

Differences in Academic Achievements among High School Graduates' from Four Career and Technical Education (CTE) Program Areas

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Career and Technical Education (CTE) is a popular trend in education due to the increased demand from American citizens to include CTE opportunities in schools along with federal funding to build new CTE programs and improve existing ones. Schools are tasked to improve student achievement. Testing performance is a central process to demonstrate satisfactory student achievement and school quality. In this study, the academic achievements of CTE completer high school graduates were measured by their performance on the nationwide American College Test (ACT), including the subjects of English, reading, writing, math, and science. CTE graduates in this study received CTE endorsements in the four program areas: 1) business and marketing education; 2) education, hospitality, and human services; 3) information and media technologies; and 4) skilled and technical sciences. The testing scores from an entire graduating class in a large school district with over 64,000 students were analyzed. The results revealed significant differences in students' academic achievements among the four CTE program areas. Especially, students in the Skilled and Technical Science cohort and the Information and Media Technologies cohort had higher mean scores on ACT examination subjects of math, reading, science, and English than those from the other two cohorts.

Keywords: Career and Technical Education (CTE), vocational education, student achievement, curricula, testing performance, college entrance, ACT, skills gap, experiential learning

INTRODUCTION

Career and Technical Education (formerly called vocational education) is a term applied to schools, institutions, and educational programs which specialize in skilled trades, applied sciences, modern technologies, and career preparation (Garza Mitchell, 2017). Career and technical education programs offer both academic and career-oriented

courses, and many provide students with the opportunity to gain work experience through internships, job shadowing, on-the-job training, and industry-certification opportunities (Smith, 2017). Career and technical programs provide a range of learning experiences spanning many different career tracks, fields, and industries, from skilled trades such as automotive technology, construction, plumbing, or electrical contracting to fields as diverse as agriculture, architecture, culinary arts, fashion design, filmmaking, forestry, engineering, healthcare, personal training, robotics, or veterinary medicine (Castellano, Richardson, Sundell, & Stone, 2017).

BACKGROUND AND LITERATURE REVIEW

Modern vocational education began to take shape in 1990 with the Carl D. Perkins Vocational and Applied Technology Education Act Amendments of 1990. What this new act of 1990 accomplished was to align secondary and post-secondary CTE programs, business partnerships to be forged between schools and enterprises, academic integration, and accountability (Wirt, 1991). In 1998, the Carl D. Perkins Vocational and Technical Act continued to emphasize alignment between institutions and in the same year, the *American Vocational Association* was renamed to the *Association for Career and Technical Education* in an effort to reflect the transition from job-specific vocational training to a skill-based and rigorous education (Imperatore & Hyslop, 2017). In 2006, the term “vocational education” was retired by legislation renaming the previous Carl D. Perkins Vocational and Technical Act to the Carl D. Perkins Career and Technical Education Act of 2006 (Stipanovic, Lewis, & Stringfield, 2012). The House of Representatives in 2016 passed the Strengthening Career and Technical Education for the 21st Century Act, a renewal of the Perkins Act, by a landslide vote of 405 to 5. The new bipartisan legislation included initiatives including increased flexibility for states to use federal funds for building and modifying CTE programs, ensuring students have the proper training and skills to enter high-wage occupations, streamlining performance measures to ensure CTE programs are delivering results to students and taxpayers, and encouraging engagement between schools and employers (United States Congress, 2018). Following the policy changes, career and technical programs flourished. Currently 58.1% of high school students in the U.S. participate in some type of CTE event and enroll in at least one CTE course regardless of race or socioeconomic status (Imperatore & Hyslop, 2017).

The Phi Delta Kappa (PDK) Poll is one of the most trusted sources regarding the public’s opinion about public education since 1969 (49th Annual PDK Poll, 2017). The poll covers all 50 states and its credibility and reliability is due to its rigor, depth, and its commitment to gathering all perspectives and opinions. Annually, the PDK Educational Foundation finances the PDK poll in an effort to gather an independent and unbiased report of American public opinion. The culminating objectives of the PDK Educational Foundation are to engage educators and serve schools with current information to best serve students. Education policy makers use the annual findings to inform their decision making, and local educators utilize the results to guide planning and objectives within their communities (49th Annual PDK Poll, 2017). The results of the 2017 PDK poll overwhelmingly showed strong public support for schools to work towards positioning and preparing students for their working lives after school along with educating students in academic subjects. Highlights from the 2017 PDK poll include: 1) 82% of Americans encourage career and job skills even if it translates to students spending less time in academic classes; 2) 89% believe schools in their community should offer licensing and certificate granting programs which students can utilize for employment in a field; and 3) 80% view technology and engineering courses as vital components of school quality (49th Annual PDK Poll, 2017).

STEM AND CTE

The developing CTE frontier in education encompasses the popular STEM initiative which aimed to increase the engagement of students with science, technology, engineering, and mathematics. The STEM and CTE overlap and emphasis can be noticed on institutional levels. In the state of Texas, House Bill 5 requires entering high school students to select one of five CTE pathways with STEM being one of the five available CTE pathways (Yoon & Strobel, 2017). To be more specific, every state already has developed programs of study which are preparing students for careers in STEM fields. Simply put, STEM must not be regarded as a separate enterprise from CTE (CTE Is Your STEM Strategy, 2013). Instead, CTE is a catalyst for STEM education. CTE programs include explicit inclusion of engineering into the curriculum, whereas many science academic subjects such as mathematics and computer science do not require engineering components for their completion (Yoon & Strobel, 2017). In addition to CTE requiring engineering components, CTE programs are designed to address students who may be more interested in entering the workforce instead of college; thus, offering students a lower entry point into STEM careers than a college-bound track (Yoon & Strobel, 2017). See Table 1 for comparisons between STEM and CTE inspired by the *Association for Career and Technical Education*.

