ACT Preparation and the Percent of Variability in First Year Engineering Student GPA Explained by ACT Scores

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ACT/SAT Preparation and the Percent of Variability in First Year Engineering Student GPA Explained by ACT/SAT Scores

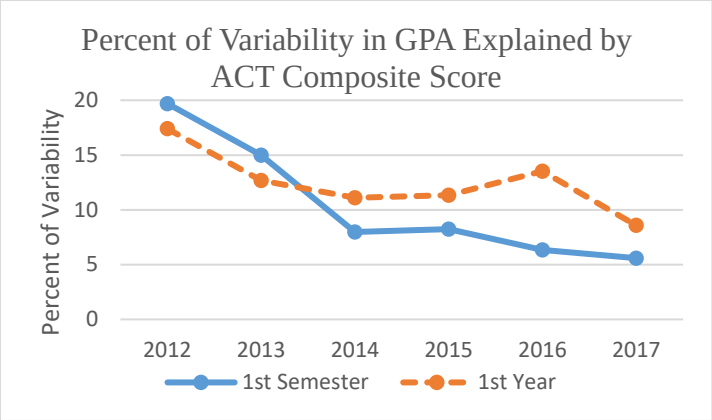
Introduction

This paper is categorized as complete research. College entrance exams in the United States date back to the late 1800's when individual colleges had their own entrance exam. Schools not using entrance exams sometimes relied on certifications from high schools which were thought to provide an adequate background to prepare students for college [1]. Due to inconsistencies and inability to audit all the high schools, standardized college entrance exams grew in popularity. From the first offering of the "College Board" in 1901, to the first SAT in 1926, to the first ACT in 1959, to today, the content, format, and scoring of the exams has changed [1]. The number of students taking entrance exams has increased dramatically; 1.78 million (52%) of the 2018 high school graduating class took the ACT alone and 15 states require all high school graduates take the ACT [2].

Although used by many schools, a growing number of schools have stopped requiring ACT/SAT scores for admissions. In 2015, when George Washington University stopped requiring that SAT or ACT scores for admissions, 850 accredited bachelor's degree granting schools were no longer requiring the scores [3]. Some of these schools made this decision based on the belief that not requiring SAT or ACT scores for admissions would increase the number of students from underrepresented groups or with lower financial means [4], [5]. Some universities have realized an increase in the number of students from underrepresented groups and lower social economic status after dropping the dropping the requirement of submitting SAT or ACT scores [4], but others have not [6]. While some universities stopped using entrance exams due to the belief that there are better predictors of performance, retention and graduation [4], [7].

Educational studies investigating college performance, retention and graduation have used scores on the ACT and SAT as a predictor or covariate variables when attempting to craft models that predict positive performance in college coursework [8]. The same is true of the research related to engineering educational research [9]–[11]. Some research has shown a decreasing trend in the amount of variability in first-year engineering students' GPA that can be explained by ACT scores [12], [13]. The current study was prompted by an observation made at one of the institutions, of a downward trend in the variability of first-semester engineering student GPA that could be explained by a student's ACT score (see Figure 1). Figure 1 also includes the trend in variability of first year GPA explained by ACT composite score since that is the measure used in the current study. The data used for the first year GPA only includes students still in engineering at the end of the second semester.

Figure 1
Trend in variability in 1st-semester and 1st year GPA explained by ACT composite score.



Test Preparation

During the time span of the noticed decrease in variability of GPA explained by entrance exam scores, the researchers also made note of an apparent increase in the number of entrance exam test preparation offerings through new business and individual promotion. In 2009 when Princeton Review was one of the largest test preparation companies, they reported over $100 million in revenue [14]. In 2018, Princeton Review laid off employees partially due to growth of competitors [15]. In financial sector reporting, the test preparation industry is combined with other educational offering so it was not possible to know how it has grown, but the sector including test preparation has been experiencing growth [7].

