Standardized Tests as a Predictor for Success in Construction Management Technology

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Dr. Yates joined the Oklahoma State University CMT Faculty in 2006 as an Assistant Professor. She received her Bachelor of Science in Engineering Technology from the OSU Construction Management Department in 1998. She graduated with a Masters of Engineering Technology from Pittsburg State University in 2002. She also earned a Specialist in Education Degree from Pittsburg State University in 2006. In 2010 she was promoted to Associate Professor. She completed her Doctorate in Higher Education from OSU in 2012 where she focused her research on women in Science, Technology, Engineering and Math. She accepted the position as Program Coordinator of Construction Management Technology at OSU in 2013.

Dr. Yates began her teaching career at Pittsburg State University in 2002, and has taught numerous construction courses throughout her academic career including: Construction Drawings, Concrete Technology, Estimating I, Strength of Materials in Construction, Structures I, Construction Contracts, and Capstone courses. She received the Halliburton Excellent Young Teacher Award in 2008, and the CEAT Advisor of the Year in 2010. Dr. Yates served as the Associated Schools of Construction Region 5 Director from 2014-17.

She also enjoys sharing her passion for increasing the recruitment and retention of women in Science, Technology, Engineering, and Math through local, national, and international presentations. Additionally, she speaks on charting your own path in college, navigating your future, and setting goals and achieving them.

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Abstract:

Universities and colleges with Science, Mathematics, Engineering and Technology (STEM) programs use standardized tests of a variety of names to place students into courses. The Assessment and LEarning in Knowledge Spaces (ALEKS) is an assessment tool created by McGraw-Hill with a mathematics placement module. Similarly, CollegeBoard’s Scholastic Aptitude Tests (SAT) and ACT Inc.’s ACT Assessment college entrance exams are used as a basis for admissions into higher education. Since 2012, data has been collected for Engineering and Technology programs to determine if these exams used for admissions and placement actually serve as a predictor for success. This study compares the ALEKS and ACT scores predict success in a comparison to grades achieved in Engineering and Technology classes. Similar studies compared the high school grade point average (GPA) with the ACT as predictors of college success. Other prediction methods are study habits or study types as a predictor for success. Although there are many possible predictors for success, the use of standardized testing is still very popular in higher education. This study seeks to determine if using or the ALEKS or the ACT composite predicts success in engineering and technology fields. More specifically, do standardized math placement tests predict success in future math, physics and engineering based courses? A previous study on learning in the classroom was the basis for this research project. A comparison of success in the course over successive years was performed. Students’ success in the classroom was compared to their previous courses and then expanded to include the college entrance exam and math placement exams. This initial research lead to the question examined in the current research, do entrance exams predict success in construction coursework? 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 limit access instead.

Introduction:

A previous study on learning in the classroom (Mosier, 2016) was the impetus for this research project. In the previous study, students were asked to perform review assignments and report on whether a student as teacher approach helped them reinforce their previous coursework. As validation, the grades of the three prerequisite courses were compared to the post-assignment grade outcomes. Although it was a one-semester project, the data indicated that a better predictor of their outcome was the students’ grades in the previous or prerequisite courses. The research expanded to include the college entrance exam and math placement exams. This initial research lead to the question examined in the current research, do entrance exams predict success in construction coursework?
Major universities and colleges require high school students take an aptitude test, either the ACT or SAT or have some other proof of ability. The aptitude or college entrance exam scores affect into which universities they are accepted. Schools also look at other aspects of a high school career to determine if they will succeed in the next level. Included in this consideration may be essays, Grade Point Average (GPA), extra-curricular activities, and volunteer work.

Engineering and Mathematics departments will also use additional standardized tests to evaluate which classes the incoming student needs to be placed. A common test administered to incoming students is the Assessment and LEarning in Knowledge Spaces (ALEKS) assessment. This tool will theoretically determine into which math class the student should be placed. If the tool is effective, the students ideally pass the course with a “C” or better achieving success.

Between the required aptitude tests (ACT/SAT) and the ALEKS assessment, colleges and universities have several tools to benchmark the expected student success or pass rate. The ALEKS placement test was implemented university-wide in 2012. 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 dataset is compared graphically to determine if there is a relationship between student standardized test scores and student success. Standardized scores are set as the minimum college entrance score for the ACT. For the ALEKS, the score to place a student directly into required coursework for their degree or above remedial coursework is set as the minimum standard. Success in that coursework is set as “C” or passing with the ability to move into the post-requisite coursework.