Table 1. *STEM and CTE Overlap*

STEM is CTE	
	<ul style="list-style-type: none"> • 50 % of all STEM jobs are open to workers with less than a bachelor's degree • 30% of today's STEM-intensive jobs are in blue collar fields.
SCIENCE (S)	61% of CTE students interested in a science career report their CTE courses provide them with skills for the workforce.
TECHNOLOGY (T)	50% of STEM jobs are in manufacturing, health care, and construction, while another 12 percent of STEM jobs are in installation, maintenance and repair.
ENGINEERING (E)	18% job growth expected for environmental engineering technicians by 2022. Technician jobs typically require an associate's degree and pay over \$45,000/yr.
MATHEMATICS (M)	45% of CTE students interested in a math career report their CTE courses help them attain higher math and/or science skills.

Along with CTE programs being relevant and engaging for students, CTE engagement influences testing performance. In a study conducted in Florida, researchers analyzed the testing patterns of CTE students as they progressed from CTE course taker, to explorer, to occupational concentrator. The analysis utilized a cohort of approximately 80,000 students enrolled in 10th grade CTE programs in 2003-2004 across the state of Florida. The analysis revealed performance on the standardized science test improved as a student's coursework in a CTE program increased in the hierarchy of course taker, explorer, and occupational concentrator (Israel, Myers, Lamm, & Galindo-Gonzalez, 2012). In a similar study, Castellano, Sundell, Overman, & Aliaga (2012) examined the impacts of CTE programs of study on high school achievement through quantitative and qualitative research methods. The researchers found few differences between 9th grade CTE students and 9th grade non-CTE students. By the end of 10th grade, student test scores, grade point averages, and progress towards graduation tended to be better for students enrolled in CTE programs. Michaels and Barone (2019) researched the academic achievement of CTE completer high school graduates and non-CTE high school graduates as measured by their performance on the nationwide ACT examination covering the subjects of English, reading, writing, math, and science in a large western school district. CTE completers had significantly higher ACT scores on the ACT composite, reading, writing, math, science, and English

assessments than those of non-CTE general academic student graduates who undertook one or no CTE courses during high school. Qualitatively, researchers found CTE schools had created a unique school culture around CTE programs, which appeared to explain the boosted engagement and achievement of CTE students. Graduation from high school affected the probability of students acquiring employment and financial security (Gammill, 2015).

The reinvented CTE advertises itself as an academic curriculum option in contrast to its predecessor known as *vocational education*. Current institutional and scholarly research validates the reputation CTE has transformed itself to be academic along with being pragmatic with respect to career and educational goals. On July 31st, 2018, President Trump signed the Strengthening Career and Technical Education for the 21st Century Act, a \$1.2 billion program last overhauled by Congress in 2006. The new law granted exclusive power to states to establish objectives without the education secretary’s approval while requiring evidence of progress in meeting set objectives (Ujifusa, 2018).

CTE PROGRAM AREAS

CTE pathways claim a reputation of being relevant, academic, and motivating to interested students entering high school. Detailed information about the four CTE program area student cohorts employed for this study were:

CTE - EDUCATION, HOSPITALITY, AND HUMAN SERVICES PROGRAM OF STUDY

The education, hospitality, and human services pathway prepares graduates for careers in skilled occupations, higher education objectives, and for personal well-being. An example of a likely program of study a CTE student in the education, hospitality, and human services pathway will undertake includes the following course work (see Table 2):

Table 2. *Education, Hospitality, and Human Services Program of Study Sample*

Grade	1 st course	2 nd course	3 rd course	4 th course	5 th course	6 th course (CTE)
9 th grade	English I	Algebra 1	Biology	Health/computer literacy	Physical education	Travel and tourism 1
10 th grade	English II	Geometry	Chemistry or Geoscience	World History	Physical education	Hospitality and Management I
11 th grade	English III	Algebra II	Science course or elective	US History	Foreign Language or Elective	Hospitality and Management II
12 th grade	English IV	Senior level math	Elective	US Government	Foreign Language or elective	Hospitality Management Advanced Studies

CTE – INFORMATION AND MEDIA TECHNOLOGIES PROGRAM OF STUDY

The information and media technologies pathway includes both computer system innovations and digital media technologies. An example of a likely program of study a CTE student in the information and media technologies pathway will undertake includes the following course work (see Table 3):

Table 3. *Information and Media Technologies Program of Study Sample*

Grade	1st course	2nd course	3rd course	4th course	5th course	6th course (CTE)
9th grade	English I	Algebra 1	Biology	Health/computer literacy	Physical education	Computer science I or AP computer science principles
10th grade	English II	Geometry	Chemistry or Geoscience	World History	Physical education	Computer Science II
11th grade	English III	Algebra II	Science course or elective	US History	Foreign Language or Elective	Computer Science III or AP computer science
12th grade	English IV	Senior level math	Elective	US Government	Foreign Language or elective	Computer science Advanced Studies

CTE – HEALTH SCIENCE AND PUBLIC SAFETY PROGRAM OF STUDY

The health science program area allows graduates the opportunity to work in diverse environments including hospitals, medical and dental offices, and athletic facilities. Students who are also interested in careers including Law, Public Safety, and Corrections and Security are encouraged to enroll in this program area. An example of a likely program of study a CTE student in the health science and public safety pathway will undertake includes the following course work (see Table 4):

