized by final grades.

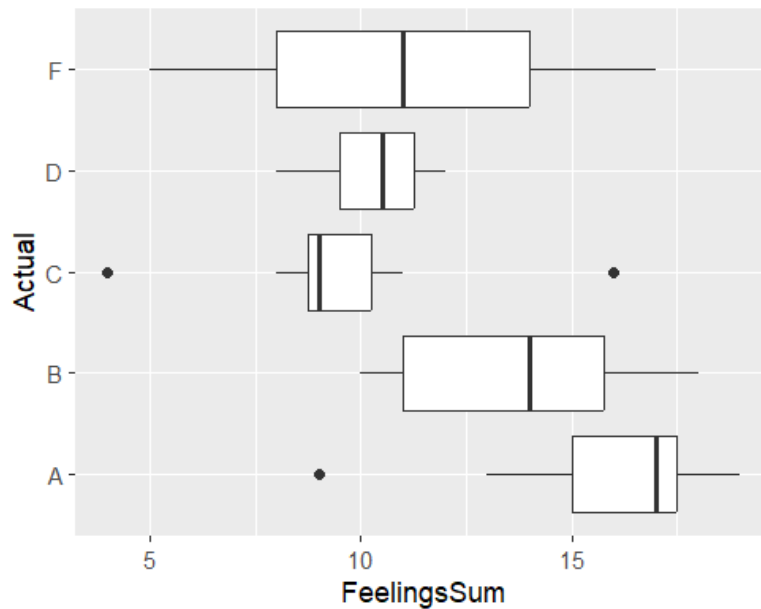


Figure 4: Boxplot of personal feelings scores categorized by final grades.

For both areas, the A grade has a higher average score value than the remaining average grades; however, since only two students received an F in the class, then one of these students gave themselves a shockingly high rating in these areas and the other a low rating in the areas. This may suggest that there is a weak correlation between efficacy and personal feelings about math and achieved grades.

Figure 5 gives the boxplot of relationship scores within final grades.

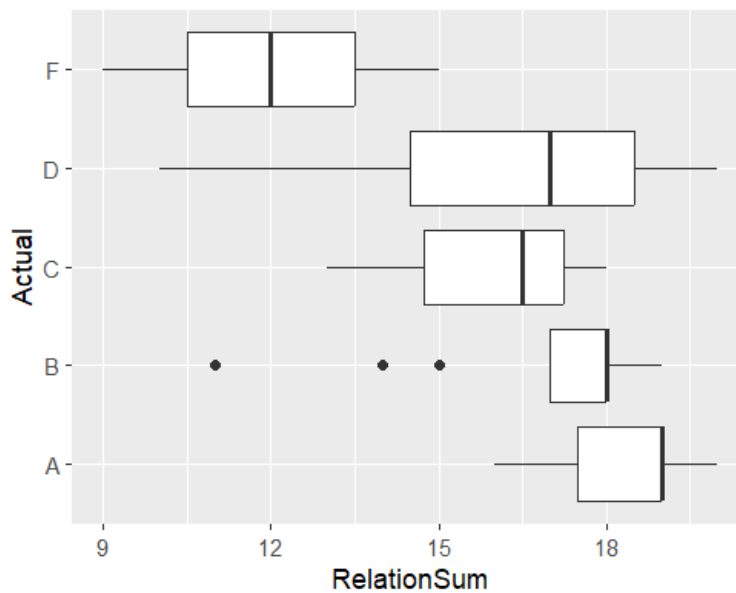


Figure 5: Boxplot of relationship with professor scores categorized by final grades.

Similar to the results of efficacy and personal feelings, final grades of an A obtain the highest score average. Those who earn grades of B, C, and D report roughly similar scores. Students who earned a grade of an F reported seemingly significantly lower scores. This may suggest that the correlation between the relationship with the course professor and final grades is strong.

