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Technology Student Characteristics: Course Taking Patterns as a Pathway to STEM Disciplines

Abstract

Rising concern about America's ability to maintain its competitive position in the global economy has renewed interest in STEM education. The power and the promise of STEM education is based on the need for technological literacy. Technology education is a discipline devoted to the delivery of technological literacy for all. Nevertheless, a decision to pursue a STEM major is a longitudinal process that builds during secondary education and carries into postsecondary studies. When analyzed appropriately, course-taking patterns may offer valuable insight into a student's academic history and momentum through college as well as illuminate patterns that effectively and wisely engage academic resources that may shape students' entrance in STEM related careers. This study utilized High School Transcipt Study data to examine and compare the patterns of STEM courses taken by technology students and those of high school students as a whole, the patterns of courses taken by technology students and those of high school students as a whole, and the GPAs of technology students with the GPAs of other high school student GPAs. Findings revealed that there was a significant difference in overall GPA between technology students, as defined in this study, and the general student population of the data set. There was also a significant difference in GPAs between technology students and the general student population in STEM courses.

Keywords: Course Taking Patterns, GPAs, High School Transcript Data, STEM

Adolescents enter high school with different home and neighborhood backgrounds, different levels of academic preparation, varying degrees of commitment to education, and a wide range of aspirations for their post high school years (Stone & Aliaga, 2005). Which concentration pattern a student follows depends on both individual choice and on the sorting mechanisms of schools (Garet & DeLany, 1988). Career and technical education courses, specifically those with a focus on science, technology, engineering, and mathematics (STEM) practices like technology education, can serve many purposes for high school students including helping them explore career options, remain engaged in school, gain skills that are broadly useful in the labor market,

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and prepare for further study in postsecondary education (Hudson & Laird, 2009).

Rising concern about America's ability to maintain its competitive position in the global economy has renewed interest in STEM education. Locke (2009) stated that "In the last decade, it has been perceived by scholars and administrators involved with K–12 STEM education as well as concerned business leaders that the shortage of engineering graduates from U.S. colleges must be resolved" (p. 23). In 2005, for example three pertinent U.S. scientific groups, the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, jointly issued a report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, that called for strengthening the STEM pipeline from primary through postsecondary education (2007). This report recommended increasing investment in STEM programs, enhancing the STEM teaching force, and enlarging the pool of students pursuing degrees and careers in STEM fields. According to Scott (2012), today, many states have created opportunities to increase students' exposure and engagement in STEM content learning.

> In order for students to pursue science careers, they must connect with their intended field. Astin reports a wide range of ways students connect to a college or university (Astin, 1984, 1993), and many of the same ideas could be expected to be true for why students complete certain majors. Specifically within the sciences, research has suggested that connecting undergraduates with authentic research experiences helps maintain interest in the pursuit of a science major (Russell, Hancock, & McCullough, 2007; Seymour, Hunter, Laursen, & Deantoni, 2004). (Sweeder & Strong, 2012, p. 52)

The integration of STEM concepts into technology education enhances the goal and promise of technological literacy. Consequently, the field has consistently been described as a discipline devoted to the delivery of technological literacy for all. As a result of studying technology education at the K–12 level, students gain a level of technological literacy, which may be described as one's "ability to use, manage, assess, and understand technology" (International Technology Education Association [ITEA], 2007, p. 9) (Havice, 2009; Daugherty, 2009). In publishing the *Standards for Technological Literacy: Content for the Study of Technology* (STL; ITEA, 2007) and *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards* (AETL; ITEA, 2003) the International Technology and Engineering Educators Association (ITEEA; formerly the International Technology Education Association) has promoted technology education and engineering as viable career options. These documents verbalize well-articulated principles that have assisted technology educators in