Other studies have determined that high school grade point average (GPA) is a good predictor of average college GPAs, while the ACT was a better predictor of an above average GPA (Noble, J. and Sawyer, R. 2004). Other prediction methods are study habits or study types as a predictor for success (Blumner and Richards, 1997). Although there are many possible predictors for success, the use of standardized testing is still very popular in higher education. This study seeks to determine if using the ACT or the ALEKS composite predicts success in engineering and technology fields. More specifically, do standardized math placements tests predict success in future math, physics and engineering based courses?

Discussion:

Students in Construction Management Technology (CMT) ALEKS and ACT scores were compared with grades in science, math, and engineering courses. Data was collected in the following classes MATH 2123/2144 (Calculus for Technology 1/Calculus 1), MATH 2133/2153 (Calculus for Technology 2/Calculus 2), PHYS 1114/2014 (Algebra based Physics 1/Calculus based Physics 1), PHYS 1214/2114 (Algebra based Physics 2/Calculus based Physics 2), GENT 2323/ENSC 2113 (Statics for Technology/Statics for Engineering), and CMT 3323/ENSC 2143 (Strengths of Materials for Construction/ Strengths of Materials for Engineering). Although CMT students are required to take Calculus for Technology, algebra based physics and technology engineering science courses, substitutions frequently are given for the more rigorous engineering courses. The University studied typically has an 80% transfer rate into CMT.
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, for a “B” the value is 8, “C” is 7, “D” is 6 and “F” is 5. For students who have taken a course twice, there is a 5.5 for an “F” averaged with a “D”. Additionally, “W” was assigned a value of “0,” as the course was not completed and must be reattempted for credit.

There is a minimum ALEKS placement scores for Math courses. For Calculus 1 the minimum score is a 65 for Technical students and the minimum is 75 for Engineering students. Calculus 2 requires prerequisite courses and not a minimum score. Students who did not make the minimum ALEKS score take remedial math courses. For the University studied, the minimum college assured admission is a combination of 3.0 GPA and a score of 21 ACT, or no GPA requirement with a score of 24 ACT minimum. A third option for admission into the university is being in the top one-third of their high school class and a minimum of a 3.0 GPA. For ACT, the entrance standard is the composite score, so only the composite score will be reviewed. For scores lower than those listed, remedial courses are available. Courses prior to Calculus 1 are considered remedial in this degree program and were not considered as a predictor for success, where success is considered a “C” or better.

To quantify the lack of success, failures were segregated. Because a “D”, “F” or “W” does not contribute to the placement in the subsequent course, they were examined separately. Students who may have received more than one “D”, “F” or “W” for their initial work could not effectively have this prerequisite work averaged into a single score. The “D”, “F” or “W” may indicate poor performance for a single semester or inability to complete a course due to unforeseen circumstances. When only a single “D”, “F” or “W” was present, the score was averaged with the passing score to more effectively indicate the student’s prerequisite grade. A more detailed consideration of multiple “D”, “F” or “W” grades is provided.

The approach was to follow a group of students from their first required math course, not a remedial course, through their math courses, physics courses and concluding with their general engineering courses. The data set includes 117 CMT students at varying stages of their degree program. Grades in each course were compared to their ALEKS scores, ACT scores and previous coursework. Not all students provided an ALEKS or ACT scores. Alternative admissions allow students to forgo the exams if they have previously attended another college and have met the requirements for entering mathematics courses. In the case of the Calculus 1 course, it was only compared to the placement/entrance exam scores. Using linear regression, a flat line indicates no correlation and a forty-five degree line indicates a high correlation. Student success will be defined as a “C” or better.

ALEKS:

As previously noted, the ALEKS exam is a math course placement exam. The Mathematics Department uses it in conjunction with prerequisite grades to determine appropriate initial placement in math courses. The ALEKS placement exam is an online exam. The software requires the student to build equations from a software specific equation writer, so basic computer skills are rewarded. Further, the exam is not proctored for the first attempt and the student has multiple opportunities to attempt the exam for no cost (McGraw-Hill 2015). As a
reminder, success is identified in coursework as a “C” or better with anything else indicating a lack of success.

In the math courses, the ALEKS exam had the lowest level of prediction. For the ALEKS exam predicting Calculus 1, twenty-five students were successful although the placement exam did not predict success or was contradictory to their success. Thirty-eight students had success as predicted. One student did not achieve success although it was predicted. The ALEKS is predicting success at about a 60% rate. A total of nine students placed by the ALEKS did not pass the course, while seven students placed by the ACT did not pass.

Figure 1 ALEKS Calculus 1 and Calculus 2 results

For the ALEKS exam predicting Calculus 2, twenty-four students were successful despite low or below standard placement exam results. Thirty-eight students had success as predicted. Two students did not achieve success although it was predicted. A total of four students placed by the ALEKS did not pass the course.

