VOLUME 35, NUMBER 2

April-June 2019

Author
Dr. Jeffrey M. Ulmer, Ph.D
Professor of Engineering Technology, Technology Management, and Industrial Management at the University of Central Missouri

ATMAE
3801 Lake Boone Trail
Suite 190
Raleigh, NC 27607

www.atmae.org

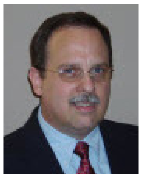
JTMAE The Journal of Technology, Management, and Applied Engineering

A Body-of-Knowledge Builder:

Does a carefully designed statistics course enable college students with below-standard ACT Math college readiness scores to significantly increase their earned descriptive statistics assignment grades?"

Keywords:
ACT, Body of Knowledge, Mathematics, Statistics, Student Success

SUBMITTED FOR *PEER – REFEREED*



Dr. Jeffrey M. Ulmer Ph. D is a Professor of Engineering Technology, Technology Management, and Industrial Management at the University of Central Missouri in Warrensburg, Missouri, teaching both undergraduate and graduate students. Ulmer is an American Society for Quality Certified Six Sigma Black Belt and a Certified Manager of Quality & Organizational Excellence. Ulmer is also an Association of Technology, Management, and Applied Engineering Certified Senior Technology Manager. His 25-year industrial background is as a trained Lean Six Sigma Black Belt, Laboratory Manager, Engineering Manager, and Resident Engineer (from the Regal-Beloit Corporation, Leeson Electric Corporation, and The Sandor Corporation); having worked in the areas of product engineering, project management, quality assurance / control, and production management.

A Body-of-Knowledge Builder:

Does a carefully designed statistics course enable college students with below-standard ACT Math college readiness scores to significantly increase their earned descriptive statistics assignment grades?"

Abstract

The course Quality Systems Engineering was offered over eight semesters (fall of 2016 to the fall of 2018) in 100% online, face-to-face, and hybrid to undergraduate and graduate students worldwide. While 148 students took the course, only 70 of those students had an ACT Math score. Study results indicate that students earning ACT Math college readiness scores is different and statistically significant ($p < 0.001$) in comparison to earned descriptive statistics assignment grades for both students earning less than 70% (ACT: 25.2 score) on ACT Math scores ($N = 49$) and for the composite of all students in this study earning an ACT Math score ($N = 70$). This means that student knowledge is increasing between the time that students take the ACT Math portion and completing descriptive statistics study in the Quality Systems Engineering course. Study results also indicate that there was no statistically significant difference between students with 70% or greater ACT Math college readiness scores ($N = 21$) in comparison to earned descriptive statistics assignment grades in this course.

Introduction

Statistics. A ten-letter word that breeds fear in the heart of students (Choudhury, Robinson, & Radhakrishnan, 2007, p. 21). This fear is real for many students and may be rooted in earlier stressful experiences with math and result in a resistance to learn statistics (Best, 2016; Illeris, 2009). Fear often equates to anxiety. The reasons for student anxiety of statistics is due to: 1) students disliking numbers, 2) difficult concepts (null hypothesis, probability, unit analysis), and 3) students avoiding statistics due to perceived non-relevancy to tasks in life or in their careers (Chermak, S., & Weiss, A., 1999, p. 362). Per Chiesi and Primi (2010), students do not master statistics course learning objectives due to a lack of understanding statistics. Misunderstood concepts such as standard deviation, central limit theorem, and sampling distribution are high on the list (Fairfield-Sonn, Kolluri, Rogers, & Singamsetti, 2009). Many former students view a statistical course as the worst course they ever took (Lindsey, 2017). In fact, those students stated that "statistics has a reputation among students as being challenging, irrelevant, dull, and an unwelcome compulsory invasion into their chosen field of study (Lindsey, 2017, p. 27; Ben-Zvi & Garfield, 2008; Croucher, 2006). This is yet more evidence to many who feel that technologists, engineers, researchers and scientists may not be equipped to take on the professional challenges of the workplace (Ayokanmbi, 2011, p. 2; Grandin & Hirleman, 2009).

This study is being conducted to add on to the body of knowledge as it relates to descriptive statistics mastery. Essentially, Do students with above or below ACT Math college readiness scores significantly increase earned descriptive statistics assignment grades in a course after entering college? While almost everyone would agree that mathematics is a necessity of life and career success, not everyone would agree that statistics, as a subset of mathematics, would be part of that necessity and is therefore viewed as irrelevant (Endereson & Ritz, 2016; Choudhury *et al.,* 2007; Pollock & Wilson, 1976; Higgins, 1999; Gober & Freeman, 2005; Moore & Roberts, 1989). Kreiner (2006) stated that additional research was needed to understand and improve performance outcomes in statistics courses. Furthermore, Grinstead (2013, p. 6) shared that "it has not been widely determined if higher achieving students enroll in more advanced mathematics courses and also score higher on the ACT or if advanced mathematics courses increase test scores."

