Standardized Tests as a Predictor for Success in Construction, Architecture, and Architectural Engineering Programs

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Predictors for Success in Construction, Architecture and Architectural Engineering Programs

Abstract:

Universities and colleges with Science, Mathematics, Engineering and Technology (STEM) programs use standardized tests with a variety of names for student placement. The Assessment and LEarning in Knowledge Spaces (ALEKS) is an assessment tool created by McGraw-Hill with a mathematics placement module. Similarly, College Board's Scholastic Aptitude Tests (SAT) and American College Testing (ACT) Inc.'s college entrance exams serve as a basis for admissions into higher education. Since 2012, the university studied has collected data for Engineering, Architecture, and Technology programs to determine if these exams used for admissions and placement actually serve as a predictor for success. This study seeks to determine if the ALEKS and ACT scores predict success in a comparison to grades achieved in Engineering and Technology classes.

Based on an existing construction program and a combined architecture and architectural engineering program, a comparison of college admission scores versus success in math, physics and engineering based courses was performed. The construction program houses about 200 students over four years of coursework. The architecture and architectural engineering program houses about 275 students over five years of coursework. Reasoning behind selecting these programs is due to the fact that the course work and the size of each of the programs are similar.

The study has not found a significant correlation with standardized test scores and success levels in engineering and technology courses. Rather, it has become apparent that success is more likely to breed success. Students who score low on placement tests and then do well in remedial coursework are more likely to find success throughout their college careers. Conversely, students who score well on placement exams and do not perform well in their initial math coursework continue to struggle with grades. Based on this information, increasing entrance exam requirements may not increase retention rates but instead limit access.

Introduction:

Generally, in order to apply for entrance into major universities and colleges, high school students will take an aptitude test, either the ACT or SAT. How the student scores will affect the universities in which they are accepted. Schools also look at other aspects of the student's high school career to determine if they will succeed in the next level. Included in this consideration are the student's (GPA), extra-curricular activities, and volunteer work.

Studies have determined that a high school grade point average (GPA) is a good predictor of an average college GPA, while the ACT is a better predictor of an above average GPA (Noble and Sawyer. 2004). Emotional intelligence surveys measuring the students' non-cognitive skills also try to predict success. Other prediction methods are study habits or study types. (Blumner and Richards. 1997). Although there are many possible predictors for success, the use of standardized testing is still very popular in higher education.

At the university in this study, an additional step is taken during the admission process to better determine placement for the incoming student. Created by McGraw-Hill, the Assessment and LEarning in Knowledge Spaces (ALEKS) is a common test administered to incoming students to determine class placement. Students may take this test up to five times. The first time not being proctored, the second though fifth times being proctored.

The ALEKS test is an adaptive computer generated exam. Students may not use a piece of paper and a pencil for calculations. All calculations must be performed on the selected software. If the test is proctored, the proctor will not answer any questions. There is no evidence supporting that students perform better in a proctored setting as opposed to a non-proctored setting. Additionally, whether a student takes the test on a computer or with pencil and paper does not significantly alter the outcome of the test. (Sawhney, Cigularov, and Kines. 2014) After implementing the ALEKS test, the university studied saw a drop in D/F/W (Drop/Fail/Withdrawal) rates by 15 percent. (McGraw-Hill. 2015)

Between the required aptitude tests (ACT/SAT) and the ALEKS assessment, colleges and universities have several tools to predict the future success rate of the student. Data has been collected since 2012, comparing the student's ACT and ALEKS score with their grades in entry level math, physics, and engineering courses. This data will be compared graphically to determine if in fact there is a relationship between student standardized test scores and student success.

An average of the students' ALEKS score will be generated and compared with how the student performed in their coursework, specifically grade difference between classes in the same department (Math to Math) as well as across departments (Math to Physics). This exercise will also be performed with the average ACT score.