Overall, test preparation targets improving the skills measured by the test and/or test taking skills [16]. Some test preparation companies have guaranteed an increase in test scores [17], but the research on whether test preparation increased scores is mixed [17]–[20]. In 2017, after years of insisting that prepping for the SAT did not help increase scores, the College Board released results of a large study of students who used the free Official SAT Practice on Khan Academy. Within the study they accounted for the average increase in scores for a test retake without additional study. They concluded students (n = 250,000) who were on the Khan site for at least 20 hours, increased their scores on average of 115 points and over 6% gained more than 200 points between the PSAT/NMSQT® and SAT [21].

Results of studies investigating the gains from test preparation need to be taken with caution as the variables, such as when the tests were taken, how many times the student took the test, when the test preparation was completed, the quality of the preparation, and the student's effort, might be hard to account for or record. It is important to note that test preparation might have benefits, other than higher exam scores, that are hard to measure and might help students perform better in college. A few potential benefits include improving study skills, learning how to use resources (i.e. Khan Academy), and improving time management.

How students perform on entrance exams and during their first year in engineering school is determined by many complex factors and has been the subject of many research studies. This study focuses specifically on investigating a potential reason for the decrease in the variability in first-year GPA for engineering students that can be explained by ACT scores. In particular, the current research sought to investigate if the amount of time students spent on test preparation was related to the usefulness of the exam score in predicting their first year GPA.

Research Question

The goal of the current study was not concerned with whether the test preparation a student completed did or did not improve their score, but instead to determine if the amount of test prep a student completed had a relationship with the amount of variability in first year GPA explained by their ACT composite score. Specifically, the research question was: *Is the amount of variability in first year GPA of engineering students explained by ACT scores different based on the amount of test preparation the student indicated they completed?*

Research Design

This study follows a case study design, providing an in-depth investigation of the retrospective recollection of first-year engineering students' report on their study preparation for their performance on the ACT exam. Employing the methods of case study research, the researchers composed a systematic archive of all the data, termed a dataset, for each university. Following the principles of case study design [22], the researchers bounded the case of study to the 2017 first-year engineering student cohort from each university, starting the dataset at the beginning of the fall-semester and ending at the end of the spring-semester.

Data Collection

During the first week of Fall 2017 semester, first-year engineering students in a required class at two large metropolitan research universities were asked to complete a survey. The survey at the University of Louisville contained 17 questions related to a variety of first-year engineering retention factors. The survey was administered during class and students were given no rewards or class credit. The survey given at the University of Cincinnati contained 52 questions also related to a variety of retention factors and was given as a homework assignment along with three other surveys. The survey questions of interest to this study pertained to the amount and type of preparation students did before taking the ACT.

The first question read as follows:

When preparing for your standardized College Entrance Exam (e.g., SAT, ACT), please estimate how many hours total you spent in:

- *ACT/SAT Preparation Course*
- *Private ACT/SAT Coaching/Tutoring*
- *Self-Study*

Other studies have investigated more detailed preparation methods, for example using a certain guidebook [18], [23]. We believed the methods could be condensed to the three areas for this study. Since we were not interested in relating the type of preparation to actual scores on the tests, but instead the time put into preparation and the amount of variability in first year grades explained by the ACT score, this is appropriate. During the design stage of the study, multiple response options were considered, including open response. After much discussion, the research team decided on the three response options for the participants: *0 hours, 1-5 hours, and over 5 hours*. This scale allowed for separation of the students who did no preparation, students who might have done a practice test or went to an evening session on test preparation, and those who took a longer preparation course, meeting multiple times with a private tutor or engaged in self-preparation that extended over time.

ACT composite scores were extracted from student records along with demographic information and first year GPA. The ACT composite score is the rounded average of the subject score (math, science, reading and English) and has a maximum score of 36. The ACT test does not claim to measure IQ, as questions are based on what students should have learned in high school and according to ACT measures of college readiness [2].