Table 4. Heath Science and Public Safety Program of Study Sample

Grade	1st course	2nd course	3rd course	4th course	5th course	6th course (CTE)
9th grade	English I	Algebra 1	Biology	Health/computer literacy	Physical education	Criminal Justice 1 or Foundation of Public Safety
10th grade	English II	Geometry	Chemistry or Geoscience	World History	Physical education	Criminal Justice II
11th grade	English III	Algebra II	Science course or elective	US History	Foreign Language or Elective	Criminal Justice III
12th grade	English IV	Senior level math	Elective	US Government	Foreign Language or elective	Criminal Justice Advanced Studies

CTE – SKILLED AND TECHNICAL SCIENCES PROGRAM OF STUDY

Students who graduate with a skilled and technical sciences endorsement will be well prepared for high-needs STEM occupations as well as higher education ambitions. Vocations within the skilled and technical sciences realm include: 1) construction

technology; 2) metalworking; 3) electrical engineering; and 4) mechanical engineering. An example of a likely program of study a CTE student in the skilled and technical science pathway will undertake includes the following course work (see Table 5):

Table 5. *Skilled and Technical Science Program of Study Sample*

Grade	1st course	2nd course	3rd course	4th course	5th course	6th course (CTE)
9th grade	English I	Algebra I	Biology	Health/computer literacy	Physical education	Intro to engineering design
10th grade	English II	Geometry	Chemistry or Geoscience	World History	Physical education	Principles of Engineering
11th grade	English III	Algebra II	Science course or elective	US History	Foreign Language or Elective	Digital Electronics
12th grade	English IV	Senior level math	Elective	US Government	Foreign Language or elective	Engineering Design and Development

Research based results yield findings CTE engagement has a positive correlation to student achievement in the forms of increasing graduating rates and improved testing performance. As the CTE frontier in education develops more and more, CTE pathway options are increasing in number. Large school districts with a developed CTE program may include four to five program areas with dozens of CTE pathways within each program area. As demonstrated above, the CTE program areas have similarities and differences in their required curricula. The objective of this research was to examine for academic achievement differences affecting graduation and college admittance of high school students who undergo and execute different CTE curricula.

RATIONALE

As CTE claims a reputation of being a viable curriculum option for schools and students which prepares them from careers, there is a need to evaluate how well CTE students who have completed varying CTE pathways perform on important academic assessments which may determine future placements at post-secondary institutions. CTE courses and programs will lose enrolment and be cut or frozen indefinitely unless leaders in education can clearly demonstrate how career programs (a) contribute to measurable student achievement; and (b) help motivate students to be engaged in school and perform better in academic classes.

This research study expands and deepens previous CTE research work. Previous CTE academic achievement studies examined overall CTE academic achievement; whereas, this study explored the academic achievement of CTE students graduating from different CTE program areas consisting of varying CTE curricula. Secondly, this research continues a newly developing pattern of utilizing high-stakes testing as a standard for measuring student achievement.

PURPOSES AND RESEARCH QUESTIONS OF THE STUDY

The purpose of this quantitative study was to examine for differences in student achievement among four CTE student cohorts in a large western school district, and which of the four CTE curriculums: 1) education, hospitality, and human services; 2) information

and media technologies; 3) health science and public safety; and 4) skilled and technical sciences reinforces academic mastery presenting itself during high-stakes national testing. All students in this study successfully graduated from high school and received CTE endorsement. Student achievement was measured by ACT examination scores in the subjects of English, math, reading, science, and writing students obtain in order to graduate high school and apply for college(s).

The research was designed to examine the following questions:

1. Are there significant mean differences in student achievement (as measured by the combination of all ACT assessment scores) for CTE completer high school graduates graduating from different CTE program areas?
2. Are there significant mean differences on the Composite ACT scores for CTE completer high school graduates graduating from different CTE program areas? If so, which CTE program areas differ?
3. Are there significant mean differences on the English ACT scores for CTE completer high school graduates graduating from different CTE program areas? If so, which CTE program areas differ?
4. Are there significant mean differences on the Math ACT scores for CTE completer high school graduates graduating from different CTE program areas? If so, which CTE program areas differ?
5. Are there significant mean differences on the Reading ACT scores for CTE completer high school graduates graduating from different CTE program areas? If so, which CTE program areas differ?
6. Are there significant mean differences on the Science ACT scores for CTE completer high school graduates graduating from different CTE program areas? If so, which CTE program areas differ?
7. Are there significant mean differences on the Writing ACT scores for CTE completer high school graduates graduating from different CTE program areas? If so, which CTE program areas differ?

METHODS

RESEARCH DESIGN

This causal-comparative quantitative study involved a nonexperimental design and employed the use of independent and dependent variables. In comparative research, the focus is the relationship between one or more categorical independent variables and one or more quantitative variables (Mertler & Vannatta, 2013). The study analyzed the differences in student achievement as measured by ACT scores for high school graduates graduating from varying CTE program areas. A one-way MANOVA statistical test, six univariate tests, and a post-hoc analysis were conducted.

SCHOOL DISTRICT CHARACTERISTICS AND STUDY SAMPLE

A large western school district with a developed career and technical educational endorsement system for high school students was utilized for this research. The district is currently serving over 18,000 high school students. Of the total student population, over 7,000 students in the district are enrolled in a CTE program. CTE programs currently available in the school district include modern computer science and environmental protection programs, construction technology, diesel and automotive technology, furniture and cabinet making, machine tool technology, and more.

The population of interest involved 312 graduated high school student ACT scores from the school district. The students successfully obtained high school CTE certifications

in the following program areas: 1) education, hospitality, and human services; 2) information and media technologies; 3) health science and public safety; and 4) skilled and technical sciences.