Pre-Discussion:

The data was separated by major. Majors selected for the study were Architecture (ARCH), Architectural Engineering (AE), and Construction Management Technology (CMT). Out of 475 students studied, 380 students had the required data (had both ALEKS and ACT scores) to make up the sample size. After the majors were selected, ALEKS and ACT scores were compared with grades received in math, science, and engineering classes. Data was collected in the following classes: Calculus I (MATH 2123 - Calculus for Technology and MATH 2144 – Calculus I), Calculus II (MATH 2133 – Calculus for Technology II and MATH 2153 - Calculus II), Physics I (PHYS 1114 - Algebra based Physics I and PHYS 2014 - Calculus based Physics I), Physics II (PHYS 1214 - Algebra based Physics II and PHYS 2114 - Calculus based Physics II), Statics (GENT 2323 - Statics for Technology and ENSC 2113 - Statics), and Strengths (CMT 3323 - Strengths of Materials for Construction and ENSC 2143 - Strengths of Materials). For simplicity, these courses will be referred to as Calculus I, Calculus II, Physics I, Physics II, Statics, and Strengths. Although AE and CMT students are required to take two calculus, two physics and two engineering science courses, ARCH students are only required to take one of each.

In order to compare the ALEKS and ACT scores with the student course grades, the grades were converted from the letter grade to a corresponding numerical value. For an "A" the value is 9,

"B" is 8, "C" is 7, "D" is 6 and "F" is 5. There are minimum ALEKS placement scores for Math courses. For Calculus I for Technology, the minimum score is a 65 and for Calculus I, the minimum is 75. Both Calculus II courses require prerequisites and not a minimum score. Students who did not achieve the minimum ALEKS score must take remedial math courses.

For the university studied, the minimum college assured admission is a combination of 3.0 GPA and a composite score of 21 on the ACT, or no GPA requirement with a composite score of 24, minimum. Additionally, a student may be admitted if they are in the top third of their high school class and have a minimum of a 3.0 GPA. Class grades were studied from Calculus I, Physics I, and Statics. A successful grade in the class will be defined as a "C" (7) or better. It should be noted that whether the student transferred from a different institution or was enrolled at the university studied for their entire college career was not determined.

ALEKS Discussion:

Figure 1 reflects a scatter plot that shows the relationship of the students' average grade earned between Calculus I, Physics I, and Statics courses and the associated ALEKS score. A point on the scatter plot is determined by grade average (y-axis coordinate) and the ALEKS score (x-axis coordinate). The trend line shows the tendency of the ALEKS score with a certain grade outcome.

When comparing the individual class grades with the ALEKS score received, the graph showed a gradual upward trend from lower scores to higher scores in relation to class grades. This is true for each of the three classes. The three class grades where then averaged together and compared to the ALEKS score. This trend line showed the students having the lower ALEKS (Below 65) score had an average of a 70% in the three classes, while the students with the higher ALEKS (Above a 75) scores showed an average of 75% between the three classes.
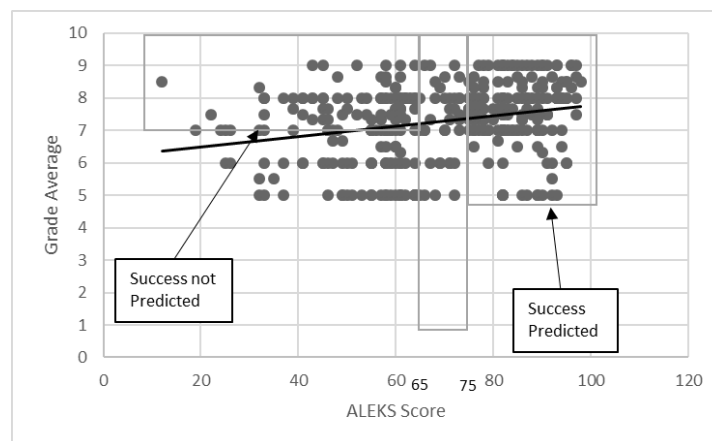

Figure 1: Calculus I, Physics I, Statics vs. ALEKS

Despite the upward trend, the ALEKS data had several outliers. ALEKS scores below a 65 that earned a 70-percent or above are shown on the left hand side of the graph. Scores above a 75 that earned below a 70-percent are displayed on the right hand sides of the graph.