Significance, Purpose, and Usefulness of the Study

The study was designed as a useful reference tool for future researchers. This "body-of-knowledge builder" investigates the question of: Do students with above or below ACT Math college readiness scores significantly increase earned descriptive statistics assignment grades in a course after entering college? Statistics is a necessary element in education, tied to the ability to understand, interpret, and critically evaluate research findings (Giesbrecht, 1996). The study is significant because Science, Technology, Engineering, and Mathematics (STEM) calls for a technological literacy for all – with a "general achievement philosophy" (including mathematics) (Asunda & Ware, 2015). This does not diminish the need for STEM to be rigorous, yet it does result in fewer students choosing STEM fields due to the required study of advanced mathematics (Love & Strimel 2016; Petroski, 2015).

Research Question and Hypothesis Statements

The research question is: Does a carefully designed statistics course enable college students with below-standard ACT Math college readiness scores to significantly increase their earned descriptive statistics assignment grades? From this question, the following null and alternative hypotheses were developed.

- H_{01}: $\mu1 = \mu2$. There is no statistically significant difference between students with 70% or greater ACT Math college readiness scores in comparison to earned descriptive statistics assignment grades in a course after entering college.
- H_{A1}: $\mu1 \neq \mu2$. There is a statistically significant difference between students with 70% or greater ACT Math college readiness scores in comparison to earned descriptive statistics assignment grades in a course after entering college.
- H_{02}: $\mu1 = \mu2$. There is no statistically significant difference between students with less than 70% ACT Math college readiness scores in comparison to earned descriptive statistics assignment grades in a course after entering college.
- H_{A2}: $\mu1 \neq \mu2$. There is a statistically significant difference between students with less than 70% ACT Math college readiness scores in comparison to earned descriptive statistics assignment grades in a course after entering college.
- H_{03}: $\mu1 = \mu2$. There is no statistically significant difference on all student ACT Math college readiness scores in comparison to earned descriptive statistics assignment grades in a course after entering college.
- H_{A3}: $\mu1 \neq \mu2$. There is a statistically significant difference on all student ACT Math college readiness scores in comparison to earned descriptive statistics assignment grades in a course after entering college

Assumptions of the Study

The following assumptions were made for this study:

1. The term "grade" and "score" are interchangeable.
2. Student-to-faculty interaction and teaching styles did not affect the study.
3. Student motivation and performance were not assumed to be affected by course delivery type (100% online, face-to-face, or hybrid).
4. Students participated to the best of their ability in taking the ACT assessment and in studying statistics.
5. The study is not biased to or against any student type (undergraduate or graduate), gender (female or male), age, or their cultural background.
6. Grades earned by students are generalizable to any student participating in a study of statistics.
7. Paired Samples T-Test score differences are parametric (normally distributed), continuous, and were randomly and independently acquired.

Limitations of the Study

The following limitations are present for this study:

1. Students were both domestic and international at one Midwestern university.
2. Some students may have lacked motivation to study statistics.
3. Students may not have been academically prepared to study statistics.
4. Some students may have taken an intermediate statistics course that could have boosted

their earned descriptive statistics assignment grades.
5. Violation of any of the Paired Samples T-Test assumptions would have created a limitation.
6. The results of this study may not be repeatable at another educational institution.

Literature Review

SUCCESS AND THE ACT

Winston Churchill, former World War II United Kingdom Prime Minister, stated that "success is the ability to go from failure to failure without losing your enthusiasm" (Hoerr, 2013, p. 84). Students require this same persistence as well. Persistence is a behavior that often predicts achievement (Zonnefeld, 2015). Per Schmitt (2012) and Delmont (2016), the American College Testing (ACT) score may be used to predict college grade point averages (GPA). Colleges and universities use ACT scores to determine a student's readiness to begin higher education studies based upon past performance (Grinstead, 2013). Furthermore, Delmont (2016, p. 7), stated that standardized assessment scores, such as the ACT, may be generalized to reflect and predict student proficiency in other areas.

Ted McCarrel and E.F. Lindquist developed the ACT program in 1959 (Delmont, 2016, p. 3; Jacobsen, 2018; ACT, 2018). The ACT Math assessment portion measures student understanding primarily in algebra and geometry, not motivation, outside activities, school culture, or course quality (Grinstead, 2013). Per the ACT website (ACT Math, 2018), the assessment consists of 60 multiple-choice questions with earned scores ranging from low (1) to high (36) and contains the following breakdown of additional areas by approximate percentage of questions in each area):

- Number & Quantity (7-10%)
- Algebra (12-15%)
- Functions (12-15%)
- Geometry (12-15%)
- Statistics & Probability (8-12%)
- Integrating Essential Skills (40-43%)
- Modeling (% not provided)

Per the ACT website (ACT Readiness, 2018, p. 7), students meet the college readiness range standard when a topic area is greater than or equal to 70% of the top score (36); this equates to 25.2.

