Trends in Texas High School Students' Enrollment in STEM Courses for Career and Technical Education (Fundamental)

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I. Introduction

While the demand for motivated students to enter STEM fields is at its highest, high school seniors' interest in and readiness for pursuing these careers have been sluggish[1]. The largest impact on STEM entrance is reported to be intent to major in STEM, which is directly affected by 12th-grade math achievement and exposure to math and science courses. In the context of Texas, House Bill 5 signifies a major policy shift requiring entering high school students in fall 2014 to choose an endorsement, STEM being one of them. Career and Technical Education (CTE) is one of the pathways to achieve the STEM endorsement (next to Mathematics, Science and Computer Science). The goal for House Bill 5 is to provide students with earlier exposure to a coherent course sequence and to increase preparedness and sustain interest in STEM careers. Given the increase in messaging on the value of STEM, we don't know how well the message is acted upon by high school students and as we barely understand students' choices before the endorsement requirement, we need to set a baseline. Therefore, this study attempts to set out the baseline through analyses of trends in several years of CTE-STEM course enrollment in TX prior to House Bill 5.

We chose to focus on the CTE-STEM pathway out of two reasons: (1) The CTE-STEM pathway includes the most explicit inclusion of engineering and technology courses whereas the Science, Mathematics, and Computer Science pathways do not specifically require engineering courses for their completion and (2) CTE courses are designed to address students who are more interested in entering the workforce after their high school degree, so CTE provides a lower entry point into STEM careers than a college-bound track.

A. Roles of Career and Technical Education

In the past, vocational education was known for job-training courses for students, who planned to directly enter the workforce after high school[2,3]. However, along with the revision of the term from "vocational education" to "career and technical education" (CTE) by Carl D. Perkins Career and Technical Education Improvement Act of 2006, states and the nation initiated reforms of CTE courses for high school students to provide an opportunity to build up students' interests and competencies in careers, so that they can have a smooth transition from secondary to postsecondary education[2, 4]. Particularly, when quality CTE education aligns with rigorous coursework, it is expected that students are performing better in academics in the secondary education[5] and earning higher salaries at work[6]. Therefore, as a link between secondary and postsecondary education, the roles of CTE are more important than ever in preparing students for college and future careers[7].

However, as shown in Figure 1, the trends in CTE course taking by U.S. public high school students were not promising according to the data on average course credits from 1990 to 2009, according to the data from U.S. Department of Education and National Center for Education

Statistics [U.S. DoE & NCES][8]. While the average numbers of credits of major subjects earned per student have been steady or slightly increasing over time, the average number of CTE credits per student has been declining.