The Calculus 2 group was also analyzed using a bar graph. The graph ALEKS+ indicates a placement score directly into the required courses. The graph ALEKS- illustrates students who placed into remedial courses as prerequisites and then moved into the required courses. Although there are over 50 students per graph, it becomes easily apparent to determine that the ALEKS did not predict success. For ALEKS+, the linear regression equation shows the slope with a y-intercept of approximately 8 or a “B”. With a slope of 0.0078, the linear regression equation indicates that for all ALEKS scores, there is little variance from a “B”. For ALEKS-, the y-intercept is a 7.4 or a “C”. There is about one half a point different in the y-intercept. However, the slope is 0.0184 or slightly steeper indicating that these students did fare better as their ALEKS scores increased. Anecdotally, the two students with the lowest scores on the ALEKS placement exam, actually received an “A” in Calculus 2.

Figure 2 Calculus 2 ALEKS Bar Graph
For Physics 1 using the ALEKS exam as a predictor, thirty-five students were successful although their placement exam results were below the standard required. Thirty-five students had success as predicted. Three students did not achieve success although it was predicted. For this course, the ALEKS exam has a 50% prediction rate. On an aside, the ALEKS is only used for placement in mathematics courses. However, if success in mathematics is a predictor for success in the next courses, then the mathematics placement test should also correlate. A total of fifteen students placed by the ALEKS did not pass the course.

Figure 3 ALEKS Physics1 and Physic 2

For Physics 2 using the ALEKS exam as a predictor, twenty-nine students were successful contradicting their placement exam score. Thirty-five students had success as predicted. Three students did not achieve success although it was predicted. At this point, all of the students who had success predicted did succeed.

In the Statics course the ALEKS exam was used as a predictor and thirty-six students were successful contradicting their expected results based on the exam score. Thirty-four students had success as predicted. Three students did not achieve success although it was predicted. At this point, all of the students who had success predicted did succeed. Again, although this exam is not expected to predict results outside of mathematics, there is only about a 50% prediction rate. A total of four students placed by the ALEKS did not pass the course.

Figure 4 ALEKS Statics and Strength of Materials
Strengths of Materials course the ALEKS exam did not predict success for twenty-seven students. Twenty-nine students had success as predicted. Two students did not achieve success although it was predicted. The 50% prediction rate holds true at this level. A total of six students placed by the ALEKS did not pass the course.

ACT:

In comparison with the ALEKS, the ACT is an aptitude test. This study focuses on the composite score, as it is the college entrance requirement. The ACT is given as a multiple-choice exam, has a cost associated with it and is proctored. Similarly, the ACT does not have a limit on the number of times it is taken. Student success will be defined as a “C” or better with a minimum of a 21 ACT score.

The ACT had a higher prediction level than the ALEKS for success in Calculus 1, but did not predict poor grade outcomes for students. Eight students were successful with low ACT test scores. Twenty-seven students saw success as would be expected with their ACT scores. Three students had lower than expected scores in the classroom based on their ACT scores.

Figure 5 ACT Calculus 1 and Calculus 2 results

The ACT also had a higher prediction level than the ALEKS for success for Calculus 2, but did not predict poor grade outcomes for students. Ten students were successful with low ACT test scores. Twenty-seven students saw success as would be expected with their ACT scores. Three students had lower than expected scores in the classroom based on their ACT scores. Five students placed by the ACT did not pass.

Figure 6 Calculus 2 ACT Bar Graph
For Physics 1 ten students placed by the ACT did not pass. Eight students were successful with low ACT test scores. Twenty-three students saw success as would be expected with their ACT scores. Seven students had lower than expected scores in the classroom based on their ACT scores. The ACT is also starting to show lower prediction rates. As the students progress through their college careers, failure rates do not match the ACT prediction.

Figure 7 ACT Physics1 and Physics 2

In Physics 2, six students were successful with low ACT test scores. Twenty-seven students saw success as would be expected with their ACT scores. One student had a lower than expected score based on their ACT score.

Figure 8 ACT Statics and Strength of Materials
For the ACT, six students were successful with low exam scores in Statics. Twenty-seven students saw success as would be expected with their ACT scores. One student had a lower than expected score based on their ACT score. Four students placed by the ACT did not pass Statics. In Strengths of Materials, eight students were successful with low ACT exam scores. Twenty-seven students saw success as would be expected with their ACT scores. Five students had lower than expected success based on their ACT scores. Six students with minimum ACT scores still did not pass the Strengths of Materials course.