Advanced mathematics goes beyond algebra and geometry and includes trigonometry, calculus, and statistics. Students who earn higher ACT Math scores have typically taken advanced mathematical courses (Grinstead, 2013).

Mathematics and Statistics: Defined

Mathematics is "a systematic treatment of magnitude, relationship between figures and forms, and relations between quantities expressed symbolically; mathematical procedures, operations, or properties. Statistics is a subset of mathematics. Statistics is a collection, classification, analysis, and interpretation of numerical facts for drawing inferences on the basis of their quantifiable likelihood (probability)" (Fullerton & Kendrick, 2013, p 135).

Statistics educators state that the following content should be in statistics courses: data collection design, descriptive statistics, boxplots, normal distributions, probability, sampling, data variability, confidence intervals, and significance testing (Lindsay, 2017; delMas, Garfield, Ooms, & Chance, 2007). Statistical calculations are often performed through software programs such as SAS, SPSS, Minitab, and Excel (Mills, 2004).

Anxiety About Statistics

Difficult concepts like statistics are sometimes hard for students to master due to anxiety (Chermak & Weiss, 1999; Macher, Paechter, Papousek & Ruggeri, 2012; Zeidner, 1991). Statistics anxiety is defined as "the negative thoughts and feelings experienced by an individual when encountering statistics in any form" (Schneider, 2011, p.3). Coupled with self-doubt and apprehension, statistical anxiety can result in the inability to apply the necessary effort needed to perform successfully (Tremblay, Gardner & Heipel, 2000; Heckhausen, 1991). Naturally this stifling situation can exacerbate a student's grade performance if their academic background was minimal (Choudhury *et al.,* 2007).

In a study by Pan and Tang (2005, p. 205), it was determined that "statistics anxiety include math phobia, lack of connection to daily life, pace of instruction, and an instructor's attitude." In a general sense, Conley (2003) states that many students are not prepared for college course work. Due to this lack of preparation, achievement measures of assignments, assessments, and final course grades are adversely affected (Tremblay *et al.,* 2000). When tied to a study of statistics, a negative correlation exists between final grades and statistical anxiety (Lalonde & Gardner, 1993).

Mathematics and Statistics Performance

Zanakis and Valenzi (1997, p. 20) determined in a study that scores at the beginning of the course (business statistics) highly affected final course grades by "computer experience, math anxiety, and prior grade point averages." In addition to these findings, Chiesi and Primi (2010) found that attitudes at the start of an introductory statistics course correlated with their resulting final course grades. Tremblay *et al.* (2000) also determined in their study that there was a significant correlation between mathematical performance and a high-level positive attitude about mathematics. Whereas students with low grade point averages typically are less conscientious about earning high course grades – whether statistics is involved or not (Hall, Kellar, & Weinstein, 2016). Various motivations in learning come from within the individual (Mosher, Freeman, & Hurburgh, 2011).

Course delivery method does not seem to affect student performance in statistics. In a study by McLaren (2004), there was no difference in several statistics class offerings in final course grades whether students participated online or face-to-face (online: 152 students; face-to-face: 139 students). While the learning method may not matter (online or face-to-face), students find statistics significantly challenging (Dotterweich & Rochelle, 2012). If a student's perception of statistics study is negative, they often score low on examinations (Gorman, 2011). Students often think they can't "do statistics", hence they fulfill their own prophecy due to their fixed mindset (Dweck, 2006). The bottom line is that students typically score lower in statistics courses than their other courses (Onwuegbuzie, 2003; Gorman, 2011).

The Relevancy of Statistics

Students require the skill of statistical application in their daily lives (Best, 2017; Bond, Creed, & Neumann, 2012; Ramirez, Emmioglu, & Schau, 2012). Industry and business require student study in statistics since almost every task requires this skill (Gorman, 2011; Glencross & Binyavango, 2018). Due to this fact, many academic programs use a course in statistics to screen out students from certain programs of study (Gorman, 2011; Onwuegbuzie, 1998). Student preparation for statistics study must begin before college. This requires that the relevancy of statistics be presented to students in a "useful, applicable, and relevant" way to their workplace situation and context (Mosher *et al.,* 2011, p. 3).

Methodology

STUDY POPULATION, TIME FRAME, AND TOPICS COVERED

The course Quality Systems Engineering was offered over eight semesters (fall of 2016 to the fall of 2018) in 100% online, face-to-face, and hybrid to both undergraduate and graduate students. Students participated in the course with a two-part assignment, and multi-week, focus in descriptive statistics. A total of 148 students were initially eligible to participate in the study from the United States of America and various countries around the world. After removing students without an ACT Math score, the total was reduced to 70. Students without an ACT Math score were international, transfer, or graduate students who did not have to take the ACT to participate in various programs within the university.