At both universities the GPA had a maximum of 4.0. Included in the GPA for a typical student at the University of Cincinnati is 32 credit hours: science/science lab (10), math (8), engineering (9) and English (3). A typical first year engineering student at the University of Louisville takes 33 credit hours: science/science lab (12), math (8), engineering (4), English (6) and general education (4).

Analysis

Considering the differences among the data collection, the distribution of responses between the two universities was analyzed for internal compatibility to determine if the data reported from both universities should be combined and further analyzed as one dataset or maintained as two separate datasets. An independent measures t-test was employed to establish if there was a difference in the mean GPAs collected from the two universities. The results of this dataset maintenance analysis can be found below.

Following the determination of dataset maintenance, the participant responses to the three survey questions were coded into 3 categories: *None* (indicating student responses of 0 for all three types of test prep), *More* (those who answered > 5 hours for at least one method of test preparation) and *Some* (representing all other responses or those responding to have 1-5 hours of test preparation). To determine the percent of variability in first year GPA that was explained by ACT scores for each group, a linear regression analysis was performed with ACT score as the predictor and GPA as the independent variable for each of the 3 preparation categories. Analysis was performed using the statistical analysis software, SPSS.

Participants

Four hundred seventy-two students for the University of Louisville and 887 students from the University of Cincinnati participated in the study. All participants were students enrolled in a required first-year engineering class. Table 1 shows the demographics for the participants. It is common at both universities for over 95% of the students in the first-year engineering courses to be traditional students directly out of high school. Table 1 also shows the percent of students coded in the ACT prep categories *None*, *Some* and *More*. The number of students that indicated they did no preparation for their ACT (13% and 14%) was lower than in a 2010 study (not specific to engineering students) where between 20% to 30% percent of the students of various financial means reported they did not prep for their college entrance exams [17]. Although the survey administration and rewards (homework grade at one university versus no credit or rewards at the other) were different, the percentage in each category were similar for the two universities. The highest percentage for both universities was in the *More* category. Table 1 is comprised of participant demographics for this study and percentages of each category of responses used for analysis in this study.

Table 1
Demographics of participants and category for prep effort based on time

	University of Louisville	University of Cincinnati
Total participants	*472*	*887*
Male	*366*	*702*
Female	*106*	*185*
Asian	*21*	*66*
Black/African American	*20*	*31*
Hispanic/Latino	*21*	*31*
Caucasian	*380*	*717*
Other race	*30*	*42*
Mean ACT score (*SD*)	*29.13*	*27.05*
1st Year Mean GPA (*SD*)	*2.98(.781)*	*3.17(.649)*
Percentage *None*	*14%*	*13%*
Percentage *Some*	*40%*	*38%*
Percentage *More*	*46%*	*49%*

Results

Dataset maintenance. To determine internal compatibility between the two independent datasets an independent t-test was used. Due to unequal sample sizes, the dataset violates the assumption of homogeneity of variances. Thus, we have chosen to report the t-test results of the unequal variances to account for this violation. Additionally, the datasets have a negative skewness, as confirmed through visual inspection of the Normal Q-Q plot and histograms of the GPAs. However, since both the University of Cincinnati and University of Louisville had similar skewness *(-1.222 and -1.018,* respectively) we chose to continue with the independent t-test analysis toward our decision toward maintaining the two datasets.

The results of the independent samples t-test indicated a significant difference, *t(694.7)=4.325, p<.0005.* The University of Cincinnati's mean GPA was *0.192 (95% CI, .273 to .110)* points higher than the mean GPA of University of Louisville. There are many possibilities for this significant difference. Some possibilities include: the slight difference in coursework (description in the Data Collection section), the courses students are advised to enroll in each semester, or the course requirements prior to entering college may vary. This result brought us to the decision to maintain each dataset independently of one another. Table 2 outlines these results.