Equation 1 gives the overall null hypothesis for the perceived ability levels, disposition, self-efficacy, personal feelings, and relationship with the professor's hypothesis tests. All assume that, for each area of concern, the mean scores of final

grades are equal regardless of what the final grade is. The alternative hypothesis states that at least one of these proportions is not equal. A cutoff value $\alpha = 0.05$ is also used for each of these hypothesis tests.

$$H_0: p_1 = p_2 = p_3 = p_4 = p_5$$

Equation 1: General ANOVA null hypothesis for perceived ability levels, disposition, self-efficacy, personal feelings, and relationship with the professor.

ANOVA results for each area of concern are shown below in Table 2 along with corresponding p-values.

Area	ANOVA p-value
Perceived Ability Level	$4.26 \times 10^{-7} *$
Disposition Toward Statistics	0.464
Self-Efficacy	$6.89 \times 10^{-5} *$
Personal Feelings about Math	$7.82 \times 10^{-4} *$
Relationship with the Professor	0.0141 *

Table 2: ANOVA p-value results for each area. * indicates significant at the 0.05 level.

As shown in Table 2, only four of the five areas produced statistically significant results. To determine what caused such extreme p-values, the individual p-values for each grade comparison may be studied. Tables 3, 4, 5, and 6 show the individual p-values from the resulting difference of means for perceived ability, self-efficacy, personal feelings, and relationship areas respectively. Disposition has been omitted due to the lack of statistical significance shown in Table 2.

	A	B	C	D
B	0.1361	–	–	–
C	0.00079*	0.0554	–	–
D	3.9e-06*	0.00017*	0.0554	–
F	0.00028*	0.0042*	0.1361	1

Table 3: Perceived ability ANOVA p-values for individual comparison of means. *indicates significance at the 0.05 level.

The most significant difference is between final grades A and D.

	A	B	C	D
B	0.345	–	–	–
C	0.0014*	0.067	–	–
D	0.0003*	0.008*	0.562	–
F	0.0786	0.423	0.961	0.7421

Table 4: Efficacy ANOVA p-values for individual comparison of means. *indicates significance at the 0.05 level.

Again, we see that final grades of A and D have the most significant difference.

	A	B	C	D
B	0.5603	–	–	–
C	0.00096*	0.0306*	–	–
D	0.0306*	0.3402	1	–
F	0.3402	0.937	1	1

Table 5: Personal feelings ANOVA p-values for individual comparison of means. *indicates significance at the 0.05 level.

For personal feelings, final grades A and C have the most significant difference.

	A	B	C	D
B	0.725	–	–	–
C	0.294	1	–	–
D	0.509	1	1	–
F	0.012*	0.065	0.287	0.324

Table 6: Relationship with professor ANOVA p-values for individual comparison of means. *indicates significance at the 0.05 level.

The only significant difference in the relationship with the professor is between final grades of A and F.

4.2 χ^2 Test for Independence Results

Instead of using totaled scores shown in Table 1, the counts for each rating students gave themselves were kept and sorted by final grade. These ratings reflect how positively they think about the area being studied. For example, out of the students who reported that they would earn a C in the class, seven gave themselves a score of one on any of the questions about efficacy, nine gave themselves a score of two, five gave themselves a score of three, 10 gave themselves a score of four, and only one gave themselves a score of five.

The overall null hypothesis for the perceived ability levels, disposition, self-efficacy, personal feelings, and relationship with the professor's chi-squared hypothesis tests is that, for all areas, the scores reflecting positive thinking are independent of the final grades. The alternative hypothesis states that the reflective scores and final grades are not independent of each other. A cutoff value $\alpha = 0.05$ is also used for each of these hypothesis tests.

Table 7 gives the chi-squared test results for each area studied.

Area	χ^2 independence p-value
Perceived Ability Level	$4.503 \times 10^{-10} *$
Disposition Toward Statistics	0.01299 *
Self-Efficacy	$2.678 \times 10^{-7} *$
Personal Feelings about Math	$3.237 \times 10^{-9} *$
Relationship with the Professor	$1.074 \times 10^{-6} *$

Table 7: Chi-Squared p-value results for each area. *indicates significance at 0.05 level.