Descriptive statistics topics covered in the course included: sampling; populations; accuracy, precision, and measurement error; graphical data analysis; frequency diagrams; histograms; mode; median; mean; skew; kurtosis; central tendency; standard deviation; range, central limit theorem; normal frequency distributions; standard normal probability distributions; Z tables; and confidence intervals.

Variables

Earned descriptive statistics assignment grades were converted to a numerical percentage. One percent equaled 1. 100 percent equaled 100. And so forth for all earned grades. Earned grades were rounded to the nearest hundredth digit.

Earned ACT Math assessment scores were converted to the same range of 1 to 100. Since the ACT Math assessment only records scores from 1 (low) to 36 (high), the conversion was performed by taking the student's earned ACT Math score, dividing it by 36, and then multiplying it by 100. Earned converted ACT Math scores were rounded to the nearest hundredth digit. Therefore, converted ACT Math scores became comparable to student-earned descriptive statistics assignment grades.

Variables such as class status (undergraduate or graduate), gender, age, course type (100% online, face-to-face, hybrid), statistics anxiety level, academic background, or cultural differences were not considered.

Statistical Analysis

The two continuous variables were provided with shortened names for SPSS analysis. Earned descriptive statistics assignment course grades was termed "Stats". Earned converted ACT Math scores was termed "ACT Math". All Stats student scores were paired with whatever ACT Math score they earned in each of the three hypotheses. Statistical tests were conducted for: 1) Stats with ACT Math scores at or above 70%, 2) Stats with ACT Math scores below 70%, and 3) Stats with ACT Math at all earned score levels.

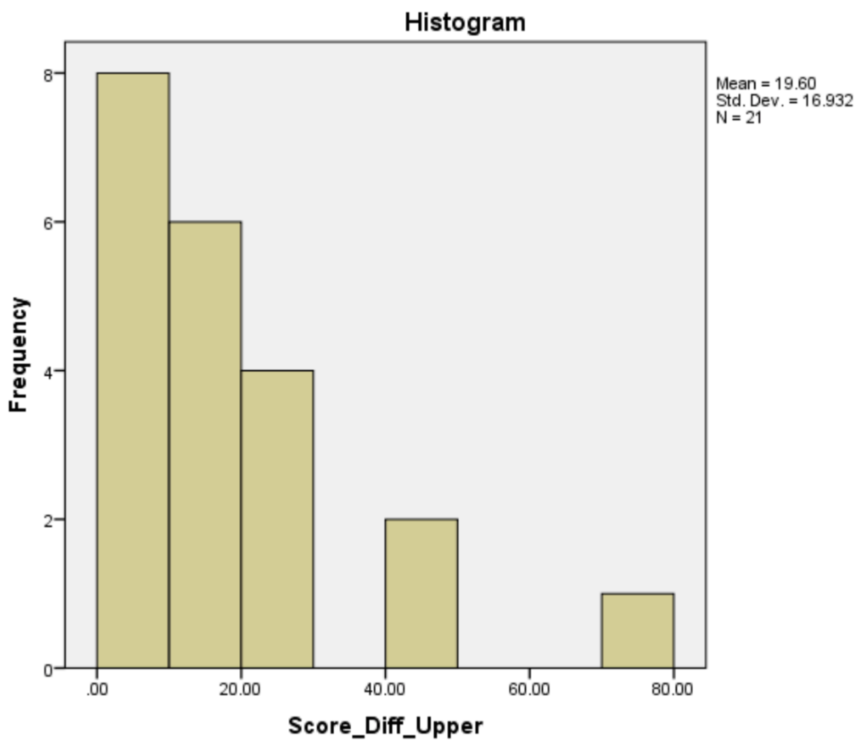
Both Stats and ACT Math were assessed for score differences using IBM SPSS Version 24.0 at a significance level of 0.05 using a Paired Samples T-Test. Per Field (2013, p. 371), a Paired Samples T-Test is a parametric test used to measure the average difference between one assessment to the next, for one data measurement on one individual, and then tallies the averaging information of all data sets, for all individuals, to determine if a mean statistical difference exists between scored results. The assumptions for Paired Samples T-Test state that score differences are parametric (normally distributed), continuous, and are randomly and independently acquired. Note that only the scores differences must be parametric, not the actual data distributions themselves (Field, 2013, p. 378).

Statistical Assumption Testing

HYPOTHESIS 1

The paired score differences between Stats (earned descriptive statistics assignment grades) and ACT Math (scores at or greater than 70%) were normal per the Kolmogorov-Smirnov statistical test with $D(21) = 0.832$, $p = 0.107$. While the histogram in Figure 1 does not look normally-distributed, the calculated value of Kolmogorov-Smirnov states that it is since the p value is greater than 0.05. As to the other two assumptions, both met requirements and: were continuous, and were randomly and independently acquired.