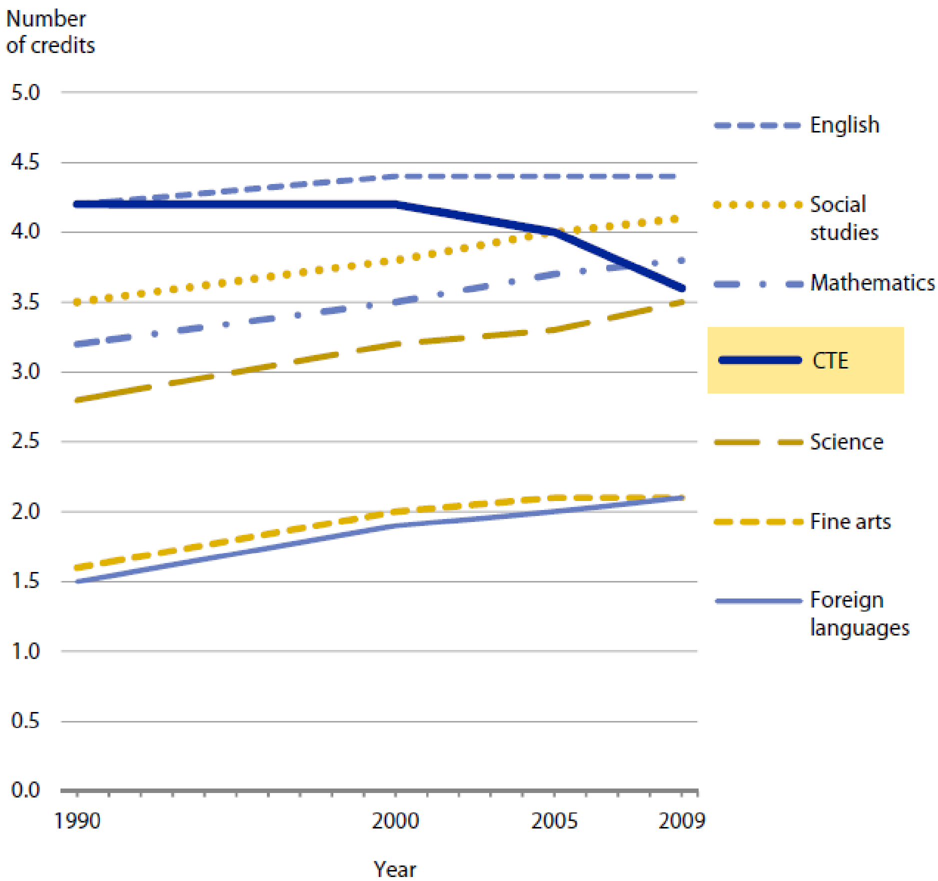

Figure 1. Average number of credits earned in each subject area by U.S. public high school graduates in 1990, 2000, 2005, and 2009.
Source: U.S. Department of Education (DoE) and National Center for Education Statistics (NCES), 2013, Figure 1)[8]

Under these circumstances in nation and by states, House Bill 5 is expected to bring substantial changes to Texas high school curricula and graduation requirements and significant effects in preparing students to be ready for college and career. Therefore, it is necessary to diagnose the student enrollment trends in the rigorous courses and CTE-STEM courses to explore the effects of the changes and to provide evidence to prepare better support and policies to draw more students into STEM.

B. Purpose of the Study

This study aims to explore trends in high school students' preferences on CTE-STEM subjects by exploring students' course enrollment data in Texas. To do this, we utilized 6-years data (from 2008 to 2013 school years) from Texas Education Agency (TEA). Guiding research questions were: (1) over a six-year time frame, do Texas high school students take increasingly more CTE-STEM courses, controlling for the effects of natural increase of population?; (2) how do the trends of students' course enrollment differ by gender and race/ethnicity?; and (3) analyzing CTE-STEM courses, what trends in student enrollment can characterize students' interest in STEM?

II. Method

A. Setting

Along with the common curriculum, Texas also offered career and technical education (CTE) programs in various areas. By selecting a program of their interests, students can take a sequence of courses with the CTE content that "is aligned with challenging academic standards and relevant technical knowledge and skills needed to prepare for further education and careers in current or emerging professions"[9]. Among various CTE programs, the CTE-STEM program in Texas consists of 15 courses with varied credits ranged from 0.5 to 3 credits. Table 1 shows a list of CTE-STEM courses with course number, titles, and credits, which is current as of the 2014-2015 year.

Table 1. CTE-STEM Courses Offered in Texas as of the 2014-2015 School Year

Course #	Course Title	Credit
130.362	Concepts of Engineering and Technology	0.5 - 1
130.363	Biotechnology[R]	1 - 2
130.364	Advanced Biotechnology[R]	1
130.365	Engineering Design and Presentation[R]	1 - 2
130.366	Advanced Engineering Design and Presentation[P]	2 - 3
130.367	Engineering Mathematics[P]	1
130.368	Electronics[R]	1 - 2
130.369	Advanced Electronics[P]	2 - 3
130.370	Robotics and Automation[R]	1 - 2
130.371	Principles of Technology[P]	1 science
130.372	Scientific Research and Design[P]	1 science
130.373	Engineering Design and Problem Solving[P]	1 science
130.374	Practicum in Science, Technology, Engineering, and Mathematics	2 - 3
130.375	Principles of Engineering	1
130.376	Digital Electronics	1

Note. [R] denotes that the course had recommended prerequisites; [P] denotes that the course had prerequisites.
Source: Texas Education Agency (2014). Retrieved from http://ritter.tea.state.tx.us/rules/tac/chapter130/index.html

While five CTE-CTEM courses had recommended prerequisites, five CTE-advanced courses require prerequisites. Advanced Engineering Design and Presentation had a prerequisite of Engineering Design and Presentation; Engineering Mathematics had a prerequisite of Algebra II; Advanced Electronics had a prerequisite of Electronics; Principles of Technology had two prerequisites of one unit of high school science and Algebra I (which are general requirements for all high school students); Scientific Research and Design had a prerequisite of one unit of high school science; and Engineering Design and Problem Solving had four prerequisites of Geometry, Algebra II, Chemistry, and Physics.