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aligning their teaching to engineering practices as well as understanding the focus of the field as a central area of study in STEM fields (McComas & McComas, 2009). In the STL, the terms *science*, *mathematics*, and *engineer* or *engineering* are used more than 60 times, 50 times, and 150 times, respectively (McComas & McComas, 2009). Currently, technology and engineering learning activities being taught at the K–12 level seek to connect real-world experiences with curricular content (Havice, 2009). It can then be argued that, technology education as a subject is well placed to provide context for STEM related concepts in future education curriculum. "This is inevitable when we live in a society that needs and uses technology at the pace we are seeing today" (Starkweather, 2011). Therefore, if America is to prepare a STEM ready workforce, there is need for greater participation of all students in technology education courses. However, reports of a serious shortage of students pursuing STEM disciplines continue (e.g., Fox & Hackerman, 1993; National Economic Council, 2011). "While the national demand for motivated students to enter postsecondary STEM fields is at its highest, high school seniors' interest in and readiness for pursuing these majors have been sluggish" (Wang, 2013, p. 1082). Hagedorn and Kress (2008) stated that for some students, "the only trace of . . . [their] presence . . . is found in their transcripts" (p. 8), and as a whole, a student's transcript serves as a map of the curriculum and their course-taking patterns. Nevertheless, a decision to pursue a STEM major is a longitudinal process that builds during secondary education and carries into postsecondary studies. When analyzed appropriately, course-taking patterns may offer valuable insight into a student's academic history and momentum through college and illuminate patterns that effectively and wisely engage academic resources that may shape students' entrance in STEM related careers.

To this end, the essence of this study is based on the National Center for Educational Statistics' (NCES) High School Transcript Study (HSTS; Chen, 2009; National Center for Educational Statistics [NCES], 2011; Roey et al., 2005), which uses data collected by the U.S. Department of Education. The study utilized HSTS transcript data to examine and compare the patterns of STEM courses taken by technology students and those of high school students as a whole, the patterns of courses taken by technology students and those of high school students as a whole, and technology student grade point averages (GPAs) with other high school student GPAs. The rationale for using only data from 2000 onwards is based on the introduction of the STL, which was first published in 2000 (ITEA, 2007). These standards consist of a defined set of 20 technological literacy standards, which are grouped into five general categories: (a) the nature of technology, (b) technology and society, (c) design, (d) abilities for a technological world, and (e) the designed world. These standards prescribe what the outcomes of the study of technology in grades K–12 should be and describe what students should know and be able to do in order to be

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technologically literate (ITEA, 2007). This study was guided by the following research questions:

- What is the average level of technology course taking per year for technology students?
- What is the mean level of mathematics coursework achieved by the average technology student and how does it compare with the overall secondary student population?
- What is the mean level of science coursework achieved by the average technology student and how does it compare with the overall secondary student population?
- What is the mean overall GPA reported for technology students by year as compared to the overall population of secondary school students?

Method

The primary source of information for this study is the HSTS of 2009, which was the continuation of the transcripts studies performed in 2000 and 2005. In these studies, participating schools submit complete 4-year high school transcripts of graduating students, and additional information about postsecondary education and vocational choices are also solicited from both the students and the staff at the school. These data were collected during the period from May 2009 until October 2009 and included 37,600 students in a nationally representative sample (NCES, 2011). In addition to the 2009 study, researchers in this study relied on the 2000 and 2005 transcript studies for comparison and trends. We utilized a jackknife replicative process to compare various high school student characteristics. Specifically, the areas of focus for the data were (a) specific courses listed and identified in state course catalogs as technology education, mathematics, and science using the Classification of Secondary School Courses (CSSC) system and (b) GPAs and earned grades in science, technology, engineering, and math courses.