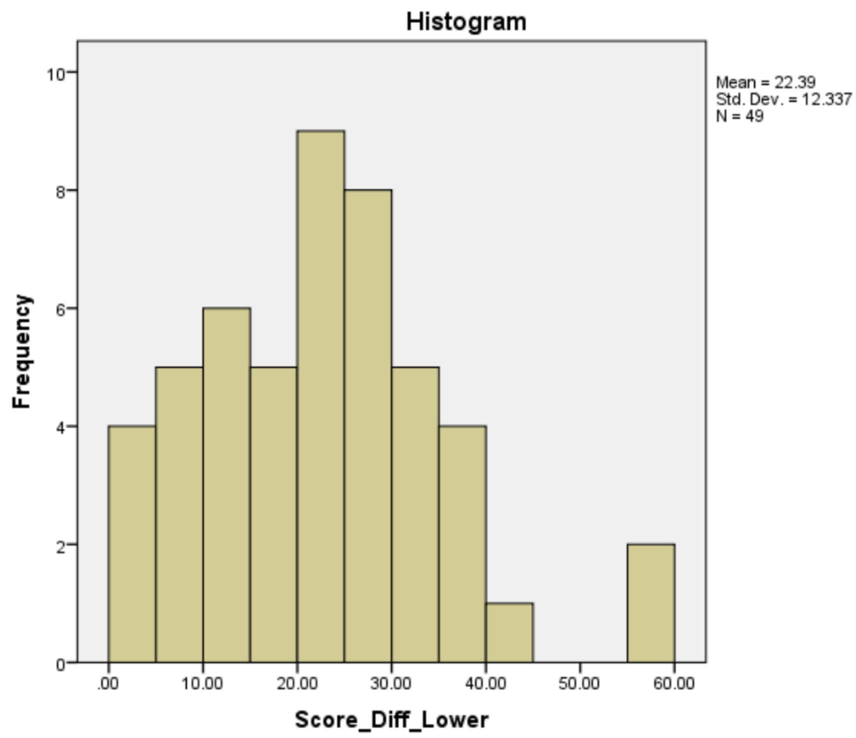
Figure 1. Stats (grade) and ACT Math (score) differences with ACT Math Scores at or greater than 70%



HYPOTHESIS 2

The paired score differences between Stats (earned descriptive statistics assignment grades) and ACT Math (scores at less than 70%) were normal per the Kolmogorov-Smirnov statistical test with D(49) = 0.959, p = 0.200. See Figure 2 for the normally-distributed histogram. As to the other two assumptions, both met requirements and: were continuous, and were randomly and independently acquired.

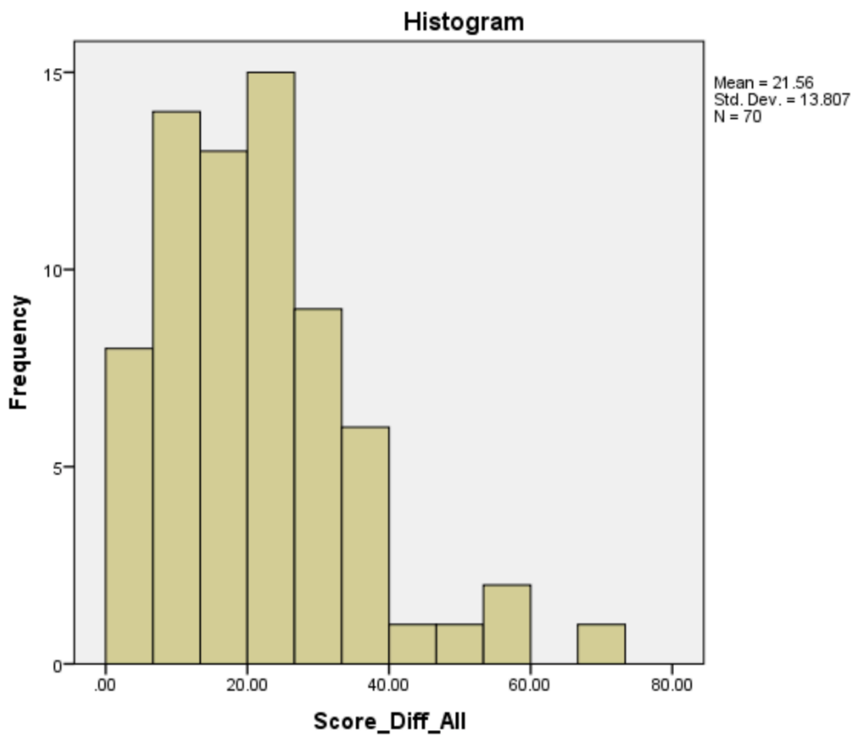
Figure 2. Stats (grade) and ACT Math (score) differences with ACT Math Scores less than 70%



HYPOTHESIS 3

The paired score differences between Stats (earned descriptive statistics assignment grades) and ACT Math (all student) were normal per the Kolmogorov-Smirnov statistical test with D(70) = 0.933, p = 0.071. See Figure 3 for the normally-distributed histogram. As to the other two assumptions, both met requirements and: were continuous, and were randomly and independently acquired.