Reflecting the House Bill 5, from the class of 2018 high school students, there are several pathways for a student to earn a STEM endorsement, achieving four credits in mathematics, science, computer science, or CTE-STEM, on top of taking Algebra II, Chemistry, and Physics. For a CTE-STEM endorsement, a student needs to have a coherent sequence of courses for four or more credits that consists of at least two courses in the same career cluster (CTE-STEM), including at least one advanced CTE course, which includes any course that is the third or higher course in a sequence.

B. Population

The population of the study is grades 9 -12 students in high schools in Texas from 2008 to 2013 school years. Based on the data from TEA, Table 2 shows demographic information of the grades 9 to 12 students in high school across the 6 years. During the six years, the total number of the high school population has been increased about 8 % from 1,292,587 to 1,407,868. Male students (~51%) were a slight majority. The student population is quite diverse in that the majority was Hispanic students (44% ~ 49%), which were close to half of the students' population, followed by White (32% ~ 38%) and Black students (13% ~ 15%). While the number of Hispanic students has been increased, Black and White students have been decreased across six years.

Table 2. Texas High School Students' Demographic Characteristics from 2008 to 2013 school years.

Year	Female (%)	Male (%)	American Indian/ Alaska Native (%)	Asian (%)	Black (%)	Hispanic (%)	Native Hawaiian/ Other Pacific (%)	White (%)	Multi-racial (%)	Total *N*
2008-09	48.9	51.1	0.4	3.7	14.7	43.5	−	37.8	−	1,292,587
2009-10	48.8	51.2	0.5	3.4	13.8	45.5	0.1	35.2	1.4	1,318,403
2010-11	48.9	51.1	0.5	3.6	13.5	46.5	0.1	34.3	1.5	1,335,617
2011-12	48.8	51.2	0.5	3.7	13.3	47.4	0.1	33.4	1.6	1,358,435
2012-13	48.8	51.2	0.4	3.7	13.1	48.3	0.1	32.6	1.7	1,381,979
2013-14	48.8	51.2	0.4	3.8	13.0	48.9	0.1	32.0	1.7	1,407,868

Note. In 2008-2009 school year, no category for Native Hawaiian/Other Pacific and Multiracial.

C. Data and Analyses

The six years data (from 2008 to 2013 school years) from TEA are open to the public and contain students' enrollment records of all the courses offered in high school (grades 9-12) by gender and race/ethnicity. For the purpose of this study, CTE-STEM courses were identified across years to explore the trends in student enrollment that can characterize students' interest in STEM career. Among the current 15 CTE-STEM courses as of the 2014-15 school year in Table 1, the following six courses, except their advanced courses, consistently existed during the 2008 to 2013 school years with the same course title: Biotechnology, Electronics, Principles of Technology, Scientific Research and Design, Principles of Engineering, and Digital Electronics. However, when similar course titles existed across years, we also counted the enrollment rates of the courses, which matched with Advanced Biotechnology, Advanced Electronics, and Robotics and Automation. Therefore, the course categories of our interests are 15 in CTE-STEM. In addition, we collectively aggregated the data on CTE-STEM courses to explore the overall trend as a whole as shown in Figure 1 in the report by U.S. DoE and NCES (2013)[8].

To explore the changes in the students' enrollment in the CTE-STEM courses, a proportional ratio was calculated, using the enrolled number of students for a course per the total number of the student population, for each course category listed in Table 1 from 2008 to 2013 school years. In compliance with FERFA, student counts less than 5, not 0, were masked with -99, so we considered the masked information counts of student between 1 and 4 with uncertainty. However, the differences caused by the uncertainty were smaller than 0.01% of the total student counts on course categories, so there were no significant changes in the results using proportional ratios caused by the uncertainty.

III. Results

A. Enrollment Rates in CTE-STEM courses

Figure 2 shows the trends of students' enrollment rates in percentage of total number of students in the 15 CTE-STEM courses across years. Overall, the enrollment rates of most CTE-STEM courses were increasing except Principles of Technology. The top three popular CTE-STEM courses were Concepts of Engineering and Technology, Scientific Research and Design, and Principles of Technology, followed by Engineering Design and Presentation and Principles of Engineering.