Table 2
GPA Mean difference results

							95% CI	
	University	**N**	**Mean**	**SD**	**t**	***p***	**Lower**	**Upper**
GPA	Cincinnati	*860*	*3.17*	*0.65*	*4.325*	*<.0005*	*.105*	*.279*
	Louisville	*413*	*2.98*	*0.78*				

Distributions of GPA an ACT scores. The distribution of ACT scores of both university participants are shown in Figures 2 and 4. The percentage of students who reponded *None*, *Some* and *More* for each of the ACT scores are shown in Figures 3 and 5. Based on these plots, the percent of students in each prep category is close for each ACT score except at the high and low ends were few students were represented.

Figure 2

University of Cincinnati, distribution of ACT composite scores by preparation categories

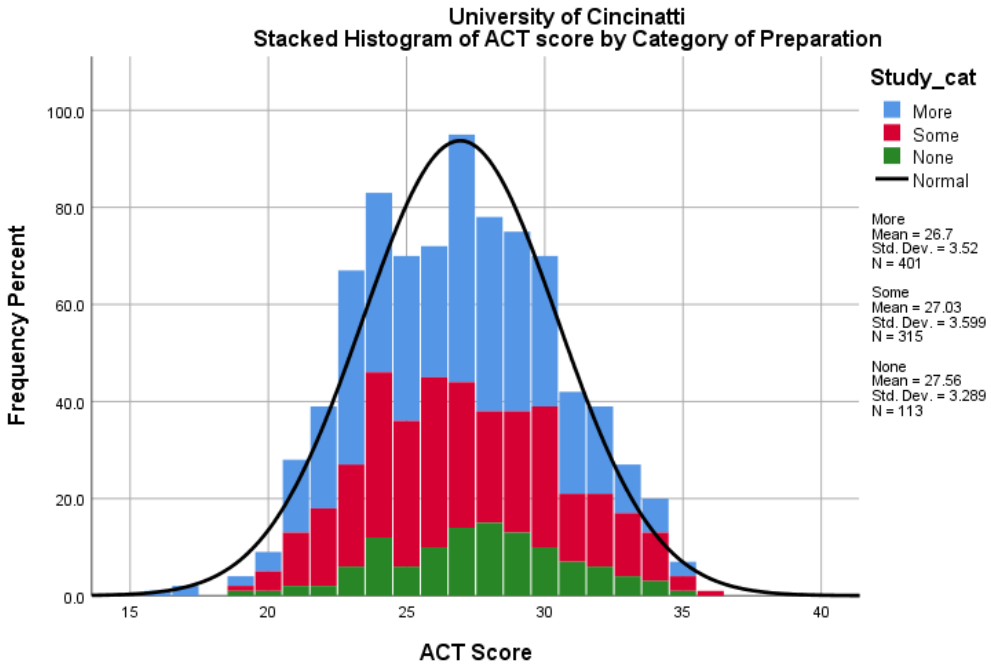


Figure 3

University of Cincinnati percent of students in prep category by ACT composite score