MEASUREMENTS: AMERICAN COLLEGE TESTING (ACT)

The ACT is the leading US college admissions test measuring what students learn in high school to determine their readiness for college and employment. The ACT is a non-profit organization devoted to helping people achieve educational and workplace success. The success of the ACT organization is founded in nearly 60 years of research. In 2011, the ACT surpassed the SAT in total test takers and all four-year colleges and universities in the U.S. accept the ACT (ACT, 2018). There are 25 states requiring high school students to undertake the ACT or SAT to qualify for graduation. The ACT examination is considered to be a high-stakes assessment because it is tied to important outcomes such as receiving a high school diploma and future educational placements (Yell, Katsiyannis, Collins, & Losinski, 2012). Two assumptions made for this study were that the ACT organization produced a reliable assessment of English, math, reading, science, and writing and the assessment was administered by the school district with fidelity.

The MANOVA analysis was conducted with fidelity by conducting several measures. The four fidelity assumptions which were met for this MANOVA study were: 1) the observations within each sample were randomly sampled and were independent of each other; 2) the observations on all dependent variables followed a multivariate normal distribution for both groups; 3) the population covariance matrices for the dependent variables for each group were equal, also known as *homoscedasticity*; and 4) the relationships among all pairs of DV's for each cell in the data matrix were linear. Multivariate normality was obtained by univariate assessments of normality for all variables along with examinations of bivariate scatter plots (Mertler & Vannatta, 2013). All skewness and kurtosis values fell between the acceptable range of +1 and -1 along with histograms and normal Q-Q plots displaying normal distributions. Consequently, the data was assessed as having a normal distribution (Mertler & Vannatta, 2013, p. 48).

DATA ANALYSIS AND STATISTICAL METHODS

An obvious advantage to the MANOVA is its ability to utilize several dependent variables. This not only creates for efficiency and a more robust research design, but two pivotal rationales are also offered (Warner, 2013). The first is any meaningful intervention or treatment will likely affect the research subjects in more than one way. This assumption offers good credibility as to why there is a need for more than one dependent measure. The rationale of treatments affecting people in more than one way leads to the second justification that the use of more dependent variables will offer the researcher the ability to obtain a more realistic and holistic picture of the phenomenon under investigation. For example, the ANOVA is capable of testing if the mean differences among a certain amount of groups on a single dependent variable hold statistical significance or if the differences between the groups occurred by chance or coincidence. In contrast, the MANOVA process is capable of measuring whether the mean differences between a certain number of groups on a combination of related and justified dependent variables are predictable or occur by random chance.

As mentioned, there were advantages to conducting a MANOVA analysis such as offering a more holistic picture of the phenomenon under investigation. Another statistical reason which offers rationale as to why MANOVA analysis was selected for this study includes the idea that by having several dependent variables at play in one analysis allowed for viewing what actually changes because of different curriculum paths being undertaken and executed.

VARIABLES

The independent variable of CTE status has four levels dictated by which of the four CTE pathways the student completed. Student achievement and the dependent variables for this study utilized the ACT examination scores students obtained in order to graduate high school. The ACT examination subjects included: 1) English; 2) math; 3) reading; 4) science; and 5) writing. The subject areas of English, math, reading, writing, and science covered on the ACT examination were evaluated on scales ranging from 1-36.

After coding was organized numerically and completed, the researcher proceeded to input all of the coded data into SPSS for analysis. It is important for all involved in the study and potential readers to understand the model was constructed by using existing data. The importance of understanding this is there were no interventions or treatments applied by the researcher. Instead, the investigator is attempting to notice the differences in results on examination marks due to students, parents, and guardians themselves choosing different options along their educational careers. Upon completion of inputting the organized and coded data into the statistical package, the actual process for a MANOVA was conducted. The utility of the MANOVA was it constructed a holistic picture of the phenomenon(s) being studied, had the capability of unearthing factors other statistical tests were incapable of, and reduced the error rate.

ERROR RATE AVOIDANCE MEASURES

One of the first steps when undertaking a MANOVA analysis is the overall multivariate hypothesis test. This translates to a test seeking to locate whether all groups are equal on the combination of dependent variables. If the null hypothesis is retained and significance was not located, then it is an accepted practice the researcher(s) halt their analysis and conclude the treatments or interventions applied to the groups have no effect on the dependent variables. In contrast, if the results are significant from the multivariate hypothesis test as was in this study, the researcher(s) is/are encouraged to continue the investigation into which independent variables are affecting the dependent variable(s). In order to facilitate the continuation of the investigation, the researcher conducted a series of univariate analyses of variance on each individual dependent variable. These tests with certainty will result in an inflated Type 1 error rate. In order to reduce the potential for Type 1 errors occurring, precautions were taken.

Bonferroni-Type Adjustment

Precautions against error(s) occurring during the multiple ANOVAs were taken including an adjustment to the alpha levels. This encouraged alpha level adjustment is known as the *Bonferroni-type* adjustment. What this adjustment accomplishes is a readjustment to a more stringent alpha level for the tests conducted on each dependent variable. This required the alpha set does not exceed a critical value for the set of DV's. The standard critical alpha level for each DV being tested is ($\alpha=.05$) divided by the total number of DV's under investigation. For this study the Bonferroni adjustment for the MANOVA procedure included five dependent variables. In order to maintain an alpha level of 0.05, each univariate test was conducted at $\alpha=0.01$ ($.05 \div 5=0.01$). Take note the final number need be rounded down after division in order to maintain the 0.05 alpha level. The final step for any of the univariate tests of a dependent variable which is found to hold significance is to conduct univariate post hoc tests in order to find where exactly the specific differences lie amongst the independent variables. In other words, to which magnitude is each independent variable influencing the dependent variables (Denis, 2018; Merler & Vannatta, 2013; Warner, 2013).