Figure 3. Stats (grade) and ACT Math (score) differences with all ACT Math student scores



Statistical Study Results

HYPOTHESIS 1 RESULTS

H01: $\mu1 = \mu2$. There is no statistically significant difference between students with 70% or greater ACT Math college readiness scores in comparison to earned descriptive statistics assignment grades in a course after entering college. Therefore, the null hypothesis has been retained and the alternative hypothesis has been rejected at N = 21.

Students with 70% or greater ACT Math college readiness scores (M = 78.70, SE = 1.63), were not significantly different when compared to earned descriptive statistics assignment grades (M = 78.73, SE = 5.58). The difference was 0.03, with statistical values of 95% CI [-11.931, 11.985], $t(20) = 0.005$, $p = 0.996$. and $r = 0.001$. Per Cohen's Criteria for r, this was a small effect size – also known as "the magnitude of the difference between the two distributions" (Minium, Clarke, & Coladarci, 1999, p. 73). This level of effect size means the difference in means is small.

HYPOTHESIS 2 RESULTS

HA2: $\mu1 \neq \mu2$. There is a statistically significant difference between students with less than 70% ACT Math college readiness scores in comparison to earned descriptive statistics assignment grades in a course after entering college. Therefore, the null hypothesis was rejected and the alternative hypothesis has been retained at N = 49.

Students with less than 70% ACT Math college readiness scores (M = 60.20, SE = 0.96), were significantly different when compared to earned descriptive statistics assignment grades (M = 75.07, SE = 2.92). The difference was 14.87, with statistical values of 95% CI [8.849, 20.879], $t(48) = 4.969$, $p < 0.001$, and $r = 0.709$. Per Cohen's Criteria for r, this was a moderate effect size in the difference of means.

HYPOTHESIS 3 RESULTS

HA3: $\mu1 \neq \mu2$. There is a statistically significant difference on all student ACT Math college readiness scores in comparison to earned descriptive statistics assignment grades in a course after entering college. Therefore, the null hypothesis was rejected and the alternative hypothesis has been retained at N = 70.

All students with ACT Math college readiness scores (M = 65.75, SE = 1.31), were significantly different when compared to earned descriptive statistics assignment grades (M = 76.17, SE = 2.63). The difference was 10.42, with statistical values of 95% CI [4.811, 16.015], $t(69) = 3.708$, $p < 0.001$, and $r = 0.443$. Per Cohen's Criteria for r, this was a small-to-moderate effect size in the difference of means.

Conclusions and Future Research

Study results indicate that students earning ACT Math college readiness scores is different and statistically significant ($p < 0.001$) in comparison to earned descriptive statistics assignment grades for both students earning less than 70% (ACT: 25.2 score) on ACT Math scores (N = 49) and for the composite of all students in this study earning an ACT Math score (N = 70). This means that student knowledge is increasing between the time that students take the ACT Math portion and studying descriptive statistics in a Quality Systems Engineering college course.

Study results also indicate that there was no statistically significant difference between students with 70% or greater ACT Math college readiness scores (N = 21) in comparison to earned descriptive statistics assignment grades in a course after entering college.

These results provide some evidence that students earning less than a 70% college readiness score may be putting forth more effort to earn higher grades when studying descriptive statistics in a course after entering college. Per Isaac, Zerbe, and Pitt (2001), people put forth more effort towards what they feel are attainable goals. Or, the anxiety and fear of earning poor descriptive statistics grades have challenged students to work harder to earn higher grades. Regarding the statistical significance of all students earning ACT Math college readiness scores in comparison to earned descriptive statistics assignment grades in a course after entering college, the students below a score of 70% may have skewed the results when all students studied were aggregated into the statistical analysis.

Recommended future research includes developing a survey method to capture students' descriptive statistics study in areas such as: anxiety / fear, topic relevancy, and motivation. Other factors to collect in the survey for analysis include: class status (undergraduate, graduate), gender, age, and culture. Lastly, increase the sample size and replicate this study.

In alignment with the body-of-knowledge building intent of this manuscript for future researchers, the following citations and dialogue are provided for several of the recommended study areas. Schneider (2011, p. 88) states that "more research could be conducted in the area of statistics anxiety, self-efficacy, and performance measures." Hall *et al.* (2016) recommends additional research on student behaviors and motivation in comparison to teaching practices as it relates to grade point averages. Zonnefeld (2015, p. 8) postulates that more research is needed on the correlation between student performance and their attitudes toward statistics. Lastly, students learning statistics need to see real world applications in order to learn it effectively (Basturk, 2005, p. 175; Yilmaz, 1996).