5 Discussion

The overarching purpose of this study was to determine if there is a correlation between student achievement and their self-efficacy, relationship with the professor, personal feelings about math, ability level in statistics, or disposition toward statistics. For this study, achievement is measured by the student's final grade. Therefore, comparing the totaled scores of all students while categorizing them by final grade is a useful way to determine if there is any notable difference in scores depending on what their final grades were. Using the totaled sums from Table 1, Figures 6, 7, 8, 9, and 10 provide a visual representation of the distribution of scores for the areas related to efficacy, relationship with the professor, personal feelings, ability levels, and dispositions respectively. It would be expected that higher scores reflect higher final grades and lower scores would reflect lower final grades.

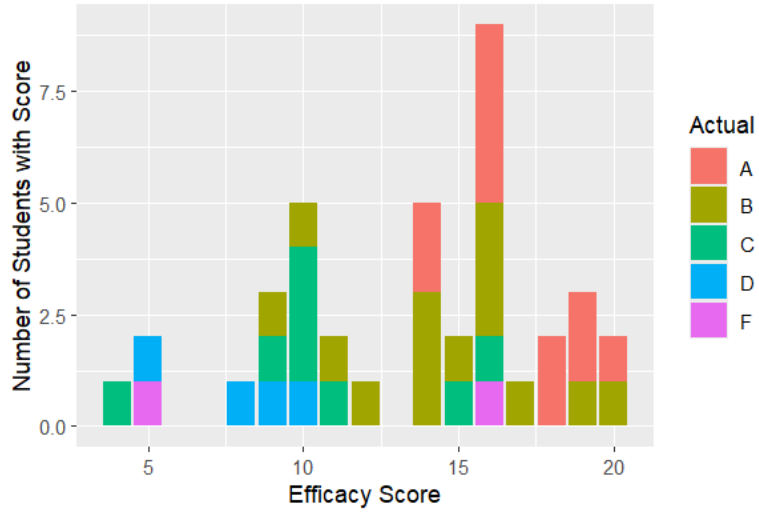


Figure 6: Distribution of efficacy scores categorized by final grades.

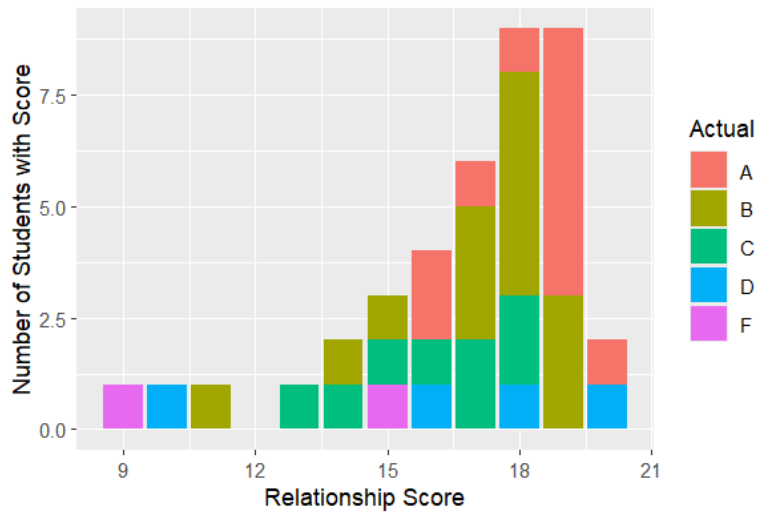


Figure 7: Distribution of relationship scores categorized by final grades.