Study Sample

The sample for the 2000 HSTS was composed of 63,790 (all samples are rounded to the nearest ten, as required by confidentiality concerns) students with an overall calculated GPA of 2.88 on a 4-point scale. Of this sample, 53,480 or 83.85% of students enrolled in at least one technology education course during their high school career. The 2005 sample had 29,870 students with a calculated overall GPA of 2.31 on a 4-point scale. Among these students, 17,180 enrolled in at least one technology education course during high school; the participation rate was 57.51%. The student sample for the 2009 study was 41,220, and the calculated overall GPA was 2.91 on a 4-point scale. Of this sample, 23,170 students enrolled in at least one technology education course, and their participation rate was 56.20%. In the period 1996–2009, the number of

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technology students enrolled as a percentage of the total HSTS sample declined 27.65%, as illustrated in Table 1.

Table 1
Technology Students as Compared to Total Students

	Technology Students vs. Total Students		
	1996–2000	2001–2005	2005–2009
Total Sample	63790	29870	41220
Technology Students	53480	17180	23170
% of Technology Students	83.85%	57.51%	56.20%

Yearly individual participation rates increased consistently over time with the number of technology courses taken by students rising over the span of their high school career. Table 2 shows the number of courses and the participation rates in the years contributing to each HSTS study with the percentages representing the percentage of individual technology enrollment yearly.

Table 2
Number of Courses and the Participation Rates in the Years Contributing to Each HSTS

Technology Education	**1996–1997**	**1997–1998**	**1998–1999**	**1999–2000**	**2000 Cohort Total**
Number of Courses	7438	8920	11750	15080	43188
% within School Year in Which Course Taken	9.97%	11.35%	15.48%	26.56%	
Technology Education	2001–2002	2002–2003	2003–2004	2004–2005	2005 Cohort Total
Number of Courses	9405	11136	15877	20167	56585
% within School Year in Which Course Taken	9.61%	10.91%	15.52%	23.40%	
Technology Education	2005–2006	2006–2007	2007–2008	2008–2009	2009 Cohort Total
Number of Courses	10933	14528	20348	25758	71567
% within School Year in Which Course Taken	7.95%	10.07%	14.06%	23.32%	

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This would appear to indicate that although the overall numbers of students enrolling in technology courses declined over the span of the study, students who did participate in technology programs tended to increase their participation as they progressed through high school.

Math and Science Participation Rates

Mathematics participation during this same time period remained consistent, with little change in participation rates during the study duration or in the individual high school career span. As illustrated in Table 3, about half of the total STEM enrollment was in mathematics courses, and this remained consistent with a slight decline in individual participation rates as time progressed. The total number of mathematics courses was much higher, not only due to the individual participation rates but also due to mathematics participation reflecting both technology and nontechnology students enrolling in mathematics classes.

Table 3
Enrollment in Mathematics 1996–2009

Mathematics	**1996–1997**	**1997–1998**	**1998–1999**	**1999–2000**	**2000 Cohort Total**
Number of Courses	35909	35707	33664	22944	128224
% within School Year in Which Course Taken	48.13%	45.43%	44.36%	40.41%	
Mathematics	2001–2002	2002–2003	2003–2004	2004–2005	2005 Cohort Total
Number of Courses	47474	47620	45697	38308	179099
% within School Year in Which Course Taken	48.50%	46.65%	44.68%	44.45%	
Mathematics	2005–2006	2006–2007	2007–2008	2008–2009	2009 Cohort Total
Number of Courses	67370	66837	64093	45771	244071
% within School Year in Which Course Taken	49.01%	46.34%	44.30%	41.44%	

Participation in science courses tended to decline during the individual high school career timespan. Roughly half of the STEM enrollments in the first 1 or 2 years tended to be in science classes, and this declines by 5–10% by the senior year (Table 4). It would appear that many students were replacing science enrollments with technology courses in the last 2 years of high school in addition to enrolling in non-STEM classes. This observation is based on the median number of technology courses per student increasing over time. Additionally, despite the percentage changes appearing congruent between

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science and technology enrollments, the numbers of individual courses are not congruent with enrollment in technology courses not accounting for the decline in the number of science courses.