RESULTS

The purpose of this ex post facto research, also known as causal-comparative research, was to determine the impact of CTE endorsement type on student achievement. In ex post facto research, there is an objective to relate an after-the-fact treatment which cannot be administered or manipulated by the researcher to an outcome or dependent measure (Cohen, Manion, Morrison, & Morrison, 2007). The exact type of ex post facto research design this study followed was criterion group. The “phenomenon” in this study was CTE concentration program area and the dependent variables were student achievement as measured by high-stakes national assessment scores. Student achievement and the dependent variables for this study utilized the ACT examination scores in the subjects of English, math, reading, writing, and science students obtain in order to graduate high school and apply for college(s).

DESCRIPTIVE ANALYSIS

The examination of the descriptive analysis provided a general understanding of the data. Each of the four CTE program areas included 78 student ACT scores creating for a total of 312 cases. The mean scores indicated students who underwent and completed a *Skilled and Technical Sciences* CTE pathway had higher mean scores on the ACT composite, ACT English, ACT Math, and ACT science dependent variables. High school graduates who completed an *Information and Technology* (IT) CTE pathway had the highest mean scores for the ACT reading component and student graduates from the health sciences cohort tested the highest on the ACT writing component. Please see the following Table for a graphical display of means and standard deviations for the ACT composite score, ACT Math score, ACT Science score, ACT English score, ACT Reading score, and ACT Writing score by CTE program area (see Table 6).

Table 6. *Descriptive Results*

Assessment	CTE Program Area	M	SD
ACT Composite (combined average of English, math, reading, and science components)	Skilled Tech	20.78	5.63
	Info Tech	20.05	5.18
	Edu Hosp	17.92	3.38
	Health Science	19.21	3.77
ACT English	Skilled Tech	18.89	6.70
	Info Tech	18.30	6.13
	Edu Hosp	16.01	4.89
	Health Science	17.08	4.61
ACT Math	Skilled Tech	21.47	5.55
	Info Tech	20.23	5.18
	Edu Hosp	18.53	3.74
	Health Science	19.40	4.27
ACT Reading	Skilled Tech	20.69	5.98
	Info Tech	20.92	6.60
	Edu Hosp	18.36	4.50
	Health Science	19.96	5.10
ACT Science	Skilled Tech	21.58	5.82
	Info Tech	20.13	5.02
	Edu Hosp	18.50	3.17
	Health Science	19.78	3.73
ACT Writing	Skilled Tech	16.21	6.10
	Info Tech	17.10	5.18
	Edu Hosp	15.30	4.39
	Health Science	18.26	4.59

RESEARCH QUESTION 1—RESULTS

Are there significant mean differences in student achievement (as measured by the combination of all ACT assessment scores) for CTE completer high school graduates graduating from different CTE program areas? MANOVA results revealed statistically significant mean differences with a medium effect among the four CTE program areas on the combination of dependent variables [Pillai's Trace = .160, $F(18, 915) = 2.870$, $p < .001$, multivariate $\eta^2 = .053$]. Because the overall test was significant, the assumption there would be no significant statistical difference between the four cohorts of CTE student graduates was ruled invalid. After it was discovered there is a significant difference on the combination of ACT scores, individual analysis of variance between the four cohorts was conducted on each ACT subject area assessment. Questions two through seven are the results of the individual analysis of each ACT score.

RESEARCH QUESTION 2—RESULTS

Are there significant mean differences on the Composite ACT scores for CTE completer high school graduates graduating from different CTE program areas? The univariate test on the individual ACT composite dependent variable revealed statistically significant mean differences between the four student cohorts [$F(3, 308) = 5.59$, $p < .01$, partial $\eta^2 = .052$]. Therefore, CTE program area differences were significant for student achievement in the academic subjects of English, reading, mathematics, and science as measured by high-stakes national testing (see Figure 1).

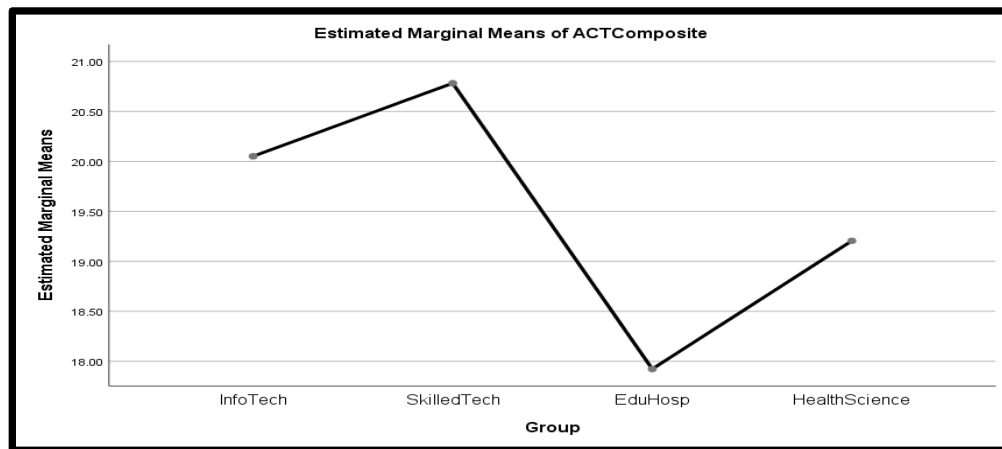


Figure 1. Means of ACT Composite Scores by CTE Program Area

RESEARCH QUESTION 3—RESULTS

Are there significant mean differences on the English ACT scores for CTE completer high school graduates graduating from different CTE program areas? The univariate test on the individual ACT English dependent variable revealed statistically significant mean differences between the four CTE program areas [$F(3, 308) = 4.01$, $p < .01$, partial $\eta^2 = .038$]. Therefore, CTE program area differences were significant for student achievement in the academic subject area of English as measured by high-stakes national testing (see Figure 2).