References

ACT (2018, December). About ACT. Retrieved from http://www.act.org/content/act/en/about-act.html

ACT Math (2018, December). ACT contents: Understanding your scores. Retrieved from http://www.act.org/content/act/en/products-and-services/the-act/scores/understanding-your-scores.html

ACT Readiness (2018, December). ACT reporting category interpretation guide Version 1.0. Retrieved from http://www.act.org/content/dam/act/unsecured/documents/wp-2016-05-act-reporting-category-interpretation-guide.pdf

Asunda, P. A., & Ware, S. (2015). Applying the congruence principle of Bloom's Taxonomy to develop an integrated STEM experience through engineering design. *Journal of Technology Studies, 41(2),* 88-100

Ayonkanmbi, F. M. (2011). Competencies for global engineers and technologists. *Journal of Industrial Technology, 27(1),* 1-6

Basturk, R. (2005). The effectiveness of computer-assisted instruction in teaching introductory statistics. *Educational Technology & Society, 8(2),* 170-178

Ben-Zvi, D., & Garfield, J. B. (2008). Introducing the emerging discipline of statistics education. *School Science and Mathematics, 108,* 355-361

Best, R. A. (2016). *An online statistics course from faculty and students' perspectives: A case study* (Doctoral dissertation, Walden University). Available from ProQuest Dissertations and Theses database. (ProQuest Number: 10099965)

Bond, M., Creed, P. A., & Neumann, D. (2012). Using the expectancy value model of motivation to understand the relationship between student attitudes and achievement in statistics, *Statistics Education Research Journal, 11(2),* 72-85

Chermak, S., & Weiss, A. (1999). Activity-based learning of statistics: Using practical applications to improve student learning. *Journal of Criminal Justice, 10(2),* p. 362

Chiesi, F., & Primi, C. (2010). Cognitive and non-cognitive factors related to students' statistics achievement. *Statistics Education Research Journal, 9(1),* 6-26

Choudhury, A., Robinson, D., & Radhakrishnan, R. (2007). Effect of Prerequisite on Introductory Statistics Performance. *Journal of Economics and Economic Education Research, 8(3),* 21

Conley, D. T. (2003). *Mixed messages: What state high school tests communicate about student readiness for college.* Eugene, OR: Educational Policy Improvement Center.

Croucher, J. (2006). Teach statistics? You bet! *Significance,* March 46-48

delMas, R., Garfield, J., Ooms, A., & Chance, B. (2007). Assessing students' conceptual understanding after a first course in statistics. *Statistics Education Research Journal, 6(2),* 28-58

Delmont, R. (2016). Comparison of classroom grades and Missouri end-of-course exam scores (Doctoral dissertation, Lindenwood University). Available from ProQuest Dissertations and Theses database. (ProQuest Number: 10253890)

Dotterweich, D. P., & Rochelle, C. F. (2012). Online, instructional television and traditional delivery: Student characteristics and success factors in business statistics. *American Journal of Business Education, 5(2),* 129-138

Dweck, C. S. (2006). *Mindset: The new psychology of success.* New York: Ballantine Books.

Enderson, M. C., & Ritz, J. (2016). STEM in general education: Does mathematics competence influence course selection? *The Journal of Technology Studies, 42(1),* 30-40

Illeris, K. (2009). A comprehensive understanding of human learning. In K. Illeris (Ed.). *Contemporary theories of learning: learning theorists … in their own words.* London: Routledge.

Fairfield-Sonn, J. W., Kolluri, B., Rogers, A., & Singamsetti, R. (2009). Enhancing an undergraduate business statistics course: Linking teaching and learning with assessment issues. *American Journal of Business Education, 2(7),* 101-112

Field, A. (2013). *Discovering statistics using IBM SPSS Statistics* (4th Ed.). Thousand Oaks, CA: Sage.

Fullerton, J. A., & Kendrick, A. (2013). The math problem: Advertising students' attitudes about statistics. *Journalism & Mass Communication Educator, 68(2),* 134-149

Giesbrecht, N. (1996). *Strategies for developing and delivering effective introductory-level statistics and methodology courses.* Alberta, Canada. (ERIC Document Reproduction Service No. ED 393668)

Glencross, J. M., & Binyavango, W. K. (2018, December). The role of technology in statistics education: A view from a developing region. Retrieved from https://www.dartmouth.edu/~chance/teaching_aids/IASE/25.Glencross.pdf

Grandin, J. M., & Hirleman, E. D. (2009). Educating engineers as global citizens: A call for action / A report of the national summit meeting on the globalization of engineering education. *Online Journal for Global Engineering, 4(1)*

Grinstead, M. L. (2013). *Which advanced mathematics courses influence ACT score? A state level analysis of the Iowa class of 2012* (Doctoral dissertation, Iowa State University). Available from ProQuest Dissertations and Theses database. (ProQuest Number: 3610642)

Gober, R. W., & Freeman, G. L. (2005). Adjusting business statistics grades for anxiety. *Proceedings of the Academy of Information and Management Sciences, 9(2),* 15

Gorman, N. P. (2011). Asynchronous online education and introductory statistics: The role of learner characteristics (Doctoral dissertation, University of Southern California). Available from ProQuest Dissertations and Theses database. (ProQuest Number: 3487905)

Hall, D. C., Kellar, G. M., & Weinstein, L. B. (2016). The impact of an activity-based learning environment and grade point average on student final course grades in an undergraduate business statistics class. *Academy of Educational Leadership Journal, 20(1),* 50-64

Heckhausen, H. (1991). *Motivation and action.* Berlin: Springer-Verlag.