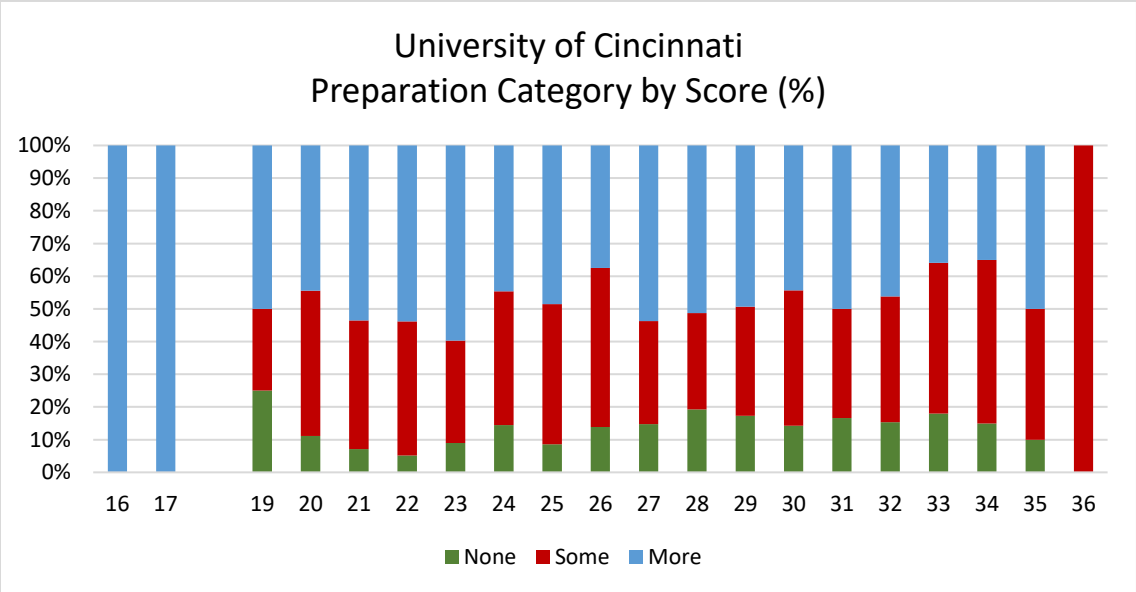


Figure 4

University of Louisville, distribution ACT composite scores