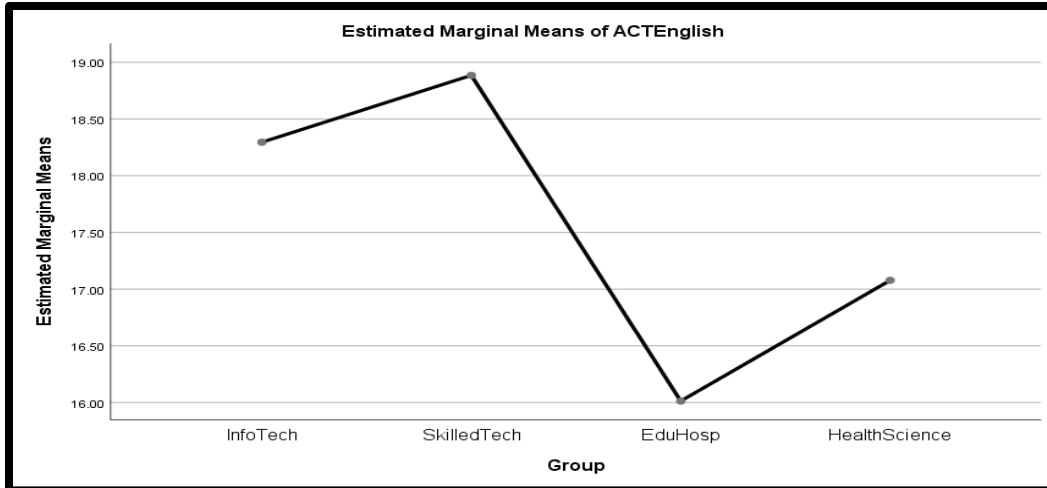


Figure 2. Means of ACT English Scores by CTE Program Area

RESEARCH QUESTION 4—RESULTS

Are there significant mean differences on the Math ACT scores for CTE completer high school graduates graduating from different CTE program areas? The univariate test on the individual ACT Math dependent variable revealed statistically significant mean differences between the four CTE program areas [$F(3, 308) = 5.47, p < .01, \text{partial } \eta^2 = .051$]. Therefore, CTE program area differences were significant for student achievement in the academic subject area of math as measured by high-stakes national testing (see Figure 3).

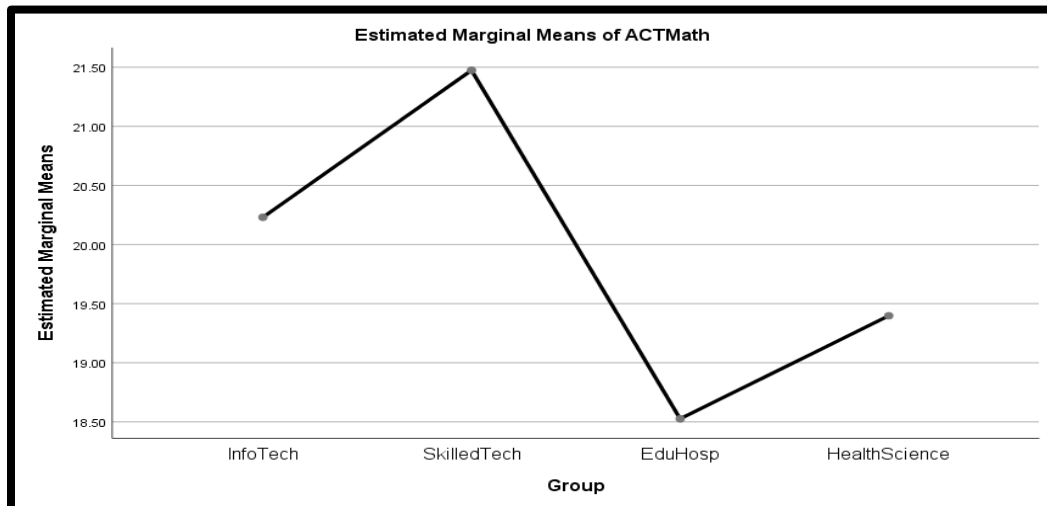


Figure 3. Means of ACT Math Scores by CTE Program Area

RESEARCH QUESTION 5—RESULTS

Are there significant mean differences on the Reading ACT scores for CTE completer high school graduates graduating from different CTE program areas? The univariate test on the individual ACT Reading dependent variable revealed statistically insignificant mean differences between the four CTE program areas [$F(3, 308) = 3.33, p > .01, \text{partial } \eta^2 = .031$]. Therefore, CTE program area differences were not significant for student achievement in the academic subject area of reading as measured by high-stakes national testing (see Figure 4).