Table 4
Enrollment in Science 1996–2009

Science	**1996–1997**	**1997–1998**	**1998–1999**	**1999–2000**	**2000 Cohort Total**
Count	31270	33980	30470	18760	114480
% within School Year	41.91%	43.23%	40.15%	33.04%	
Science	2001–2002	2002–2003	2003–2004	2004–2005	2005 Cohort Total
Count	41000	43320	40710	27720	152750
% within School Year	41.89%	42.44%	39.80%	32.16%	
Science	2005–2006	2006–2007	2007–2008	2008–2009	2009 Cohort Total
Count	59150	62860	60250	38920	221180
% within School Year	43.03%	43.58%	41.64%	35.24%	

Overall, the enrollment in mathematics and science courses substantially exceeded those of technology offerings in the samples. This may be accounted for by the graduation requirements in many states detailing the completion of certain levels of mathematics and science for a high school diploma and many technology courses counting for elective credit, with the caveat that many programs also have a requirement for completion of a technology course in either middle or high school. This may account for the high overall participation rate in technology courses.

Procedures and Analysis

Using a collection of high school transcript records, students identified as technology education students were compared to the rest of the student population in terms of course enrollment patterns, mean GPA, and the GPA for both mathematics and science classes. The primary challenge of the study was the organization and classification of the coursework reported by high school transcripts and collected by the HSTS study. Although the HSTS research provided tremendous raw data, the classification system was not designed for the reporting or comparisons of either specific courses or the use of alternative classifications. Further, all of the HSTS data is confidential as there are sufficient identifiers in the data for someone to connect a pattern of courses to an individual student. Therefore, several steps were taken by the NCES and the

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researchers for this study to protect the identity of the individual subjects. This created a challenge for this study because there was no included matrix connecting a student ID directly to a CSSC number. To this end, the first step was to recode the course name data into a CSSC. Each course name was identified with a CSSC number in the HSTS catalog data set, and each student was associated with a course name in the HSTS course data set, thus recoding the course data set to include a CSSC number with each course was the task necessary to connect the two. This was done in SPSS Version 21, and the result was a CSSC code associated with every course taken by every student.

The standards for determining the course code included the interpretation of course catalog descriptions and the comparisons of those descriptions to those used by other secondary institutions, which resulted in all the courses reflecting a standardized course number. This particular numbering system, the CSSC, was developed specifically for the HSTS study series. It was also envisioned as a potential common course numbering system, but it has not been adopted by most state secondary systems. The primary issue of working with the HSTS data for this project was that the CSSC classifications did not provide information specific to the course descriptions necessary to distinguish between courses designed for comprehensive high school students and those in specific vocational programs. Because this study is designed to look only at technology education students, there was a necessity for more precise classification of courses.

In 2003, NCES started a project to create a system to ease longitudinal record keeping and to facilitate secondary course transfers between school districts (Bradby, Pedroso, & Rogers, 2007). This program was called School Codes for the Exchange of Data (SCED) and many states have adopted this coding system for course catalog management. So, the use of state course catalogs provided SCED codes, and the HSTS studies provided CSSC codes. The final step was to convert one to the other.

The method used for this conversion was to examine the SCED codes associated with the secondary course catalogs from Illinois (Illinois State Board of Education, 2012) and New Jersey (State of New Jersey Department of Education, 2013) and to use the text descriptors from Florida (Florida Department of Education, 2011) and New Mexico (New Mexico Public Education Department, 2011) to provide validation of those conversions. To provide this conversion, courses identified as STEM or technology education courses in the New Jersey catalog were compared by using the text descriptors to the courses in Illinois, New Mexico, and Florida; additionally, the SCED codes were compared between the Illinois and the New Jersey catalogs. If there was a match, the common descriptors were then compared to the course descriptors in the catalog data set in the HSTS data. If that matched, the CSSC code was added to a list of technology education courses used for comparison in the study. So, if these four state education departments assigned the course as a

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technology course, it was included for comparison. If there was disagreement, the course was still used as part of the overall comparison for overall GPA but not for STEM reporting. If the course could be classified as either technology education or vocational in the state systems, it was included as part of the STEM comparison group because many of the course catalogs were in flux during the period from 2000–2009 and many technology education programs were administered by vocational divisions or departments.

