Not Your Parent's Vocational Education: CTE Concentration and Mathematics College Readiness

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Abstract
Career and technical education (CTE) is often perceived to be focused primarily on career readiness, and not necessarily on college readiness. The purpose of this study was to examine the influence of CTE concentration on high school students' college readiness in mathematics. The researchers obtained a convenience sample of ACT Aspire (mathematics) scores for 865 students at a rural high school in Arkansas. The sample included scores for students who participated in three or more CTE courses as well as for students who took fewer than three CTE courses. The results show that neither CTE concentration nor sex appear to have a significant influence on the mathematics readiness of high school students. The researchers argue that this neutral influence may be related to a broader change in the scope of CTE programs.

Keywords: Applied STEM; sex; mathematic achievement; CTE concentrator; college readiness

Introduction
In the past decade, there has been a renewed interest in Career and Technical Education [CTE] (Jacob, 2017), that is reflected in the number of students who enroll, participate, or complete CTE courses and programs. The US Department of Education (2019) revealed that 77% of American students take at least one CTE course. Trends also show more participation across the states. Dougherty (2016) reported 89% of Arkansas students take at least one CTE course while McVicar (2017) reported an increase in Michigan enrollment from 21.4% in 2014 to 22.7% in 2016. In many ways, modern CTE, described as the "new vocationalism" by Dougherty (p.2), is fundamentally different from traditional vocational education. CTE now attracts students with sequenced career courses embedded with college readiness skills. CTE's role in improving student engagement, graduation rates, and career and college readiness has also gained momentum among educators (Kantrov, 2014). Integrating academics into CTE is more popular than ever, with many programs offering core academic credit as CTE and academic instructors collaborate (Richnor, 2014). In spite of these gains, Bottoms (2020) recognizes the need for even closer integration between CTE projects and assignments and college-readiness standards. One area of integration that has become particularly relevant in CTE is mathematics.

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Mathematics achievement at the high school level has always been an area of concern for educators and researchers. In a recent study, Cogan, et al, (2019) observed a strong connection between exposure to a rigorous mathematics curriculum, real-world applications of mathematical concepts and the mathematics literacy of high school students. Ironically, the National Center for Education Statistics (NCES, 2019) revealed a stagnation of 12th-grade scores on the National Assessment of Educational Progress in mathematics between 2015 and 2019. In fact, 40% of the scores were at Below Basic performance levels. Moreover, scores decreased among lower-performing students at the 10th and 25th percentiles. Furthermore, when compared to students in 79 other countries, US students ranked 31st in math literacy (Richards, 2020). Efforts to curb this trend have focused on reforms in mathematics instructional methods. This includes improved reasoning and problem-solving skills through activity-based learning (Jonsson & Johan, 2014). Modern CTE courses, therefore, integrate standards-based academic content such as mathematics into cooperative, problem-based, and project-based learning. In this regard, CTE courses can play a role in improving mathematics college readiness. This may explain why the US Department of Education (2019) observed that CTE concentrators were as likely as non-concentrators to complete a four-year degree. Additionally, the department found concentrators to be more likely than their peers to complete an associate's degree and earn a higher annual income after eight years.

Review of Literature

Not Your Parent's CTE

Modern CTE offerings differ from the vocational education of the past. One way is the designation of a CTE participant and a concentrator. In CTE, the term "participant" refers to a student who has earned at least one CTE credit. A "concentrator", on the other hand, is a student earning two or more CTE credits within a program of study (US Department of Education, 2019). Yet, states may require students to take more than the minimum two credits to be a concentrator. For example, in Arkansas, a CTE concentrator is any student who earns three credits in a program of study (Arkansas Department of Education [ADE], 2021). Dougherty (2016) noted that CTE students in Arkansas were offered 62 programs of study; states can decide which programs of study to offer, the courses included, and credits necessary to be a concentrator. Whereas in Oregon, concentrators only have to earn "...one or more CTE credits in a single secondary CTE program" (Arnerson, et al., 2020, p. ii). CTE concentrators have many course options within the programs of study, making CTE more appealing than ever.