Data was additionally analyzed by reviewing the relationship of performance from one class to another and the coinciding ALEKS scores. Ratios were given between class grades, the ratios are grade decrease, grade remained equal, and grade increase. Grade comparison was performed between classes Calculus I, Calculus II, Physics I, Physics II, Statics, and Strengths. Once the total number of students in each ratio was calculated, the average ALEKS score was developed for each ratio. In the following bar graphs, Figures 2 through 5, the number of students that had a certain grade outcome is on the left y-axis. The grade result between the courses is on the x-axis and the average ALEKS score is on the right y-axis. For example, in Figure 2, thirty students had on average a grade decrease between the three pairs of classes. Additionally, the average ALEKS score of these thirty students is approximately 67.

Overall, the outcome of all three pairs of classes and average ALEKS score had an upward slope between Grade Decrease (Average 67), Grade Equal (Average 70), and Grade Increase (Average 74).
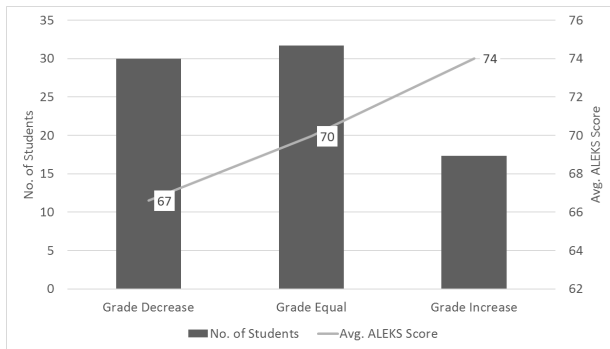
Figure 2: Average Grade Result of Calculus I, Physics I, and Statics Combined
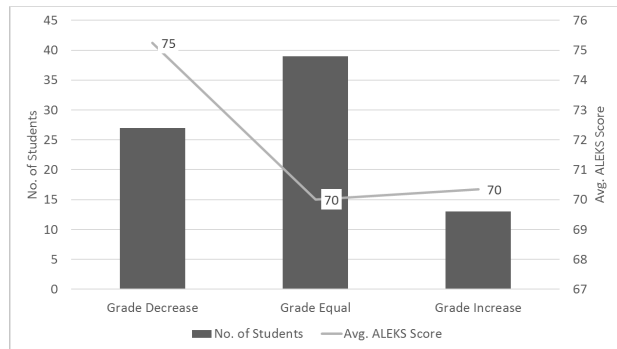

Figure 3: Grade Comparison from Calculus I to Calculus II

A more detailed analysis was performed, comparing grades received in classes of the same department. The grade relationship was observed from Calculus I to Calculus II, Physics I to Physics II, and Statics to Strengths separately. These comparisons are documented in Figures 3 through 5. Average ALEKS score was determined by the success between the two classes, whether the grades increased (Grade Increase), remained the same (Grade Equal), or decreased (Grade Decrease).

 Figure 3 shows grade comparisons from Calculus I to Calculus II. Corresponding ALEKS scores showed a negative slope from Grade Decrease to Grade Equal - the average ALEKS score dropped from a 75 to a 70. When comparing whether the grades remained the same (Grade Equal) or had an increase (Grade Increase), the slope of the ALEKS score is close to zero. ALEKS scores between the two outcomes is 70.

Figure 4 shows the comparison between Physics I and Physics II. The comparison showed an increase in average ALEKS scores from Grade Decrease to Grade Equal. ALEKS scores increased from an average of 57 to an average of 72. Data continued to show an increase in ALEKS scores when relating Grade Equal (Average 72) to Grade Increase (Average 76).
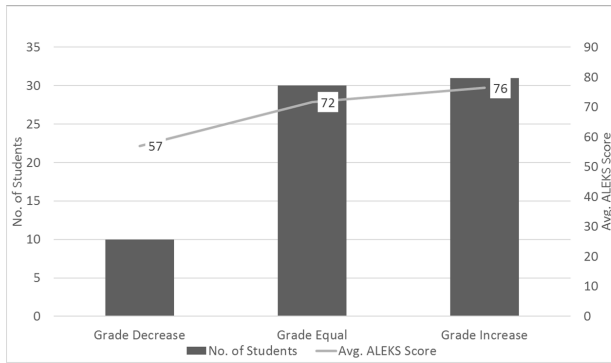
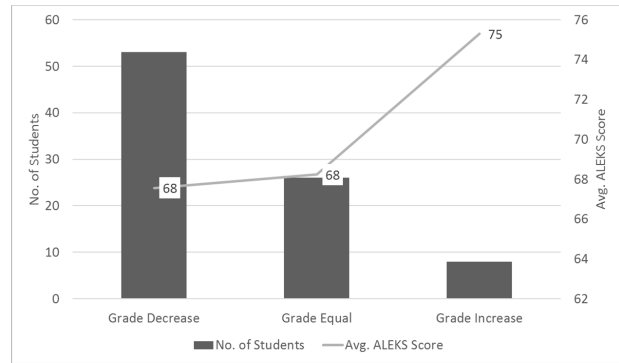Figure 4: Grade Comparison from Physics I to Physics II