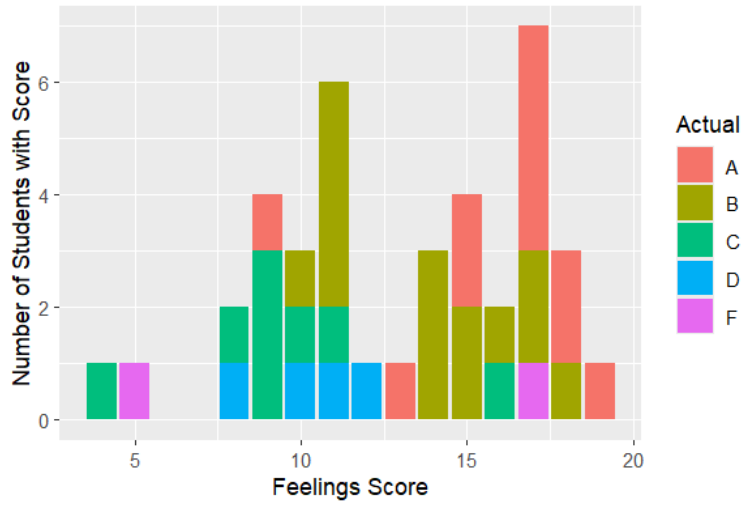


Figure 8: Distribution of personal feelings scores categorized by final grades.

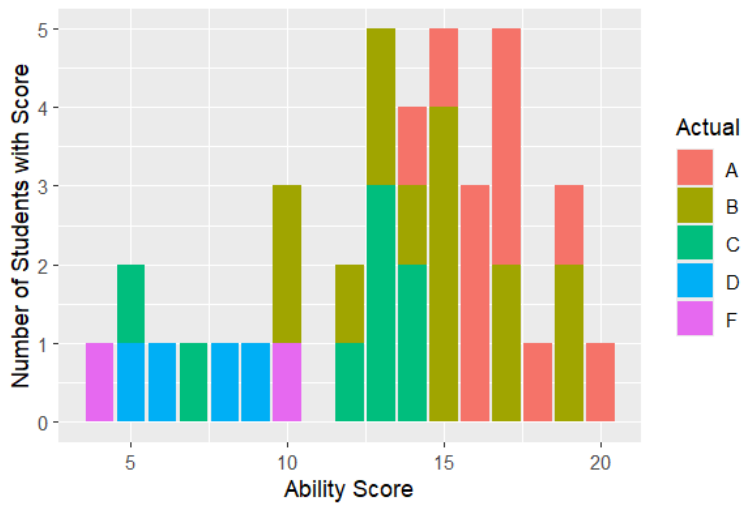


Figure 9: Distribution of ability level scores categorized by final grades.

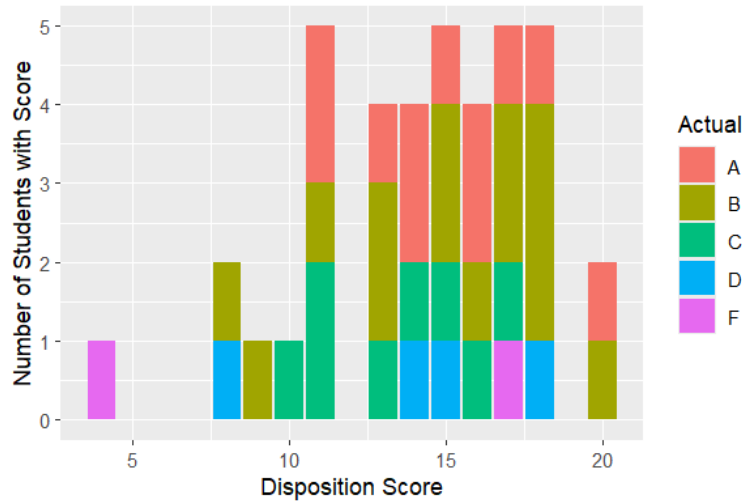


Figure 10: Distribution of disposition scores categorized by final grades.

Figures 6-10 show that students who ended up earning a final grade of an A in the class consistently ranked themselves high in each of the areas. However, it appears that there is more variation in the rankings for other grades. Since it is not overtly obvious if there is a correlation between grades and areas, other measures of variation must be considered. Namely, ANOVA and chi-squared tests for independence hypothesis tests provide more insight into these results.

5.1 ANOVA Discussion

Equation 1 provided the null hypothesis for the ANOVA hypothesis test. It would be expected that, if there is no correlation between the scores in each area and the final grades, then the mean scores found in each grade would be equal. However, the p-values found in Table 2 show that there are statistically significant differences between the mean scores of final grades for the perceived ability level, self-efficacy, personal feelings, and relationship areas. Because these p-values are significantly lower than the cutoff value $\alpha = 0.05$, then it is clear that the null hypothesis can be rejected for these four areas only. At least one of these indicates that each grade is not equal; thus, it follows that

higher scores concerning the students' perceptions of self-efficacy, ability levels, personal feelings about math, and their relationship with the professor lead to higher achievement.

On the other hand, since the p-value for disposition was not lower than the cutoff value $\alpha = 0.05$, then the null hypothesis is unable to be rejected. The mean scores of each grade may be equal; therefore, students' dispositions toward statistics would not affect their achievement in the course.

5.2 χ^2 Test for Independence Discussion

The chi-square test for independence sought to determine whether final grades were independent of the area. Using this as a null hypothesis, Table 7 shows that the p-values state that every area is statistically significant at the $\alpha = 0.05$ level. Therefore, the null hypothesis can be rejected for all areas, and the alternate hypothesis that grades and areas are dependent on one another can be accepted. That is, students who have a more positive outlook on self-efficacy, their relationship with their professors, personal feelings about math, statistics ability level, and disposition toward statistics will earn higher grades in the course.

6 Limitations

This study only used collected data from two Introduction to Statistics courses; thus, only 39 students participated. Due to the small sample size, the results from ANOVA and chi-squared test for independence may be affected. In particular, the mean scores found for the ANOVA tests relied on a small amount of provided data. Since only two students received an F in the class, then the mean only relied on those two scores; therefore, it is unlikely that the mean scores found for the F grades were accurate. Similarly, for the chi-squared test, large discrepancies between scores assigned to each

grade will significantly affect the p-values for each area. A much larger sample size may show that these p-values do not have such a high statistical significance. Overall, the conclusions surrounding ANOVA and chi-squared test for independence are subject to change once applied to a much larger population.

7 Conclusion

While this study was limited to only two classes of Introduction to Statistics students in one school, the trends predicted in consulted sources held firm. Findings from this study suggest that there is a strong, positive correlation between students' confidence and academic achievement in an Introduction to Statistics course where confidence consisted of the five areas studied. Therefore, the information obtained from this study may be utilized by current and future educators to understand the direct effects of student confidence on academic achievement within a math classroom.

Additionally, Waples (2016), Schunk (1982), Schunk (1981), and Oppong-Gyebi et al. (2023) provided suggestions for how teachers can work to build academic achievement in their students. This included building positive and healthy relationships with students by being approachable to students, maximizing opportunities that build self-efficacy, and providing opportunities for teachers to work together with their students (Waples, 2016). A relationship with the professor or teacher of a course had a significant impact on the grades of students. Schunk (1982) gave specific ways that students and teachers build relationships when he stated that "feedback linking past achievement with effort promotes task involvement, skill development, and perceived self-efficacy" (Schunk, 1982, p. 553).

Similarly, mathematical connectedness is important in building the confidence of students in a math classroom. If students feel that what they are learning is relevant, then they are connected to the material and they are more likely to obtain academic achievement (Oppong-Gyebi, 2023). Schunk (1981) agreed with this statement when he said “active engagement in activities promotes the development of skills and self-efficacy [in students]” (Schunk, 1981, p. 94). Overall, the findings of this study suggest that connectedness, dispositions, self-efficacy, relationships, perceived abilities, and personal feelings are all elements that associate with students’ academic achievement in a math classroom, and educators have an opportunity to play the unique role of one who guides students to build their confidence and their academic success.

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