On one hand, as Concepts of Engineering and Technology is a recommended prerequisite of four CTE-STEM courses (i.e., Biotechnology, Engineering Design and Presentation, Electronics, and Robotics and Automation), the enrollment rates across time were relatively high compared to other courses and were increasing. On the other hand, Scientific Research and design had one prerequisite and Principles of Technology had two prerequisites, their enrollment rates across time were also relatively high. This is because their prerequisites are the courses required for all students to graduate from high school, so students are easily able to meet the requirements. Interestingly, Engineering Design and Problem Solving had four prerequisites, the enrollment rate in the last year was higher than two courses with no prerequisites (Digital Electronics and Practicum in STEM) and three courses with recommended prerequisites (Electronics, Biotechnology, and Advanced Biotechnology).

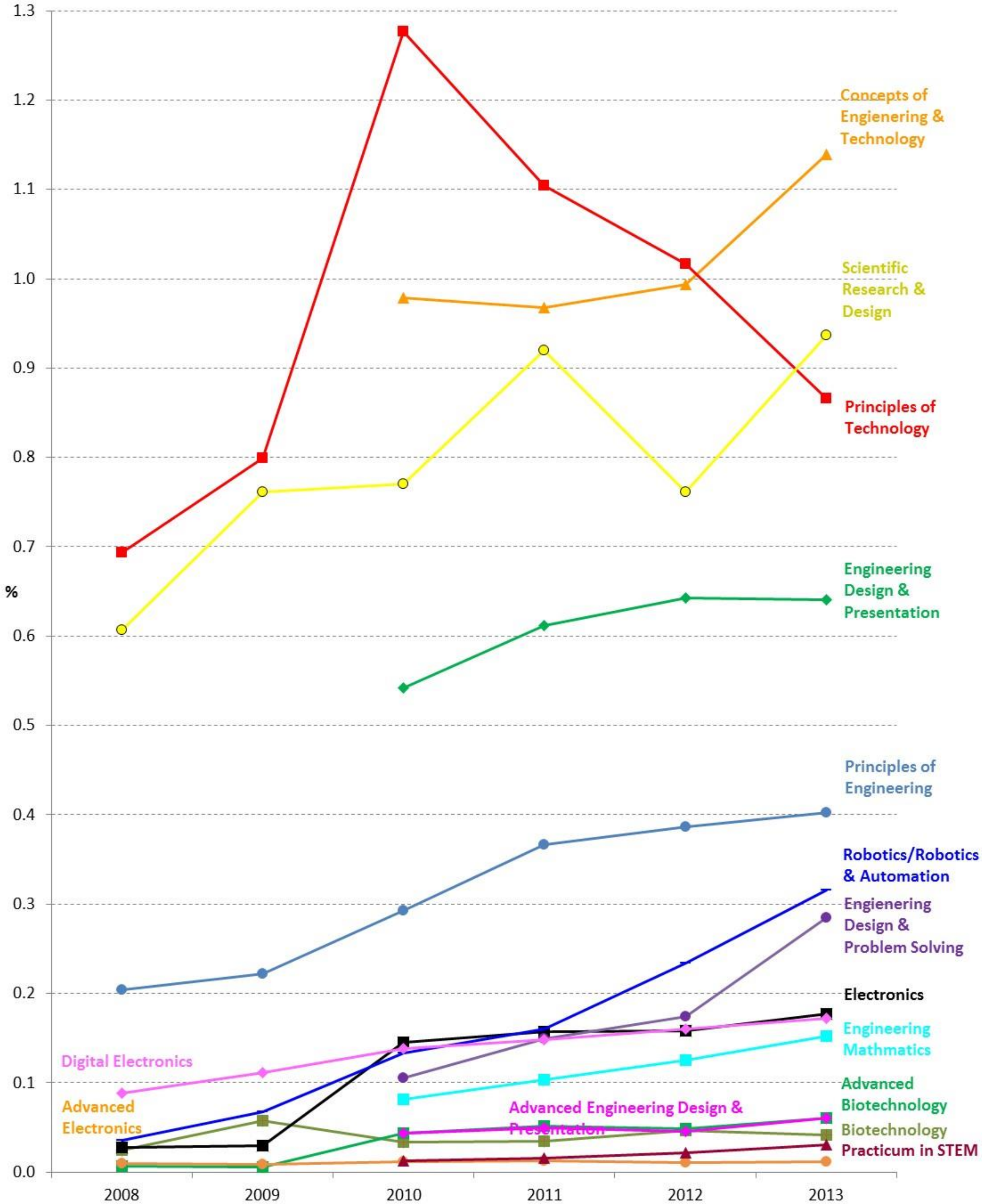

Figure 2. 15 CTE-STEM course enrollment rates in percentage of total number of students**B.**