Another way modern CTE offerings are different is through programs of study. CTE offers different programs of study so students enroll in courses that relate to their interests and career pathways. The National Assessment of Career and Technical Education's final report to Congress in 2009 found 85% of high school students completed one or more CTE courses, 76% earned at least one CTE credit, and of these, 19% were CTE concentrators who earned at least three credits in one CTE program (US Department of Education, 2014). A few years later, the US Department of Education (2019) reported 77% of students taking at least one CTE credit. While more students are participating and becoming concentrators in CTE, they continue to take advanced academic courses in subjects like mathematics. In fact, Aliaga et al. (2012) found students who took three CTE credits or more also took higher levels of mathematics. This reinforces the idea that CTE and academics can work well together. The US Department of Education (2014) reported CTE concentrators accounted for 14% of students completing a higher-level mathematics course in ninth grade compared to 24% having completed a lower-level course or no mathematics course at all. As CTE concentrators learn career readiness skills, they are also learning how academics, such as mathematics, relate to different career pathways.

CTE and STEM- Making Connections for Tomorrow's Workforce
As in traditional academic courses, CTE programs incorporate STEM subjects like mathematics, but deliver the content through hands-on, real-world activities (Bozick & Dalton, 2013; Gottfried, et al., 2014). In fact, according to *CTE is your STEM strategy* (2013), STEM should not be viewed as a separate program from CTE because high-quality CTE programs can provide students with a strong foundation for STEM skills and competencies. This connection between CTE and STEM is crucial as over the last decade, graduates with STEM-related training have been projected to be in high demand (Snyder et al., 2016). Additionally, Rothwell (2013) reported the Brookings Institute estimated that by 2011, 20% percent of all jobs required a high level of knowledge in the STEM fields. Half of which require a bachelor's degree but nearly all of which pay well above the national median salary. Furthermore, Yoon Yoon and Strobel (2017) believe STEM programs within CTE will open pipelines to supply America with motivated and prepared students, thus strengthening the US workforce. High school students in STEM related modern CTE programs stand to benefit from this strong connection as they prepare for college and career opportunities.

The Intersection of CTE Concentration, Sex, and Mathematics Performance
Modern CTE courses differ from traditional vocational education because they equally attract both male and female students. Although Plasman et al. (2020) found that nationwide, the gap between male and female student enrollment in CTE courses has remained about the same over the last decade; in states such as California (Reed et al., 2018) and Oregon (Arneson et al.,2020), male students continue to outnumber their female counterparts in CTE courses. However, in Arkansas, Dougherty (2016) found that CTE students were more likely to be female than male. Given these disparities, understanding gender differences in CTE participation requires looking beyond the overall enrollment figures.

Common stereotypes hold that males and females perform better in certain classes may not be entirely unfounded. For example, female students tend to score higher in English and social sciences, while male students score higher in mathematics and science (ACT, 2014). In 2017, the national average ACT score for males in mathematics was 21.2 and 20.4 for females. Male students also outperform female students on all the mathematics subtests (ACT, 2017). In contrast to the national data, the ACT profile report provided by the ADE (2016) shows that 26% of males and 30% of females met mathematics benchmarks.

Beyond this, there is a growing interest in exploring the influence of assessment format on male and female students' mathematics performance. Ghasemi et al. (2019) noted studies that found gender differences are based on the Programme for International Student Assessment (PISA) exam. They argued that no study to date that employed other international mathematics assessment data (e.g., The Trends in International Mathematics and Science Study - TIMSS) supported the difference hypothesis. Ultimately, these types of investigations will lead to better insights into gender and mathematics performance. Overall, regardless of gender, current literature suggests positive academic and career outcomes for students who choose to participate in CTE. These trends signal that significant changes are taking place in the academic performance of students who choose to enroll, participate, and concentrate in CTE. In the current study, the researchers focus on college readiness at the 10th and 11th grade levels, as this is the point when high school students begin to hone in on college and career preparation (Wyatt, et al., 2014). Furthermore, exploring college readiness at the senior high school level is consistent with prior research on the topic (Bonner & Thomas, 2017).