Prerequisite Grades:

In a previous study on learning in the classroom (Mosier, 2016), a correlation between previous grades and current or future expected grades became apparent. Students who made a “C” or “D”, despite their ALEKS or ACT scores, were likely to continue to make similar grades. The same was true for students with low ALEKS or ACT scores, once the student received an “A”, the student was more likely to continue to be successful. Success here again is identified as a “C” or better otherwise it is a lack of success.

The prerequisite grades in Calculus 1 had the highest success rate for predicting both good and bad grades in Calculus 2. The data lines up deceptively well making it look like fewer data points, when the data points are actually stacked. Students who received a (6) or “D” in the first math are relatively likely to receive the same grade. Students who passed with a (7) or higher were much more likely to make a passing grade. The steeper incline indicates a higher correlation.

Figure 9 Calculus 2 Prerequisite Grades

For Physics 1, the previous grades still have a high success rate for predicting both good and bad grades. The steeper incline indicates the higher correlation.

Figure 10 Physics 1 and Physics 2 Prerequisite Grades
For Physics 2 the previous grades still have a high success rate for predicting both good and bad grades as indicated by the steeper incline. For comparison, four students placed by the ALEKS did not pass the course, and four students placed by the ACT did not pass.

Figure 11 Statics and Strength of Materials Prerequisite Grades

Previous grades still provide better prediction in Statics for both good and bad grades shown by the steeper incline than that for either the ALEKS or ACT. For Strength of Materials, previous grades provide a better predictor as well.

Combined Results:

Of the students studied, there were 564 course enrollments. The students passed 79.6% of the courses. They had a “D”, “F” or “W” in the other 20.4% of the coursework. By reviewing the combined results, it becomes even more apparent that the college success is based on success.

Figure 12 Combined Results - ALEKS
The ALEKS has a 50% prediction rate for success overall. The same number of passing grades were achieved by students who passed the ALEKS as those who required remedial coursework or did not pass the ALEKS. The ALEKS is a placement exam and an argument can be made that students are placed into the remedial courses and then go onto do well in their required coursework. The remedial courses were outside the scope of this project, but may be a subsequent area to research.

Figure 13 Combined Results ALEKS

An ALEKS score of 65 is the minimum to place directly into Calculus 1. The graph is split into two parts, with those scoring below a 65 in the first graph and those placing directly into Calculus 1 with a score of over 65 in the second graph. Further in looking at the increase in ALEKS score versus grades, one would expect the grades to increase with the ALEKS score. However that is not apparent. For both the students whose placement exam scores required remedial work and those who placed directly into required coursework had approximately a “C” average. Looking at the special GPA, those who placed into remedial coursework were about one-half a GPA point lower than those who placed directly into required courses.

An ACT score of 24 is the minimum to place directly into Calculus 1. The graph is split into two parts, with those scoring below 24 or below in the first graph and those scoring 25 or above in the second graph. The ACT has similar results to the ALEKS. For both the students whose placement exam scores required remedial work and those who placed directly into required coursework had approximately a “C” average. Like the ALEKS, those who placed into remedial coursework were about one-half a GPA point lower than those who placed directly into required courses. However, the results for the ACT scores shows the students making about one-tenth of a GPA point lower than the ALEKS. The ALEKS appears to be a better predictor in this sense.

Figure 14 Combined Results ACT
Conclusion:

Although the placement exams were valid indicators of future success, even more indicative of future success was past and current success. In general, students who passed their initial courses continued to make that grade or better in subsequent courses. Students initially failing a course, continue to have poor success in subsequent courses despite initial placement exam scores. If the placement exams are not a better indicator of student success than GPA, why do universities use the exams? If the GPA is a better predictor, why is it not used and why is it a better predictor?

Other factors that bear on the differences in student grades may have to do with the difference in delivery method. These factors include difference in faculty, pedagogy, delivery methods whether online, in class or hybrid, and the opportunity to take either Engineering Science courses versus Technology focused courses. The admissions requirement to the university may also have bearing on the differences in student success.

In each courses examined, previous grades were as good if not better predictor for future success. Although these exams are able to capture knowledge and ability, they do not have a factor for work ethic or ability to transition into a college environment. When looking at the prediction level for the entirety of the coursework evaluated, it becomes obvious that the ALEKS exam is not able to predict future success in coursework outside of mathematics. The ACT exam is much better at predicting future success. Both have outliers where success is predicted, but the student does not achieve success.

The data comparison between both ACT scores and ALEKS scores showed a minor relationship between students success and scores achieved on these tests. The relationship indicated in the data was that the higher the placement score leads to higher grades, but not by much. There were several outliers on both ends of the data. In general, the standardized tests scores are a fair indicator of a students’ success in college.
References:


