

Success of Construction Management Students in Statics

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Statics is a course within a Construction Management curriculum that teaches critical thinking and problem-solving skills. ACT exam scores have long been a part of admission requirements into Construction Management programs. This research uses Construction Management students ACT math score to determine if any correlation exists between their statics score. The hypothesis was that Construction Management students who score better on the ACT math exam or prerequisite math classes would perform better in statics. This could be useful in targeting the correct students to recruit for Construction Management programs. Independent variables were the ACT math score and the average prerequisite math score while the statics scores were the dependent variable. Analysis was performed using the Data Analysis function within Microsoft Excel and data was collected from a mid-sized Construction Management program over a two-year span. The results showed that a strong positive correlation between either the ACT math score or average prerequisite math score and statics score received did not exist. It was concluded that this research showed that using ACT math scores or average prerequisite math scores to predict how a Construction Management student would perform in statics was not reliable.

Key Words: ACT, Construction Management, Critical Thinking, Predict, Statics

Introduction

Problem-solving and critical thinking are two major components of being a successful construction manager. Projects are rarely identical and each one has unique obstacles that must be overcome to successfully complete. One of the challenges that academia is faced with is to present "real-world" situations that students have to complete promptly. Faculty have to be creative in developing assignments that teach students to think critically and solve unique problems under time constraints. There are several classes in a Construction Management curriculum that faculty can use to test a student's ability to think critically.

One entry-level Construction Management (CM) class that teaches students to think critically is engineering mechanics. Engineering mechanics, more commonly referred to as statics, is the study of objects in static equilibrium. This class creates the building blocks for how structures behave. Only a small percentage of construction managers will be involved with the design of structures. However, the problem-solving skills learned from statics can train CM students to think critically and better prepare them for industry jobs. Although there is no better experience than solving problems on a job site, the critical thinking students get from statics can help transition them into industry jobs.

The purpose of the study was to determine if any correlation existed between CM student's American College Testing (ACT) math score and the grade they obtained in statics. It was hypothesized that students with higher ACT math scores performed better in statics and thus exhibited potential to be better critical thinkers. If any such positive correlation existed then it would help CM programs recruit the correct students for their program. If a benchmark ACT math score existed that predicted success in statics (and problem-solving skills) then admission guidelines could be implemented for CM programs. It could also be used to identify those students who excel at problem-solving.

Additional indicators of success in statics were also examined. The majority of statics courses have prerequisite math classes that CM students must complete (or achieve a certain letter grade) before they can enroll in statics. The grades in these prerequisite math courses were compared to a student's grade in statics to determine if any

correlation existed between the two. A second hypothesis was developed that students with higher prerequisite math class scores would perform better in statics. Additionally data could provide CM programs with a list of students who might struggle in statics and need extra help to successfully complete the course.

Thus, this research investigated ACT math component scores and prerequisite math scores as predictors for success in statics classes for CM students. The data was collected from a mid-sized Construction Management program over a two-year span. Statistical analysis techniques were used to determine if any correlation existed between the independent variables (ACT math component scores and prerequisite math scores) and the dependent variable (statics score).

Literature Review

What is the ACT

The ACT is a national college admission examination that consists of four subject areas: English, Mathematics, Reading, and Science. Typically, students take the exam before admittance into an undergraduate program of study in U.S. universities. Each subject area has a series of multiple-choice questions that the exam taker has a certain amount of time to complete. Results for each subject area range from 1-36 with 36 being the highest possible score. An overall ACT composite score is the average of all four subject areas. The national average in the United States for 2017 was 21.0 while the national average in 2017 for just the math portion was 20.7 (ACT 2017).

Prerequisites Math Classes for Statics

A review of Construction Management programs which offer statics (or engineering mechanics I) revealed that either Calculus I or College Trigonometry were used as prerequisite classes. Additionally, some programs required that students must achieve a "C" or better to enroll in statics. Typical Calculus I curriculum covers the properties of derivatives and integrals. College Trigonometry covers trigonometric functions, identities, and equations used to solve triangle solutions.

Investigating reliability of ACT scores as predictors

Research has been completed which investigates both ACT (and the Scholastic Aptitude Test, also known as SAT) composite score results and high school grade-point average as predictors of undergraduate success. One study (Wao 2017) narrowed down the parameters and only looked at the successes of Construction Management students. ACT composite scores were used in assessing the success (prediction of undergraduate grade-point average) of students from two different CM programs. The research concluded that both exams were reliable predictors of undergraduate grade-point averages in CM programs.

Review of readily available research found no other reports of ACT scores as predictors for success in Construction Management programs. Thus, the authors looked to review publications for predicting success of all undergraduate degree programs. Research showed varying results as to the accuracy of using ACT (or SAT scores) along with high school grade-point average as predictors for undergraduate success. One study (Sawyer 2010) reviewed both high school grade-point average and ACT scores to predict undergraduate academic success. The results yielded that overall admission test (ACT) scores were better predictors of undergraduate success than high school grade-point average. However, the results were not definitive, and there were some scenarios where high school grade-point average was more useful in predicting undergraduate success. Another study (Radunzel 2012) found that using a combination of ACT scores and high school grade-point averages was effective for predicting undergraduate success.

Conversely, some publications found high school class rank (or high school grade-point average) was a better predictor of undergraduate graduation rates than ACT exam scores. One study (Sun 2017) reviewed ACT scores

and high school class rank to predict undergraduate graduation rates. The conclusion was that high school class rank (or high school grade-point average) was the better predictor of graduation rates. Individual ACT component (English, Mathematics, Science, and Reading) scores were reviewed to determine if any one of the four components was more useful than the others. Only the English and Mathematics portions of the ACT exam showed any significance of predicting undergraduate success. The research also concluded that if the ACT math score increased by one point. the probability of graduation increased by 11.44%. Although available published data was mixed on which indicator was a better predictor of undergraduate success, the majority leaned towards concluding that the ACT exam was a better predictor of undergraduate success.

A review of published materials showed a lack of publications on the topic of correlating Composite ACT and ACT math component scores with success in statics courses for Construction Management students. The lack of available data on this subject matter was the driving force for this research. As previously mentioned, the authors wanted to determine if students with above-average problem-solving skills could be identified.

Statics in construction review

Research has shown that CM students struggle with statics (McCrary 2008). They examined ways to improve statics scores by introducing large-scale, in-class models into the classroom. It was concluded that this method of teaching increased the students understanding of the material. Additional research has been completed to help determine methods in which students understand statics material easier (Lesko 1999). Different hands-on methods were developed to help with the effort. However, the results with the hands-on methods were not positive.

Others (Kirk 1996) have suggested that successful CM students need to use both sides (left and right) of their brain. It has been proposed that the right side of the brain controls ones creative or artistic characteristics, and the left side is responsible for ones analytical thinking. While most CM curriculums focus on the engineering (left side of the brain) more emphasis needs to be put on critical thinking (or right side of the brain). Different exercises for CM educators were presented to help develop critical thinking skills for the students.

Problem Solving in Construction

There are generally eight characteristics every successful construction manager should have (Holtkamp 2017). They are enthusiasm, organization/priorities, knowing your workers' skills, team player, communication skills, optimism, calmness under pressure, and problem-solving. Most of these traits cannot be easily learned/taught in the classroom and for some it takes years to master. Although no one textbook exists which presents all the problems a construction manager will encounter on the job, one can be given problems that make them critically think. This training of the brain on problems that are outside their comfort zone will better prepare them for "real-life" situations. It can be agreed upon that most CM students struggle with statics (McCrary 2008). Statics is a beneficial class within a CM curriculum that teaches students to critically think and gets them out of their comfort zone. Thus, statics is a good class to prepare CM students for solving problems once in industry.

Statics is a very beneficial class for all CM students because it provides students a platform to practice their critical thinking and problem-solving skills while at the same time introducing them to the behavior of simple structures. Most CM students may never be responsible for the structural design of load-carrying members of a building or structure. However, many components of the construction process require knowledge of basic structural behavior. The understanding of simple structural behavior can be used for many applications once they reach industry. These areas can include life-safety situations such as crane placement, concrete formwork design, simple wood structure design, temporary shoring capacities, existing structure renovation, plus many more. Hence, it is critical for CM students to have a general understanding of statics before entering the workforce.

Research Methods

Scores and grades were gathered from a mid-sized Construction Management program over a two-year period. Correlation and regression analysis was performed on ACT math component scores, average letter grade results from both College Algebra and College Trigonometry, and letter grade results from statics to determine if any relationship existed between the three different variables. The statics class used for this research was a sixteen-week three-hour course. Topics covered included force systems, reactions, truss analysis, shear/moment determination, and wood beam design. Coursework consisted of weekly assignments and quizzes with three exams and a final.

Objectives and Hypothesis

The objective of this research was to determine the correlation between either ACT math scores or average prerequisite math scores, and the result that CM students receive in statics. Additionally, a second objective was to determine if the ACT math score and the average prerequisite math class scores could predict a student's final letter grade in statics.

The hypothesis was that CM students who score better on the ACT math exam or prerequisite math classes would perform better in statics, Figure 1. This could be useful in targeting the correct students to recruit into CM programs. Further, it would help programs identify students who might struggle in statics and provide proper help to those students prior to enrolling in statics.

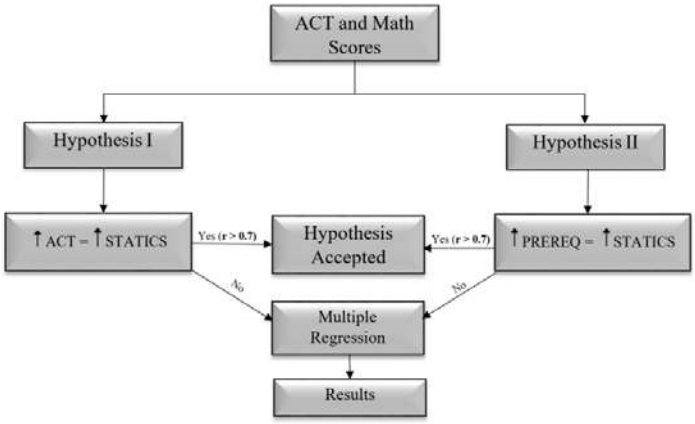

Figure 1: Hypothesis of research performed

Data Collected

The original sample size consisted of 73 students (N=73). However, ACT exam scores were not collected for every student. The CM program where the data was collected only required ACT scores for incoming freshman or transfers with less than 24 credit hours. Thus the number of students with ACT scores (N_{ACT}=51) recorded do not match the number of students with prerequisite average math score results and statics score results. Any student who dropped the statics course was not included in the data set. However, students who did receive a failing grade (F) were included in the analysis. To normalize the letter grade results into numerical values, the following conversions were used: A=4, B=3, C=2, D=1, and F=0. Further, College Algebra and College Trigonometry results were averaged to create one single data point (average prerequisite math score).

Data Analysis

Data recorded consisted of ACT math component scores, average prerequisite math scores, and statics scores of CM students. ACT math scores ranged from 14 to 32, average prerequisite math scores ranged from 1 to 4, and statics

scores ranged from 0 to 4. For data analysis purposes the ACT math score and the average prerequisite math score were the independent variables while the statics scores was the dependent variable. Analysis was performed using the Data Analysis function within Microsoft Excel.

Individual statistics of each of the three variables analyzed were calculated and shown in Table 1, and Figures 2-4 show the distribution of each variable.

Table 1

Calculated statistics of ACT math scores, average prerequisite math score, and statics scores

Variable	N	Mean	Median	Std	Min	Max
ACT Math	51	22.2	22.0	4.26	14	32
Prereq Math Average	73	2.82	3.00	0.73	1	4
Statics	73	2.42	2.00	1.28	0	4