Research Questions
To guide the investigation, the researchers developed the following research questions:

RQ1 - To what extent does CTE concentration and sex affect mathematics college readiness among Grade 10 students in Arkansas?

RQ2 - To what extent does CTE concentration and sex affect mathematics college readiness among Grade 11 students in Arkansas?

Method

Design and Sampling

A causal-comparative, non-experimental design was used for this study. The researchers obtained a convenience sample of scores for 865 students in Grade 10 (n = 428) and Grade 11 (n = 437) at two Arkansas high schools. The demographic characteristics of the four schools used in this study as published by ADE (2020) are provided in Table 1.

Table 1
Demographic Characteristics of Schools

Demographic		School A	School B
Enrollment		749	949
Low Income		38%	42%
Receive Special Education		12%	10%
Race/Ethnicity			
	Native American	0.5%	0.3%
	Asian	1.1%	1.4%
	African American	0.5%	4.5%
	Hawaiian/Pacific	0.1%	4.6%
	White	93.2%	87.7%
	Two or More Races	0.5%	1.5%

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Approximately 10-12% of the students at both schools required special education services (not including language support). The sample included scores for students receiving special education services but excluded scores for students identified as English language learners.

Measures, Procedure and Data Analysis Data for this study was obtained in the form of scores from the 10th-grade mathematics ACT Aspire and the ACT mathematics subtest. Both assessments are published by ACT Inc. The ACT Aspire is administered to 3rd-10th-grade students in Arkansas (ACT, 2020). It is a norm-referenced test that includes English, Mathematics, Science, Reading and Writing assessments. The mathematics subtest has 60 questions to assess student knowledge and provide insights into student preparedness for the ACT assessment (ACT Aspire, 2016). The ACT is also a norm-referenced test that includes English, Mathematics, Science, Reading and an optional Writing assessment. The mathematics subtest comprises 60 multiple-choice items that cover pre-algebra, quantity, probability, functions, elementary algebra, intermediate algebra, plane geometry, coordinate geometry, statistics, and trigonometry. Scaled scores on the ACT range between 1 and 36 with the benchmark score for the mathematics subtest being 22 (ACT, 2017). By setting benchmarks for subtests, minimum scores help establish achievement levels necessary for student success in first-year college courses.

After receiving Institutional Review Board approval, the records of students' mathematics scores were obtained from the high school administrators. The data were coded, screened, and analyzed using IBM Statistical Packages for the Social Sciences Version 22 (IBM, 2013). To address each research question, the researchers conducted 2 x 2 between- groups factorial ANOVA at a 0.05 level of significance.

Results

Research Question One
To address the first research question, the researchers conducted a 2 x 2 Factorial ANOVA. Researchers examined the assumptions of independence of observations, normality, and homogeneity of variances. No significant outliers were identified in the sample and despite a violation of the assumption of normality, the researchers deemed ANOVA an appropriate method of analysis as it is robust to violations of this assumption under certain conditions (Leech et al., 2011). Table 2 provides a summary of the group means and standard deviations for mathematics achievement of Grade 10 students by CTE concentration and sex.

Table 2
Descriptive Statistics for Mathematics Achievement by CTE Concentration and Sex of Grade 10 Students

Sex	CTE Concentration	*M*	*SD*	*N*
Female	Concentrators	427.45	7.53	117

	Non-Concentrators	427.64	7.96	100
	Total	427.54	7.71	217
Male	Concentrators	426.40	8.12	117
	Non-Concentrators	426.70	8.43	94
	Total	426.54	8.25	211
Total	Concentrators	426.93	7.83	234
	Non-Concentrators	427.19	8.19	194
	Total	427.04	7.99	428

Results of Levene's test revealed no violation of homogeneity of variances on mathematics achievement between the groups $F(3, 424) = 0.912$, $p = .435$. The results of the ANOVA are displayed in Table 3.