B. Enrollment in CTE-STEM Courses by Gender

Figure 3 shows the trend of enrollment in the six CTE-STEM courses (excluding advanced courses) continuously offered across six years. Among them, Principles of Technology had the highest enrollment rates, followed by Scientific Research and Design and Principles of Engineering across years. Comparatively, the enrollment rates of Biotechnology, Electronics, and Digital Electronics were small, less than 1% of the total population. While the enrollment rates in Scientific Research and Design and Principles of Engineering were increasing across years, the enrollment rates in Principles of Technology started to decrease from 2010.

Interestingly, in early years, more female students enrolled in Biotechnology and Scientific Research and Design than male students but the gender gaps in the enrollment rates became smaller in Biotechnology and disappeared in later years in Scientific Research and Design, respectively. While more male students enrolled in Principles of Technology and Principles of Engineering than female students, the gender gaps were constant in Principles of Technology yet became larger in Principles of Engineering. However, the gender gap in Electronics and Digital Electronics became larger in the later years with more male students enrolled in those courses.

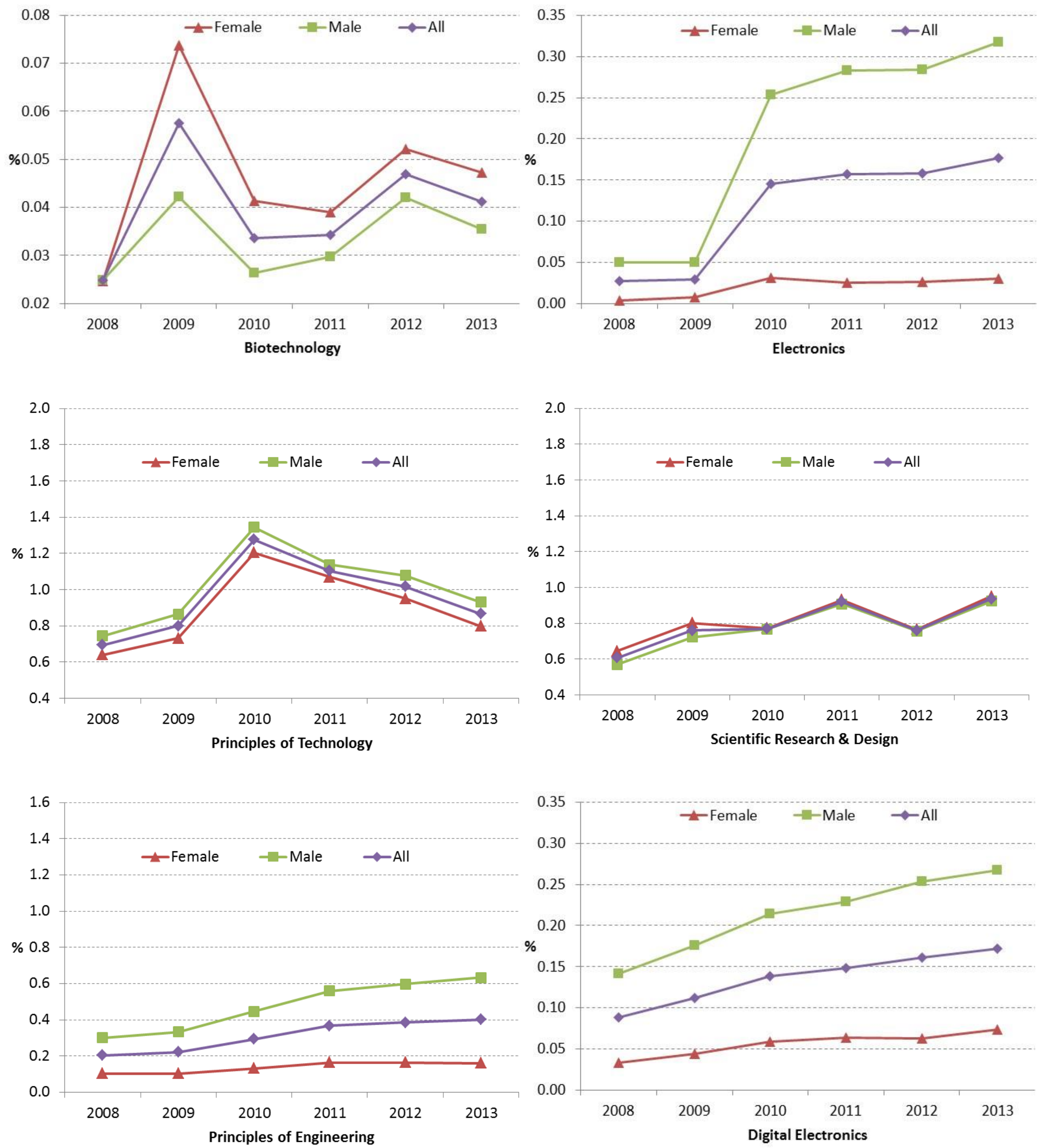

Figure 3. Six CTE-STEM course enrollment rates in percentage of all female, male, and total number of students

When the data of students' enrollments were aggregated by all CTE-STEM courses, Figure 4 shows several interesting trends. First, the overall enrollment rates in CTE-STEM courses have increased across years, which is a positive sign. Second, the enrollment rates in CTE-STEM courses spiked in the later years and were continuously increasing, which implies increased student interests in CTE-STEM courses. Third, the collective gender gap in CTE-STEM courses was increasing with more enrollments of male students.