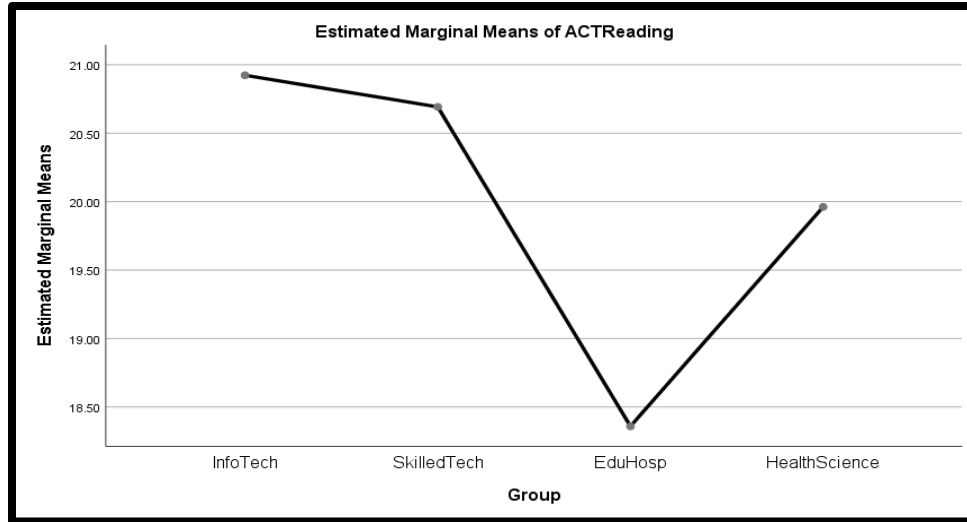


Figure 4. Means of ACT Reading Scores by CTE Program Area

RESEARCH QUESTION 6—RESULTS

Are there significant mean differences on the Science ACT scores for CTE completer high school graduates graduating from different CTE program areas? The univariate test on the individual ACT Science dependent variable revealed statistically significant mean differences between the four CTE program areas [$F(3, 308) = 6.02, p < .01, \text{partial } \eta^2 = .055$]. Therefore, CTE program area differences were significant for student achievement in the academic subject area of science as measured by high-stakes national testing (see Figure 5).

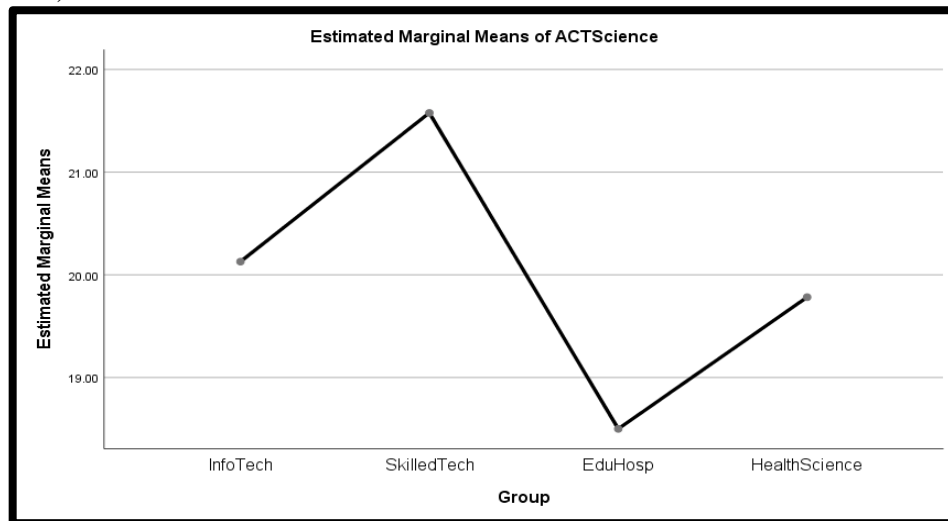


Figure 5. Means of ACT Science Scores by CTE Program Area

RESEARCH QUESTION 7—RESULTS

Are there significant mean differences on the Writing ACT scores for CTE completer high school graduates graduating from different CTE program areas? The univariate test on the individual ACT Writing dependent variable revealed statistically significant mean differences between the four CTE program areas [$F(3, 308) = 4.81, p < .01, \text{partial } \eta^2 = .045$]. Therefore, CTE program area differences were significant for student achievement in the academic subject area of writing as measured by high-stakes national testing (see Figure 6).