Table 3
Factorial ANOVA Results of the Mathematics Achievement of Grade 10 Students

Source	*SS*	*df*	*MS*	*F*	*p*	*ES*
Intercept	77332557.19	1	77332557.19			
Sex	104.86	1	104.86	1.64	.201	<0.01
CTE Concentration	6.30	1	6.30	0.10	.754	<0.01
Sex*CTE Conc.	0.34	1	0.34	0.01	.942	<0.01
Error	27117.81	424	63.96			
Total	78080271.00	428				

The results revealed that the interaction between CTE concentration and sex was not statistically significant, $F(1, 424) = 0.005$, $p = .942$, $ES < 0.01$, with a small effect size. Therefore, the researchers could not reject the interaction null hypothesis. Figure 1 displays the mean mathematics achievement for male and female Grade 10 students by CTE concentration. Analysis of the main effects for CTE concentration and sex revealed no statistically significant effect for either CTE concentration, $F(1, 424) = 0.01$, $p = .754$, $ES < 0.01$ or sex, $F(1, 424) = 1.64$, $p = .201$, $ES = 0.004$. In summary, for students in Grade 10, neither CTE concentration or sex (in combination or singularly), had a discernable effect on their mathematics achievement.

Research Question Two

To address the second research question, the researchers also conducted a 2 x 2 factorial between-groups ANOVA. Table 4 provides a summary of the group means and standard deviations for mathematics achievement of Grade 11 students by CTE concentration and sex

Table 4
Descriptive Statistics for Mathematics Achievement by CTE Concentration and Sex of Grade 11 Students

Sex	Program Participation	*M*	*SD*	*N*
Female	Non Concentrators	18.12	3.51	43
	Concentrators	17.63	2.74	176
	Total	17.73	2.91	219
Male	Non-Concentrators	18.27	3.84	33
	Concentrators	19.11	4.03	185
	Total	18.98	4.00	218
Total	Non-Concentrators	18.18	3.64	76
	Concentrators	18.39	3.53	361
	Total	18.35	3.55	437

The researchers checked for homogeneity of variances using Levene's test $F(3, 437) = 8.61$, $p < .001$. Although there was a violation of this assumption, ANOVA is considered robust to this violation (Leech et al., 2011) The results of the ANOVA are displayed in Table 5.

Table 5
Factorial ANOVA Results of the Mathematics Achievement of Grade 11 Students

Source	*SS*	*df*	*MS*	*F*	*P*	*ES*
Intercept	82722.35	1	82722.35			
Sex	104.86	1	41.30	3.38	.067	<0.01
CTE Concentration	1.89	1	1.89	0.16	.694	<0.01
Sex*CTE Conc.	26.99	1	26.99	2.21	.138	.005
Error	5285.80	433	12.21			
Total	152672.00	437				

The analysis revealed that the interaction between sex and CTE concentration was not significant, $F(1, 437) = 2.21$, $p = .138$, $ES = .005$ with a small effect size. Figure 2 shows the means for mathematics achievement as a function of sex and CTE participation level. As with the interaction effect, the researchers found no statistically significant main effect for CTE concentration, $F(1,437) = .155$, $p = .694$, $ES < 0.01$ or sex $F(1, 437) = 3.38$, $p = .067$, $ES < 0.08$. In other words, neither CTE concentration or sex had discernable interaction or main effects on the mathematics achievement of Grade 11 students. In summary, results revealed that although concentrating in CTE classes did not have a significant beneficial effect on mathematics performance for Grade 10 or Grade 11 students, it did not have a detrimental effect for either group. Furthermore, this outcome was the same for male and female students.