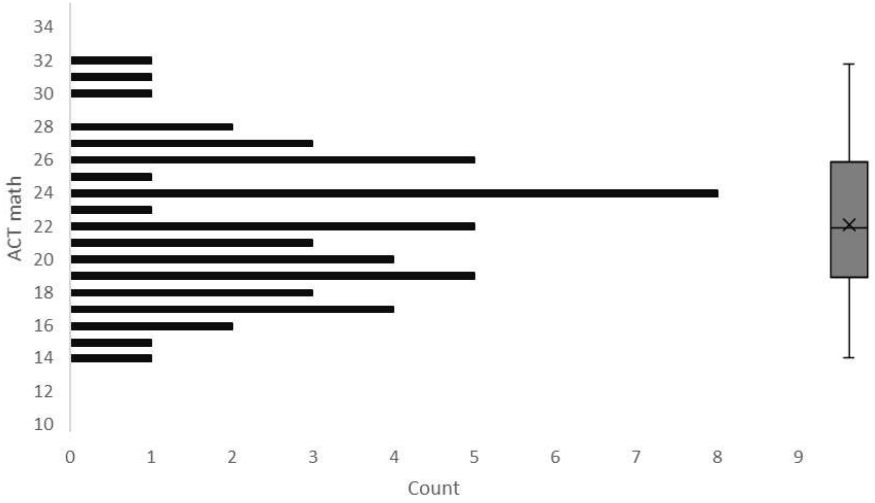

Figure 2: Distribution of ACT math scores

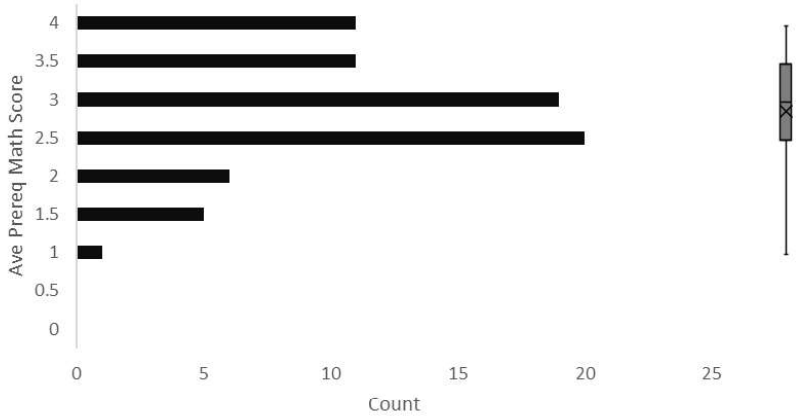

Figure 3: Distribution of average prerequisite math scores.

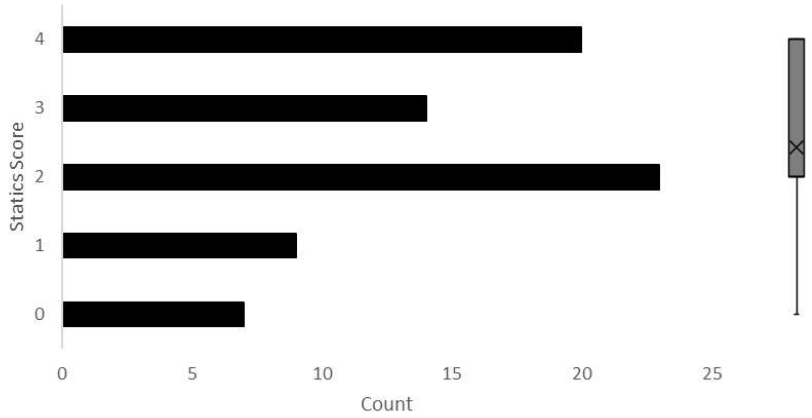

Figure 4: Distribution of statics scores

Figure 2 shows that the average ACT math score was near 22. As mentioned in the Literature Review, the national average for the ACT math component in 2017 was 20.7. Thus, the data pool was slightly higher than the national average. Figures 3 and 4 show that the average prerequisite math score (2.82) was slightly higher than the average statics score (2.42). Figure 5 presents all the data on one single chart breaking the data into five separate areas corresponding to each possible statics score result (0-4). Across the top of the chart, the statics score results are separated by score (0-4) and then their corresponding ACT math score and math prerequisite are shown. For example, for all the students who received an F (or 0) in statics, it shows the average prerequisite math score and the students corresponding ACT math score. Figure 5 also shows the data for all the students who received an A, B, C, or D in statics (1-4).