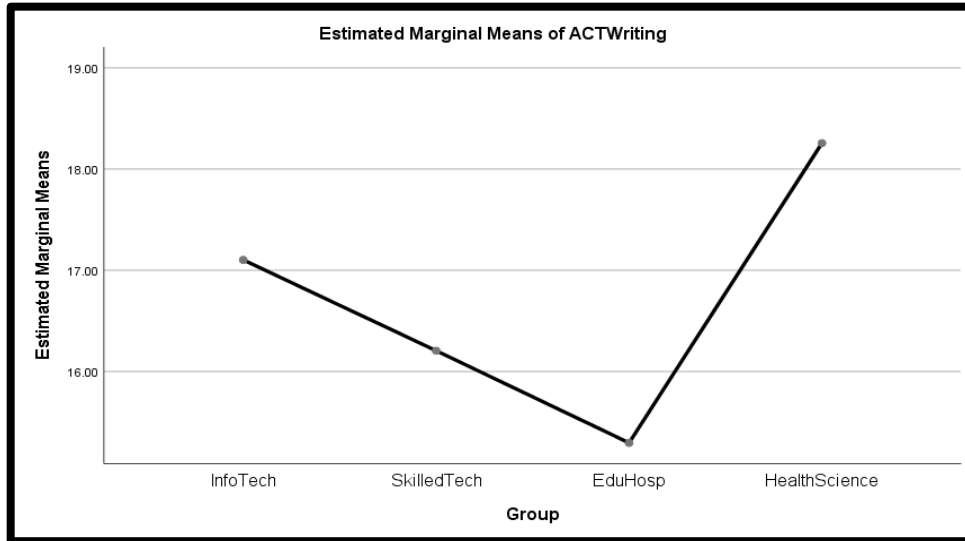


Figure 6. Means of ACT Writing Scores by CTE Program Area

SUMMARY OF RESULTS

MANOVA results revealed significant differences among the CTE program areas on the combination of dependent variables [Pillai's Trace = .160, $F(18, 915) = 2.870$, $p < .001$, multivariate $\eta^2 = .053$]. Analysis of variance (ANOVA) was conducted on each variable as a follow-up test to MANOVA. CTE program area differences were significant on each dependent ACT variable except for the reading dependent variable. The Bonferroni post hoc analysis revealed: 1) the ACT composite scores for students in the education, hospitality, and human services cohort significantly differs from the information-tech and skilled and technical sciences cohorts; 2) the ACT English scores for students in the education, hospitality, and human services cohort significantly differs from the skilled and technical sciences student cohort; 3) the ACT math scores for students in the education, hospitality, and human services cohort significantly differs from the skilled and technical sciences student cohort; 4) the ACT reading scores for students in the education, hospitality, and human services cohort significantly differs from the information and technology student cohort; and 5) the ACT science scores for students in the education, hospitality, and human services cohort significantly differs from the skilled and technical sciences student cohort.

The ACT STEM score measures overall performance on the science and mathematics components of the ACT. The skilled & technical and IT student cohorts posted higher ACT STEM scores. The skilled and technical student cohort posted ACT STEM scores which were 9% points higher than the education and hospitality CTE cohort.

DISCUSSIONS AND IMPLICATIONS

The purpose of this quantitative study was to investigate the student achievement of CTE completer high school graduates graduating from four different CTE program areas. Given the vast array of CTE pathways available to incoming high school students, the curiosity of whether certain CTE pathways strengthen and reinforce academic skills arose. The rationalization for why the four CTE program areas were selected for this study and not others was due to their popularity and completions. The IT, Skilled and Technical, Education/Hospitality, and health science CTE cohorts experienced the highest enrolment numbers and completion rates.

Science, technology, engineering, and mathematics problem solving, which calls on students to apply experience, skills, knowledge, and methods to solve original and difficult problems is a formidable task. CTE courses are designed to provide contexts for applied and experiential learning. Applied learning is the application of curricula within a relevant, natural, and presumably more engaging context. Experiential learning is the development of leaning through experience. In order for experiential learning to occur, the student must have four dispositions according to Kolb (1984): 1) the learner must be willing to be actively involved; 2) the learner must be able to reflect on the experience; 3) the learner must possess and use analytical skills to conceptualize the experience; and 4) the learner must possess decision making and problem solving skills in order to use the new ideas gained from experience. For example, horticulturists are called upon to estimate the number of flower and tree pots of varying diameters and depths which can fit inside a greenhouse. This dilemma calls on students to engage in applied and experiential learning. There is limited to no empirical or quantitative evidence suggesting the geometry and arithmetic skills learned in such a context transfers to the workplace and/or educational settings and testing. This study begins to quantify what many have instinctively suggested for millennia. The concept of learning through experience is ancient. Aristotle in 350 BCE wrote: “for the things we have to learn before we can do them, we learn by doing them” (Guseynov, 2016).

IMPLICATIONS FOR PRACTICE

As states and school districts make important decisions regarding the continuations, modifications, or elimination of CTE programs, the findings of this research should be reviewed. This study found students who execute CTE programs in *Information and Technology* or *Skilled & Technical Science*, post significantly higher STEM ACT scores by a noticeable margin when compared to other CTE cohorts.

Implication 1: Community of Practice

A necessary practice in order for academic material to be integrated into CTE courses is a community of academic and CTE teachers working together in an effort to imbed CTE applications in academic courses and visa-versa, embedding academic material into CTE courses. The process of curriculum mapping is a team process requiring everyone to work together towards the same goal of raising quantifiable student achievement rates. In the previously mentioned example of the horticulturist dilemma, curriculum mapping between a CTE teacher and math teacher will create for a realistic, motivating, and engaging student experience reinforcing the transfer of knowledge from one learning context to another

Implication 2: Maximize STEM Education in Other CTE Program Areas

Educators concerned with increasing the testing rates should encourage increasing the application of science and math in other CTE program areas. Often, information and technology and skilled and technical science curriculums and textbooks automatically include science and math embedded into the curriculum. CTE program areas which are limited in math and science practice are encouraged to modify their curriculums by imbedding more math and science.

Implication 3: Continued Vigilance

School administrators should continue to collect data on the student achievement of CTE students to monitor the effectiveness of CTE programs. In order to advocate for CTE programs, data connected to specific program areas and achievement should be researched. During this time of changing teaching standards and accountability, CTE programs need

to be capable of demonstrating their effectiveness in meeting the responsibility of equipping students with skills they need to prosper after high school.

RECOMMENDATIONS FOR FURTHER RESEARCH

Similar CTE program studies should be conducted across the nation and worldwide. As technology, policies, and teaching methods in CTE are tried-and-tested, new and more efficient teaching and learning methods emerge. A current trend in CTE education which is being emphasized is the rapid placement of students in company apprenticeships. There students can acquire first-hand practical experience which may lead to full-time employment following graduation. Research studies should be piloted tracking the academic achievement and outcomes of CTE students following graduation as CTE continually improves by providing desirable outcomes for high school graduates.

NOTES

DECLARATION OF CONFLICTING INTERESTS

The author(s) claim no potential conflicts of interest with regards to the research, authorship, and/or publication of this journal article.

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