by preparation categories

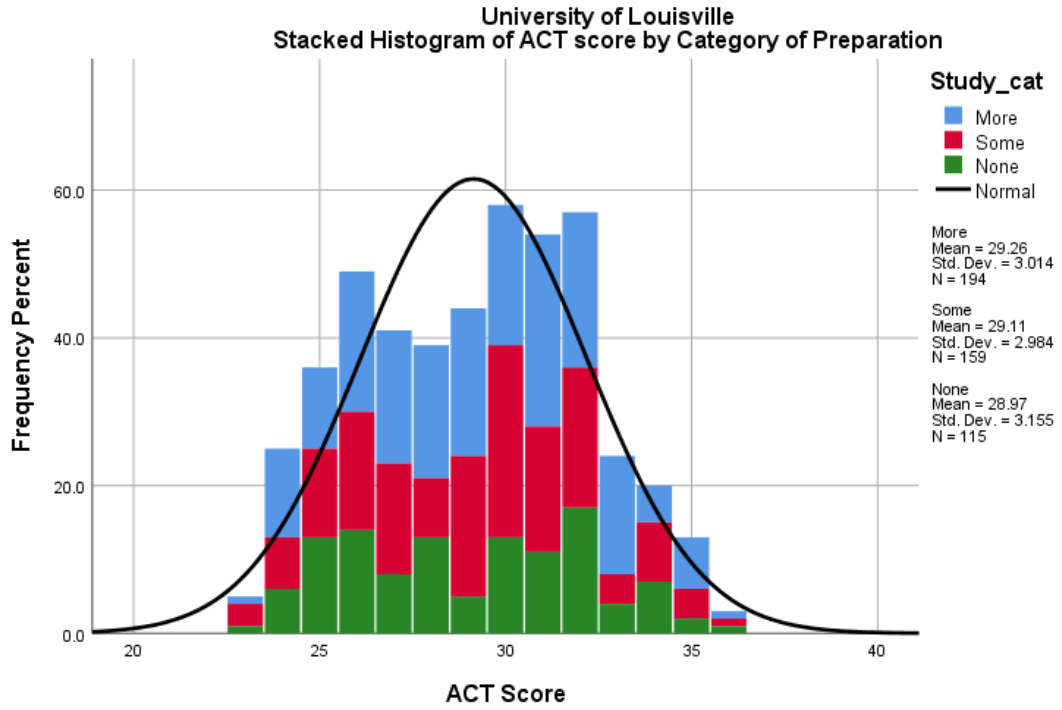
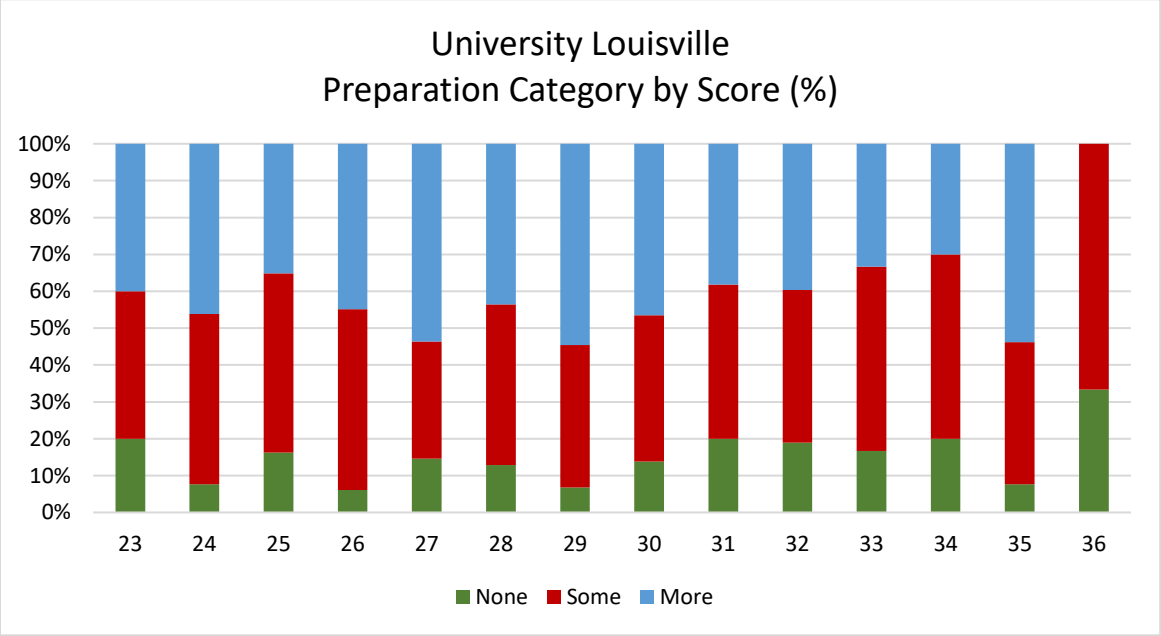