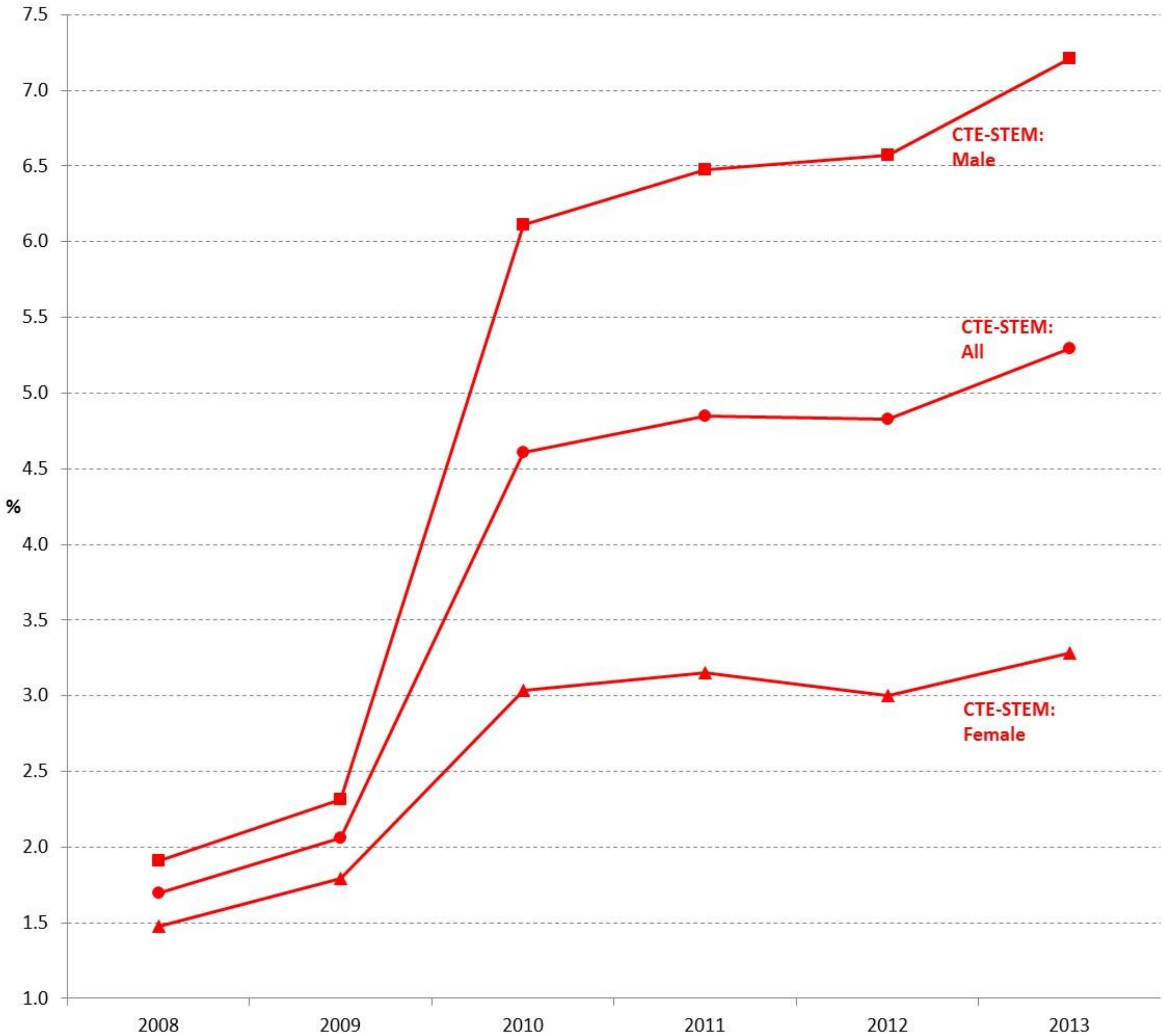

Figure 4. CTE-STEM course enrollment rates in percentage of all female, male, and total number of students

C. Collective Enrollment Rates in CTE-STEM Courses by Race/Ethnicity

Figure 5 shows student enrollment rates in proportional percentages aggregated by all CTE-STEM courses but disaggregated by race/ethnicity. Interestingly, in CTE-STEM courses, there were no apparent racial/ethnic group gaps in early years, but the gaps became apparent in later years, with a soar in Asian students' enrollment in 2013.