Figure 5: Grade Comparison from Statics to Strengths

In studying the correlation between the grade outcomes from Statics to Strengths, Figure 5, it was found that the average ALEKS score is constant from Grade Decrease to Grade Equal (Average 68). Average scores from Grade Equal to Grade Increase rose with the ALEKS test (Average 68 to 75).

Another analysis of the data was performed, comparing grades received in different departments. This cross department comparison was done between Calculus I and Physics II (Figure 6), Calculus I and Strengths (Figure 7), Physics I and Strengths (Figure 8), Physics I and Calculus II (Figure 9). The average ALEKS scores were again calculated for the different grade outcomes.

When comparing the grade results of Calculus I and Physics II with the average ALEKS scores received, it was found that average ALEKS score had a downward slope from Grade Decrease (Average 75) to Grade Equal (Average 72). The average ALEKS score continued to drop from Grade Equal (Average 72) to Grade Increase (Average 69). Refer to Figure 6.
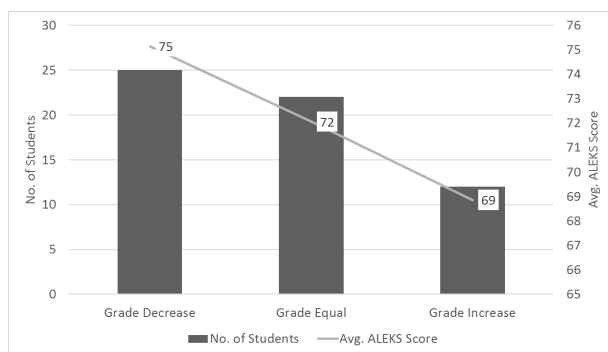

Figure 6: Grade Comparison from Calculus I to Physics II
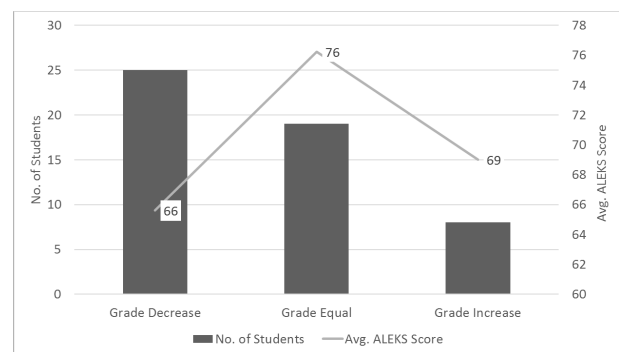

Figure 7: Grade Comparison from Calculus I to Strengths

Grade and score trends were evaluated between classes Calculus I and Strengths as shown in Figure 7. It was found that both average ALEKS scores increased from the final grade result of Decrease to Equal. The average ALEKS score increased from 66 to 76. In comparing the average

test scores with the increasing grade trend, the ALEKS score decreased. When the grade remained the same between the two classes, the average ALEKS score is 76, when the grade increased the average is 69.