Figure 5

University of Louisville percent of people in prep category by ACT composite score



Regression Results

University of Cincinnati A linear regression established that for each study preparation category, *None, Some,* and *More,* the ACT composite scores of University of Cincinnati students was statistically significant in predicting 1st-year GPA. For the category of *None*: *F(1, 105) = 5.372, p = .022* and accounted for *4.9%* of the variability in GPA which is considered a small effect size [24]. For the category of *Some*: *F(1, 301)=35.568, p < .001* and accounted for *10.6%* of the variability in GPA, a small effect size [24] but an improvement from the 'none' category. And for the category of *More*: *F(1, 392) = 57.353, p <. 001* and accounted for *12.8%* of the variability in GPA, still a small sized effect [24] but even more improved from the *None* or *Some* categories. Although the average ACT score was highest for the students in the *None* category and the average first-year GPA was highest for the students in the *More* preparation category, **analysis of variance found the difference was not significant** (difference between mean GPA, *F(2, 838)=.407, p=.67) (*difference between mean ACT score, *F(2, 826)=2.804, p=.061).*

University of Louisville. A linear regression established that for each category, *None, Some,* and *More* of study preparation for the ACT reported by University of Louisville students, each category was statistically significant in predicting 1st-year GPA. For the category of *None*: *F(1, 57)=3.711, p=.059* and accounted for *6.2%* of the variability in GPA, a small effect size [24]. For the category of *Some*: *F(1,163)=23.639, p<.001* and accounted for *12.7%* of the variability in GPA, a small effect size [24] but improving from the '*none*' category. For the category of *More*: *F(1, 190)=15.587, p<.001* and accounted for 7.6% of the variability in GPA, still a small effect size effect [24] and only slightly higher than the 'none' category. The mean GPA and ACT composite scores are presented in Table 3 below. Again, students in the *None* category had the highest average ACT score and the students in the *More* category had the highest average first year GPA, but **analysis of variance found the difference was not significant** (difference between mean GPA, *F(2, 410)=2.436, p=.089)(* difference between the categories based on mean ACT score, *F(2, 469)=1.485, p=.227).*

Table 3

Overview of regression results

	University of Cincinnati			**University of Louisville**		
Category	*None*	*Some*	*More*	*None*	*Some*	*More*
N	106	302	393	58	164	191
Mean GPA	3.12	3.16	3.17	2.85	2.92	3.07
Mean ACT	27.74	27.05	26.72	30.03	29.23	28.99
% Variability in GPA	***4.9%***	***10.6%***	***12.8%***	***6.2%***	***12.7%***	***7.6%***
R	0.365	0.357	0.337	0.312	0.246	0.322
R^2	*0.049*	*0.106*	*0.128*	*0.062*	*0.127*	*0.076*
Adjusted R^2	0.040	0.103	0.126	0.045	0.122	0.071
F	5.372	35.568	57.353	3.711	23.639	15.587
p	***.022****	***<.001****	***<.001****	***0.059***	***<.001****	***<.001****
B	0.044	0.060	0.065	0.072	0.089	0.069

Note: * indicates statistically significant

Conclusion and Discussion

This study was the first step in investigating if the amount of test prep for the ACT is related to the amount of variability in first semester GPA that can be explained by ACT composite score. The results of this study show that the ability of the ACT composite score to explain variability in the first year GPA of engineering students is not diminished if the student engages in preparation for the exam. On the contrary the results of this study showed that at both universities the amount of variability in first year GPA that was explained by ACT scores was higher for those who had studied for the ACT versus those who had not.

Following examination of the results, the researchers investigated if the amount of test prep was different for students who earned certain scores. Tables 1 and 2 display the ACT scores and the distribution of scores within each test preparation category was close, with the exception of high- and low-end values where the sample sizes were small. The analysis of variance showed no statistical difference in the ACT scores or the first semester GPA for students in the three prep categories.

Future research

Based on the results of this study, the researchers anticipate more investigation to be done to better understand the relationship between ACT composite scores, test preparation and GPA for engineering students. In this study, data was not gathered that would allow for the determination if test preparation improved students' scores. If this data were available, analysis could be done to see which score (before or after preparation) explained more of the variability in GPA. It would also be interesting to research whether the testing skills gained in ACT prep carried further and helped students score higher on exams in college.

Limitations of the study

It is imperative that the results of this study be viewed with the limitations of the study in mind. The amount of time spent preparing for the ACT was self-reported and retrospective, thus there is no way to verify the reported values. The survey questions were administered at two separate universities under two different administration conditions (i.e. counted for homework and not counted for homework at the other university). Additionally, the distributions of *None*, *Some* and *More* were similar at both universities leading to more confidence in the responses. The data gathered does not account for the quality of the preparation work or how effective students used their time while study, nor is there a way to know if the test preparation impacted the scores students received on the test. Finally, the *More* category was any student who indicated they prepped more than 5 hours in self-study, a class or with a tutor, but there could be a tremendous amount of variability in the number of hours students within the *More* category prepped

The participants in this study were all engineering students enrolled in first-year coursework at two large state, metropolitan research institutions. The results of this study can be applied to similar colleges of engineering with similar distribution of ACT Composite scores (average between 27 and 29 with standard deviations between 3.0 and 3.6), but it is unwise to apply results to students at dissimilar universities.

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