Discussion

In this study, the relationship between CTE concentration, sex, and mathematics readiness of 10th and 11th-grade students was examined. Results revealed that neither CTE concentration nor sex had significant interaction effects or main effects on students' mathematics readiness of either group. In discussing these findings, the researchers outline the limitations, implications, and recommendations for further inquiry about the impact of CTE concentration on the current and future academic success of high school students.

Specifically, results show that CTE concentration (four or more classes) neither helped nor hindered mathematics readiness. In essence, the mathematics performance on the ACT Aspire of 10th-grade students who completed four or more CTE courses was not different from their peers who completed fewer CTE courses. The researchers found the same to be true for 11th-grade students taking the ACT mathematics assessment. These findings are in line with Levesque et al. (2011), who found that CTE coursework had a neutral effect on academic achievement. Levesque et al. concluded that the achievement gap between CTE concentrators and other high school students has narrowed due to more students concurrently enrolling in both CTE programs of study and college-preparatory pathways. Partin (2016) reported equally interesting results for CTE students in Arizona where CTE concentrators outperformed the general high school population on the state examination. Partin inferred that this was because academic content was deeply embedded within CTE courses and instruction was aligned with state standards. The research findings however stand in contrast to those of Yettick et al. (2012) and Jacob (2017) that raise questions about the academic rigor of CTE programs and suggest that students in these programs have lower educational aspirations and lack strong academic outcomes.

The researchers found no interaction effect between CTE concentration and sex on students' mathematics performance. The mathematics performance of males and females did not differ whether or not they were CTE concentrators. The findings support Kersey et al. (2019) who found similarities between male and female neural functioning, indicating that mathematical processing develops at the same rate for boys and girls. Gunderson et al., (2011) found math attitudes form as a result of influences and interactions with parents and teachers due to sex expectations and biases.

Limitations

The findings in this study must be considered in light of the following limitations. The researchers employed a causal-comparative strategy, which means findings should not be interpreted as implying causal relationships between gender, CTE concentration, and mathematics achievement. Furthermore, this study did not account for the effect of other factors like parental expectations and intrinsic motivations (Froiland & Davison, 2016) that have been shown to influence high school mathematics performance. Additionally, the sample was limited to scores from students at two schools in Arkansas. This sample restriction could inadvertently affect external validity and the generalizability of the findings. Despite these limitations, the findings serve as an entry-level step to a clearer understanding of the complex relationship between high school curricular pathways and student outcomes.

Implications

The study had two fundamental implications for CTE practitioners. Firstly, it signals a neutral relationship between CTE concentration and students' mathematics college achievement. This would suggest authentic mathematics learning experiences comparable to those in college preparatory mathematics classrooms are taking place in CTE classrooms. Indeed, with regards to mathematics performance, CTE concentration seems to have moved beyond the era of strictly vocational education outcomes. CTE concentration no longer reflects deficits in academic preparation but may actually lead to positive high school outcomes and post-secondary academic and career success.

Secondly, the researchers found no difference between male and female performance on the ACT Aspire or ACT. Like Ghasemi et al. (2019) researchers found very little separation between the sexes concerning mathematics achievement. But even beyond this, the research begins a conversation which has not been previously explored regarding the mathematics achievement of male and female CTE concentrators. Ultimately, this study provides a signal that CTE curricula as a whole is changing in a manner that makes old stereotypes about CTE just that - stereotypes. Invariably, further research is needed to confirm the findings and affirm the implications we have suggested in this paper.

Future Research

It would be worthwhile to direct future research at uncovering other factors that may explain the closing gap in mathematics achievement between CTE concentrators and students in other high school pathways. Studies are also needed that operationalize mathematics achievement with measures other than the ACT and ACT Aspire (e.g., GPA, PISA). In the past, questions have been raised concerning the alignment of ACT-based assessments with Arkansas state standards and standards in other states (e.g., Achieve 2018, Davis-Becker, 2019). One thing is certain though, the mathematics preparation CTE concentrators are now receiving appears to provide them appropriate preparation for their college and career needs. It is no longer just your parent's vocational education.

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