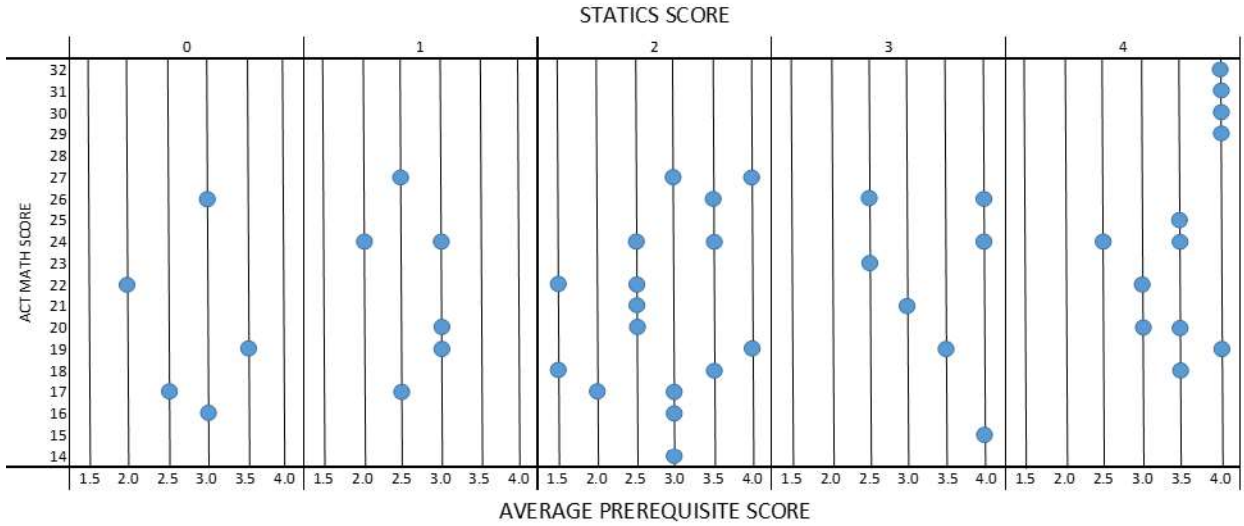

Figure 5: Breakdown presenting all data points

Results

Correlation analysis investigated the relationship between the ACT math scores, average prerequisite math scores and statics scores. The following guideline was used to determine the correlation relationship (r) strength of each independent variable compared to the dependent variable (+/-0.01 to 0.09 = negligible relationship, +/-0.1 to 0.19 = very weak relationship, +/-0.2 to 0.29 = weak positive/negative relationship, +/-0.3 to 0.39 = moderate

positive/negative relationship, +/- 0.4 to 0.69 = strong positive/negative relationship, +/- 0.7 and higher = very strong positive/negative relationship). The correlation between ACT math scores and statics scores was a weak positive relationship (r = +0.28). The correlation between average prerequisite math scores and statics scores was a moderate positive relationship (r = +0.38). Although this result was closer to +1.0 (strong positive relationship) it was still in the moderate positive relationship.

Multiple regression analysis was performed to determine if ACT math score and average prerequisite math scores combined could accurately predict ones students' statics score. The prediction of statics score were as follow:

Statics score = -1.2931+0.0506*(ACT math score) +0.8137*(average math prerequisite score)

The regression model resulted in an coefficient of determination (R^2) value of 0.23 implying a weak positive relationship.

Conclusions & Discussion

Critical thinking and problem-solving are two major components of a successful construction manager. One class in a Construction Management curriculum that promotes critical thinking and problem-solving is statics. The authors sought to see if they could predict which students would be successful in statics based in their ACT math scores and/or prerequisite math scores. It was hypothesized that CM students who score higher on the ACT math exam or prerequisite math classes would perform better in statics. The students with higher scores would be expected to be better problem solvers and ultimately make successful construction managers. If a strong positive correlation (r > +0.70) between ACT math scores and statics scores existed, then students who exhibit strong problem-solving skills could be identified. University admission departments could then use the data in admitting the correct students into a CM program. Further, if a strong positive correlation (r > +0.70) between average prerequisite math scores and statics scores existed, CM programs could determine which students would be successful in statics. Being able to identify those students who might be unsuccessful in statics would allow CM programs to adjust their prerequisite requirements in College Algebra and College Trigonometry before they enroll in statics.

The results showed that a strong positive correlation between either the ACT math score or prerequisite math score and statics score received did not exist. The correlation of r = +0.28 between ACT math and statics along with a correlation of r = +0.38 between average prerequisite math score and statics indicated that no confident predications could be made. A multiple regression model using ACT math and prerequisite math scores as the independent variables and statics score as the dependent variable was computed and once again, no reliable prediction equations could be developed. This resulted in a coefficient of determination (R^2) of 0.23. It was concluded that using either ACT math scores or prerequisite math scores to predict how CM students would perform in statics was not feasible.

Data showed (Figure 5) there were students who had performed well on both their ACT math and prerequisite math classes but did not perform well in statics. Conversely, the data also showed students who performed poorly on the ACT math but performed well in statics. There were also students who performed above average on all three variables and students who did poorly in all three areas. If the hypothesis would have been confirmed, then an obvious trend line in Figure 5 would have shown a pattern going from the bottom left to the upper right. However, it can be seen that the data points are scattered throughout each section of the chart.

Several reasons for unsuccessful correlation were derived. The ACT exam is used for undergraduate admission and students typically take it during high school. Undergraduate students typically take statics during their sophomore or junior years in college. A significant amount of time has eclipsed between the two events and the study habits and maturity levels of students can change drastically. Those who performed poorly in high school have since developed better study habits; explaining the improvement in statics. In addition, statics has construction applications introduced into the curriculum that can keep the interest of students while math classes might not be able to keep their interest, which may explain increased statics scores over ACT math and math prerequisite score.

Conversely, in a college setting, undergraduate students have more freedom and other outside distractions than they typically do in high school, thus explaining why some did well on the ACT exam but performed poorly in the statics class.

In conclusion, this research showed that using ACT math scores or average prerequisite math scores was not reliable in predicting how a CM student would perform in statics. Although the average prerequisite math score did produce a better correlation ($r = +0.38$) than the ACT math score ($r = +0.28$), they both were categorized as being weak to moderate positive correlations.

Further research is ongoing to survey the students once they have five years of construction industry experience to see if they consider themselves successful construction managers. The authors need three to four years before the data will be available.

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