The average ALEKS score was
 examined with the final grade results of Physics I and Strengths. Scores increased in ALEKS tests from the Grade Decrease outcome to the Grade Equal. ALEKS had an average of 67 when the grade decreased as opposed to an average of 80 when the grade remained the same. Again, when comparing the Grade Equal outcome with the Grade Increased outcome, the ALEKS scores decreased, 80 to 64, see Figure 8.
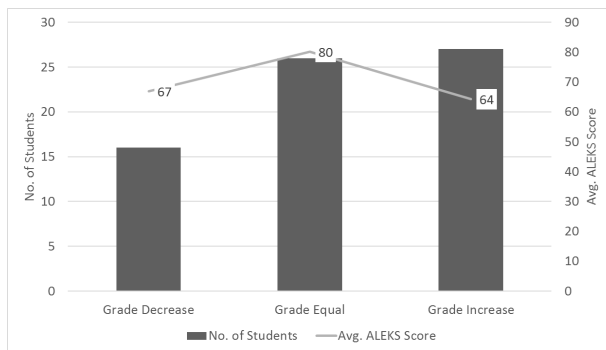

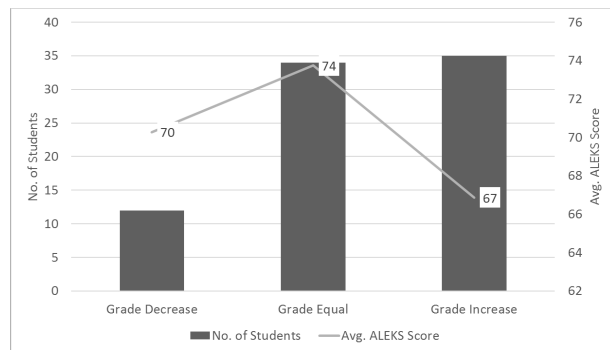Figure 8: Grade Comparison from Physics I to Strengths

Figure 9: Grade Comparison from Physics I to Calculus II

Physics I and Calculus II final grade data was collected and compared with the coinciding average ALEKS score. This relationship is shown in Figure 9. It was determined that the average ALEKS score increased from a Grade Decrease class result (Average 70) to Grade Equal (Average 74). Between Grade Equal and Grade Increase, the ALEKS score decreased from an average of 74 to an average of 67.

ACT Discussion:

A similar procedure was implemented comparing ACT scores with grades received in class, first comparing the scores to the individual class grades, then averaging the three class grades together and comparing with ACT scores. The scatter plot in Figure 10 shows the relationship of the students' average grade earned between Calculus I, Physics I, and Statics courses and the associated ACT score. A point on the scatter plot is determined by grade average (y-axis coordinate) and the ACT score (x-axis coordinate). The trend line shows the tendency of the ACT score with a certain grade outcome. The comparison showed an upward trend from lower ACT (Below 24) scores to higher ACT scores (Above 26) and grades received in class. When the ACT scores were compared to the Calculus I, Physics I, and Statics grade average, the lower scores received a grade of approximately 70%, whereas the higher scores received a grade of approximately 75%. Again, success is defined as a "C" (70%) or better.
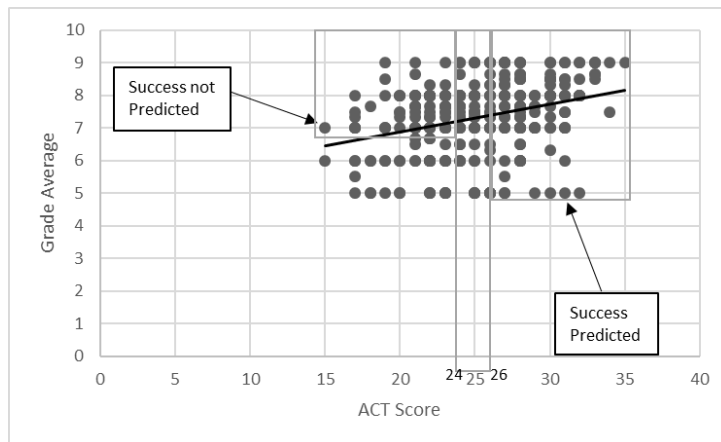
Figure 10: Calculus I, Physics I, Statics vs. ACT

Despite the upward trend, the ACT data had several outliers. ACT scores that are lower than 24 and had success (above a 70%) are identified on the left side of the graph, above the trend line. Scores above a 26 that did not have success (below a 70%) are identified on the right hand side of the graph, below the trend line.

Data was additionally analyzed by reviewing the relationship of performance from one class to another and the coinciding ACT scores. Ratios were given between class grades, the ratios are Grade Decrease, Grade Equal, and Grade Increase. Grade comparison was performed between classes Calculus I and Calculus II, Physics I and Physics II, Statics and Strengths. Once the total number of students in each ratio was calculated, the average ACT score was developed for each ratio. In the following bar graphs (Figures 11-18), the number of students that had a certain grade outcome is on the left y-axis. The grade result between the courses is on the x-axis and the average ACT score is on the right y-axis. For example, in Figure 11, thirty students had an average grade decrease between the three classes. Additionally, the average ACT score of these thirty students is approximately 24.
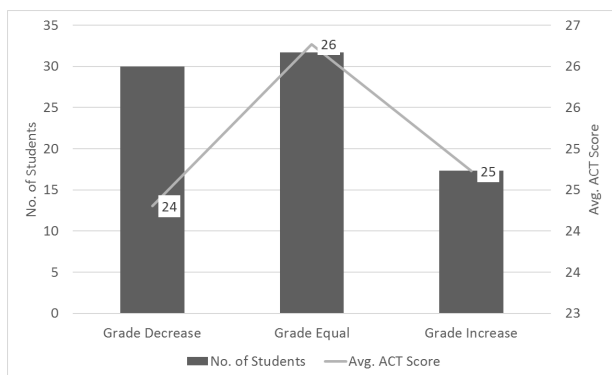

Figure 11: Average Grade Result of Calculus I, Physics I, and Statics Combined
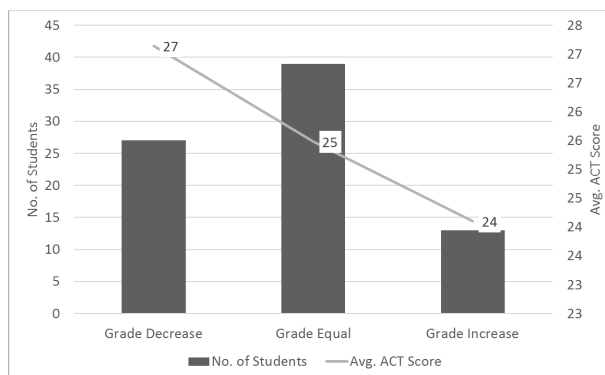
Figure 12: Grade Comparison from Calculus I to Calculus II

Average ACT score and grade outcome showed a positive slope from Grade Decrease (Average 24) to Grade Equal (Average 26). However, the average ACT score went down from Grade Equal (Average 26) to Grade Increase (Average 25). The average ACT score is still higher between Grade Decrease (Average 24) to Grade Increase (Average 25).

A more thorough analysis was performed, comparing grades received in classes of the same department. The grade relation was observed from Calculus I to Calculus 2 (Figure 12), Physics I and Physics II (Figure 13), and Statics to Strengths (Figure 14) separately. Average ACT score was determined by the success between the two classes (whether the grades increased, remained the same, or decreased).

Grade outcomes from Calculus I and Calculus II when compared with average ACT scores showed a negative slope from Grade Decrease to Grade Equal. The average ACT score dropped from 27 to 25. When comparing whether the grades remained the same or had an increase, the slope of the ACT score continued to be negative. ACT scores between the two outcomes fell from 25 to 24.

The Physics I to Physics II comparison showed an increase in average ACT scores from Grade Decrease to Grade Equal. Average ACT scores rose from 23 to 27. Data showed a decrease in ACT scores when relating Grade Equal (Average 27) to Grade Increase (Average 25).
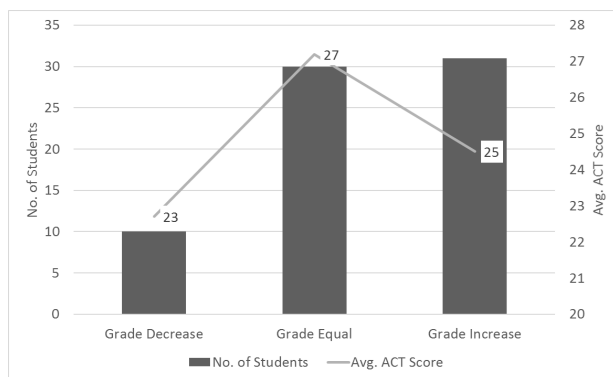

Figure 13: Grade Comparison from Physics I to Physics II
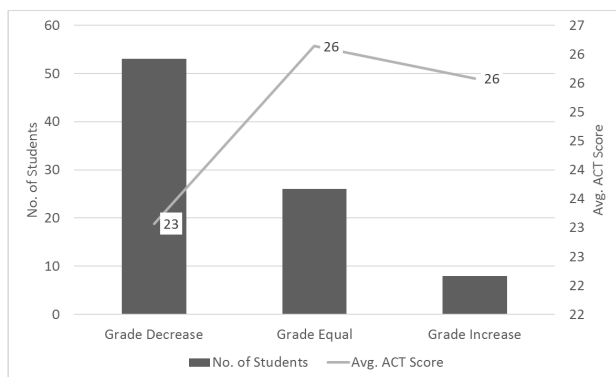

Figure 14 Grade Comparison from Statics to Strengths

In studying the correlation between the grade outcomes from class Statics to Strengths, it was found that the average ACT score increased from Grade Decrease (Average 23) to Grade Equal (Average 26). Average scores from Grade Equal to Grade Increase remained constant with the ACT test (Average 26). This comparison is shown in Figure 14.

Another analysis of the data was performed, comparing grades received in different departments. This cross department comparison was done between Calculus I and Physics II, Calculus I and Strengths, Physics I and Strengths, Physics I and Strengths. The average ACT scores were again calculated for the different grade outcomes.

When comparing the grade results of Calculus I and Physics II with the average ACT scores received (Figure 15), it was found that the average ACT score had an upward slope. Average ACT score for a Grade Decrease outcome is 24, the average score for the Grade Equal is 26. The average ACT score dropped between these same two outcomes, falling from an average of 26 (Grade Equal) to an average of 25 (Grade Increased).
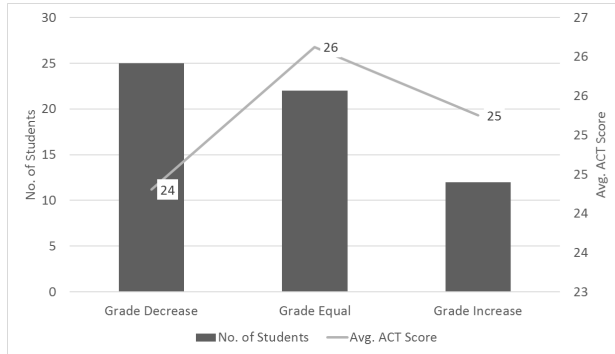

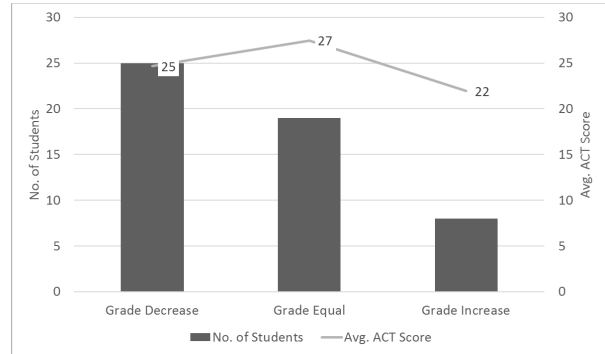Figure 15: Grade Comparison from Calculus I to Physics II

Figure 16: Grade Comparison from Calculus I to Strengths

Grade and score trends were evaluated between classes Calculus I and Strengths, and are shown in Figure 16. It is found that the average ACT scores increased from the final grade result of decrease to equal. The average ACT score increased from 25 to 27. In comparing the average test scores with the increasing grade trend, the ACT score decreased. When the grade remained equal between the two classes, the average ACT score is 27, when the grade increased the average is 22, falling between the two criteria for university acceptance, scores of 24 and 21 respectively.

The average ACT score was examined with the final grade results of Physics I and Strengths. Scores increased in ACT tests from the Grade Decrease outcome to the Grade Equal. ACT scores are 22 (Grade Decrease) and 27 (Grade Equal). Again, when comparing the Grade Equal outcome with the Grade Increase outcome, the ACT scores decreased. The ACT scores decreased from 27 to 25 as shown in Figure 17.
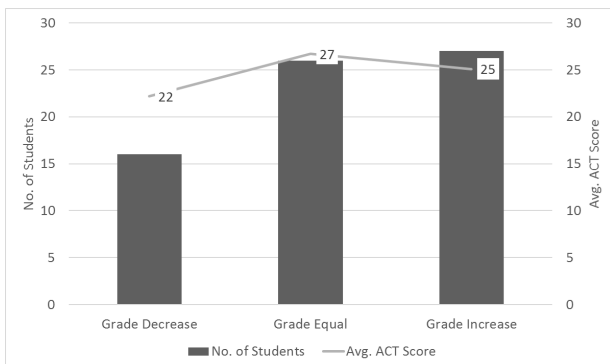

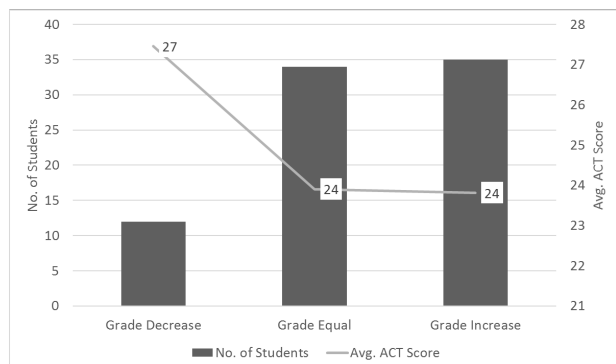Figure 17: Grade Comparison from Physics I to Strengths

Figure 18: Grade Comparison from Physics I to Calculus II

Physics I and Calculus II final grade data was collected and compared with the coinciding average ACT score. The average dropped in the case of the ACT scores. Scores dropped from 27, when the result is a grade decrease, to a 24 when the grade remained equal. Between Grade Equal and Grade Increase, the ACT score remained constant at an average of 24 (Figure 18).

Conclusion:

The data comparison between both ACT scores and ALEKS scores did not show a relationship between a students' success and scores achieved on these tests. The relationship indicated in the data is inconclusive. Approximately the same amount of students succeeded with lower standardized test scores as students with higher test scores. This is a case-by-case basis, but in general; if a student had lower scores on the standardized tests, but did well in the classroom, he or she would have a higher success rate in college. Contrarily, a student who initially scored well on the standardized tests and did not perform well in the classroom would continue to struggle throughout their college career. Therefore, based on the students surveyed, raising the entrance exam requirements will not raise retention rates in construction management, architecture, and architectural engineering students, and could possibly hinder the overall success rate of the student body.

Moreover, it has become obvious that success is more likely to produce success. A student's attitude towards the remedial coursework is key in their success through their college and professional careers. A high ACT or ALEKS score is not reliable if the student does not have the proper personal skills to complement it.

Studies have been conducted comparing students' personal skills and rate of success in college. These studies measured students' Emotional Intelligence (EI) or "common sense". An example survey has a 5-point response scale, ranging from not true of me (1) to very often true of me (5). There are 125 questions to complete the survey. Once it is completed, the results will show the level of the students' Intrapersonal skills (including Self-Regard, Emotional Self Awareness, Assertiveness, Independence, and Self-Actualization), Interpersonal skills (including Empathy, Social Responsibility, and Interpersonal Relationship), Stress Management skills (including Stress Tolerance, and Impulse Control), Adaptability skills (including Reality-Testing, Flexibility, and Problem-Solving), and General Mood (including Optimism and Happiness). (Sparkman, Maulding, and Roberts. 2012)

Two personal skills in particular showed a higher success rate in college. The first skill being Interpersonal and the second skill being Stress Management. Within the Interpersonal skill, two specific traits had a higher rate of graduation. These traits were Empathy and Social Responsibility. Within the Stress Management skill, the trait Impulse Control had increased graduation levels. (Sparkman, Maulding, and Roberts. 2012) A students' attitude towards his or her coursework either increases or decreases their success in college, depending which traits they possess. If a university could accurately depict a students' Emotional Intelligence, it could possibility give them a better predictor for success in the classroom.

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