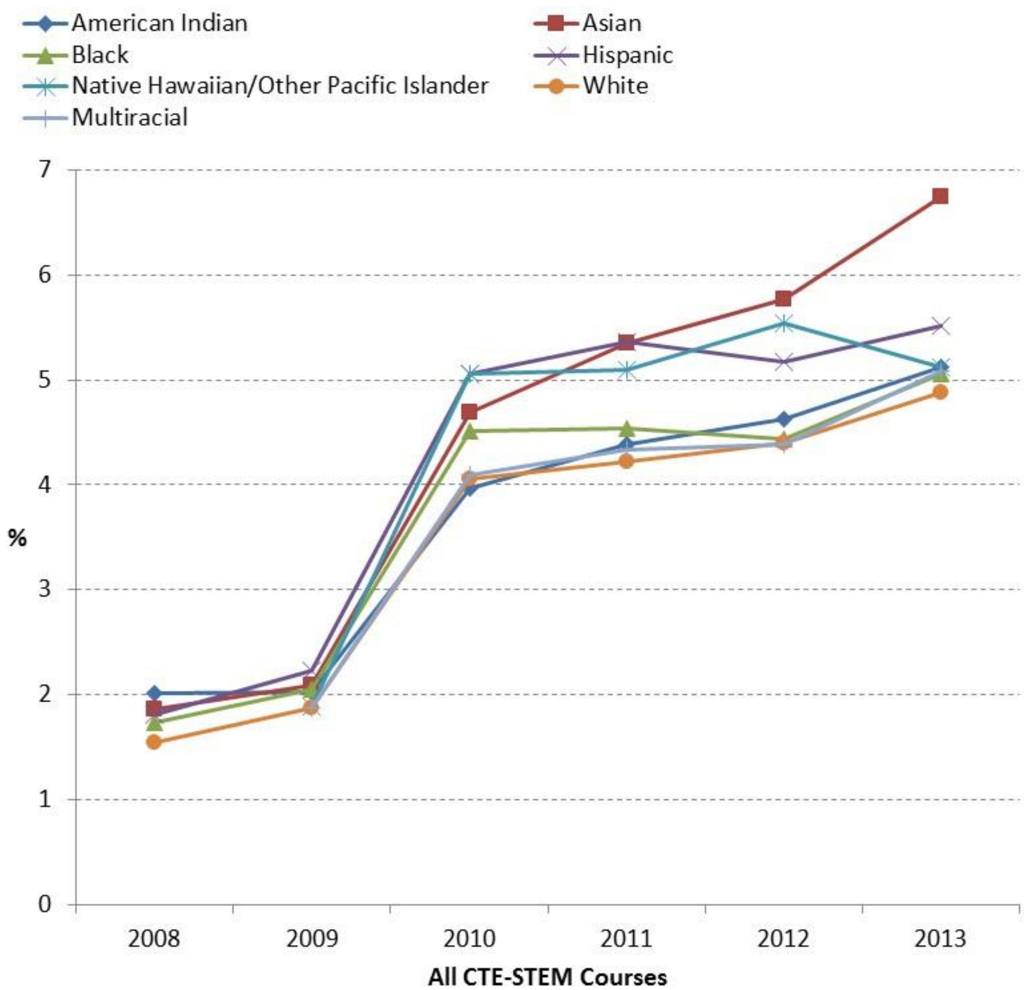

Figure 5. CTE-STEM course enrollment rates in percentage of total number of students in each racial/ethnic group

IV. Discussion

Using student enrollment data on CTE-STEM courses over a six-year period, the findings of this study provide a basis for exploring high school students' interests in STEM. In sum, the results showed wide variations in the enrollment rates on the CTE-STEM courses by types of courses, gender, and race/ethnicity. While most courses showed increased enrollment rates, which indicate a promising prospect for STEM career pathways, there were exceptions in several courses and gender and racial/ethnic differences in the trends. Based on the findings, we identified several interesting characteristics in the trends of student course-taking in CTE-STEM courses and addressed each characteristics one by one with discussion.

A. Overall, Student Enrollment Rates Increase across Time in CTE-STEM Courses

As shown in Figures 2 through 5, overall over a six-year time frame, Texas high school student enrollment rates were increasing in CTE-STEM courses when the effects of natural increase of population were controlled in enrollment rates. Even though the proportion of students taking the CTE-STEM courses is relatively small, the trends are promising as it reflects a continuous increase of students' interested in STEM across years. Therefore, reinforced educational strategies and policies are necessary to boost the increasing trends and enticing more students in CTE-STEM Courses.

B. Collectively, Gender Inequality in CTE-STEM Courses Increase.

As shown in Figures 3 and 4, the gender gaps in CTE-STEM course enrollment rates seemed to be increasing across time. In detail, the gender gaps in Electronics, Principles of Engineering, and Digital Electronics, except Biotechnology and Principles of Technology, were gradually increasing (see Figure 3).

As our data include all Texas high school students as participants of this study, the trend is similar to the results by Riegle-Crumb and Moore (2013)[10], who explored the gender gap in an upper-level high school engineering course employed by university faculty in six high schools in Texas. They observed a smaller proportion of female students' enrollment than male students in the course and significant gender gaps in the attitudes toward and perceptions of science and engineering, which were favored by male students.