Higgins, J. J. (1999). Nonmathematical statistics: A new direction for the undergraduate discipline. *The American Statistician, 53(1),* 1-6

Hoerr, T. R. (2013). Good failures. *Educational Leadership, 71(1),* 84-85

Isaac, R. G., Zerbe, W. J., & Pitt, D. C. (2001). Leadership and motivation. The effective application of expectancy theory. *Journal of Managerial Issues, 13,* p. 212-226

Jacobsen, E. (2018, December). A (mostly) brief history of the SAT and ACT tests. Retrieved from https://www.erikthered.com/tutor/sat-act-history.html

Kreiner, D. S. (2006). A mastery-based approach to teaching statistics online. *International Journal of Instructional Media, 33,* 73-79

Lalonde, R. N., & Gardner, R. C. (1993). Statistics as a second language? A model for predicting performance in psychology students. *Canadian Journal of Behavioral Science, 25,* 108-125

Lindsay, H. L. (2017). *Self-efficacy, student engagement, and student learning in introductory statistics* (Doctoral dissertation, Montana State University). Available from ProQuest Dissertations and Theses database. (ProQuest Number: 10269823)

Love, T. S., & Strimel, G. J. (2016). Computer science and technology and engineering education: A content analysis of standards and curricular resources. *The Journal of Technology Studies, 42(2),* 76-88

Macher, D., Paechter, M., Papousek, I., & Ruggeri, K. (2012). Statistics anxiety, trait anxiety, learning behavior, and academic performance. *European Journal of Psychology of Education, 27(4),* 483-498

McLaren, C. H. (2004). A comparison of student persistence and performance in online and classroom business statistic experiences. *Decision Sciences Journal of Innovative Education,* 2(1), 1-10

Mills, J. D. (2004). Learning abstract statistics concepts using simulation. Educational Research Quarterly, 28(4), 18-33

Minium, E. W., Clarke, R. C., & Coladarci, T. (1999). *Elements of statistical reasoning* (2nd ed.). Danvers, MA: John Wiley & Sons, Inc.

Moore, T. L., & Roberts, R. A. (1989). Statistics at liberal arts colleges. *The American Statistician, 43(2),* 80-85

Mosher, G. A., Freeman, S. A., & Hurburgh, C. R. (2011). Design of an online course in quality management systems for adult learners. *Journal of Industrial Technology, 27(4),* 1-9

Onwuegbuzie, A. J. (1998). Teachers' attitudes toward statistics. *Psychological Reports, 83,* 1008-1010

Onwuegbuzie, A. J. (2003). Modeling statistics achievement among graduate students. *Educational and Psychological Measurement, 63(6),* 1020-1038

Pan, W., & Tang, M. (2005). Students' perceptions on factors of statistics anxiety and instructional strategies. *Journal of Instructional Psychology, 32(3),* 205-214

Petroski, H. (2015). Constraining courses: Math should not be a barrier to success in engineering. *PRISM, 25(1),* 8

Pollock, K. H., & Wilson, I. M. 1976). Statistics service teaching in universities. *The Statistician, 25(4),* 247-252

Ramirez, C., Emmioglu, E., & Schau, C. (2012). The importance of attitudes in statistics education. *Statistics Education Research Journal, 11(2),* 57-71

Schmitt, N. (2012). Development of rationale and measures of noncognitive college student potential. *Educational Psychologist, 47(1),* 18-29

Schneider, W. R. (2011). *The relationship between statistics self-efficacy, statistics anxiety, and performance in an introductory graduate statistics course* (Doctoral dissertation, University of South Florida). Available from ProQuest Dissertations and Theses database. (ProQuest Number: 3450237)

Tremblay, P. F., Gardner, R. C., & Heipel, G. (2000). A model of the relationships among measures of affect, aptitude and performance in introductory statistics. *Canadian Journal of Behavioral Science, 32(1),* 1-16

Yilmaz, M. R. (1996). The challenge of teaching statistics to non-specialists. *Journal of Statistics Education. 4(1),* 1-9

Zanakis, S. H., & Valenzi, E. R. (1997). Student anxiety and attitudes in business statistics. *Journal of Education for Business, 73(1),* 10-16

Zeidner, M. (1991). Statistics and mathematics anxiety in social science students: some interesting parallels. *British Journal of Educational Psychology, 61,* 319-328

Zonnefeld, V. L. (2015). *Mindsets, attitudes, and achievement in undergraduate statistics courses* (Doctoral dissertation, University of South Dakota). Available from ProQuest Dissertations and Theses database. (ProQuest Number: 3714377)