From the representative national sample, Sadler, Sonnert, Hazari, and Tai (2012)[11] observed that (a) STEM career interests were stable by male students but volatile by female students during high school; (b) the STEM interests at the start of high school was a strong predictor of the STEM interest at the end of high school; and (c) the difficulty in attracting female students to STEM fields during high school. Therefore, shaping STEM interests prior to high school seems to be important to reduce the gender gap at the end of high school.

C. Racial/Ethnic Inequality is Rising in CTE-STEM Courses in Recent Years

While overall increase of the enrollment rates in CTE-STEM courses regardless of gender and race/ethnicity is a promising trend, the recent trend in racial/ethnic gaps is an alarming signal because of the rising gaps among racial/ethnic groups with increasing enrollments of Asian students compared to other racial/ethnic groups, as shown in Figure 5. This implies that students' interests in CTE-STEM courses are varied by their racial/ethnic groups due to some reasons, and if there are no efforts made to reduce this racial/ethnic gaps, then the gaps can become wider in the later years. Therefore, this finding recommends actions from educators and education administrators.

D. Conclusion

As we have been working on increasing pathways of diverse students pursuing STEM degrees for decades, the findings from this study have several potential merits since little is known about students' preferences in course-taking in STEM courses at the state-level[12]. The findings on the trends in students' CTE-STEM course-taking provide needed insights on what institutional K-12 changes would be effective for impacting the pipeline. Results of this study have broader impact and can inform career counselors and university recruitment efforts to tailor their messaging to students' behavior of course selection.

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