The other complexity introduced into this study by the use of the HSTS data was the determination of variability due to the sampling method used. Unlike many studies, the HSTS research used a complex multistage sampling process, and this invalidates many of the standard methods of calculating variance by violating the assumptions associated with those statistics (Spence, Cotton, Underwood, & Duncan, 1983). The process of sampling is to best approximate the characteristics of a population desired for study and represents a balance between approximating the characteristics of a population as closely as possible, along with insuring that the characteristic of interest in the research is present in the sample. In the case of the HSTS, the sampling design used the jackknife process (Rodgers, 1999), which compares a series of subsample variance measures to compute an overall variance (Roey et al., 2005). This was designed to ensure the inclusion of specific population characteristics relevant to the National Assessment of Educational Progress (NAEP) research that was ongoing.

The HSTS researchers used a weighted sampling process to ensure the inclusion of specialized population members for examination, meaning that the probability for selection was not equal across all members of the population. Because most statistical software will tend to assume that this probability is equal across the population, they will tend to underestimate the variability of the population (Wolter, 2007). To address this concern, WesVar software was used to calculate the variability of the sample for each statistical model used. WesVar software is designed for use in variability estimating in projects using complex sampling and uses resampling to determine variability estimates. In the case of the HSTS, 62 sampling weights were provided as part of the data set, and these allowed the WesVar software to replicate the process by creating a series of subsamples using the existing sample base. The variability for each subsample is measured, and by adding and subtracting specific cases from the subsample, the change in variability is calculated. The overall variance can then be estimated by comparison of the subsample variability measures.

The other strategy for attempting to increase the accuracy of variance estimation was to use conservative measures for post hoc analysis. This strategy, as described by Hahs-Vaugh (2005), includes possible strategies such as using an adjusted alpha level, the use of specialized software or using adjusted sampling weights to allow for the disproportionate sampling process.

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The statistical design of the study is also very straightforward, using linear regression to compare technology students (students taking at least one technology course) to nontechnology students on the basis of the number of mathematics and science grades earned and the GPA associated with those courses. Students were also compared on the basis of overall GPA. The comparisons were done in three operations; each HSTS study was done as a separate comparison. This was due to the differences in the data structures in each HSTS because the design of each HSTS changed in the process or variable definition to meet the needs of the particular interest area of the study. For example, in the 2005 study (Brown, 2008), data were collected in concert with the NAEP. These data were not included in the 2000 (Brown, 2004) or 2009 (Brown, 2011) HSTS. Although the information essential for this research was included in the datasets, there were subtle differences which made many direct comparisons subject to unreasonable assumptions in the opinion of the researchers. Thus, the decision was made to complete the analysis on each set of data separately and to report them in this manner. There are some overall comparisons deemed to be acceptable, for example, the conversion of grades to a common four point scale which required converting some grade data to a less precise value, in one case, taking values reported on a 4-point scale with two decimal places and rounding them to whole values and, in another, converting values on a 1-to-100 scale to a whole-number 4-point scale. This procedure, although less precise, was held to be acceptable because it is a commonly used measure and was in fact used by one of the HSTS studies as the recorded grade values.

The primary statistic for this study was a series of regressions comparing mathematics, science, and technology course-taking patterns and performance scores, including GPA and numbers of enrolled technology, mathematics, and science courses. These regressions report an F statistic for use in determining statistical significance at the .05 level.

Findings

Specific comparisons between technology and general students were conducted. Each study cohort was classified as either a technology student or a nontechnology student; the number of technology, mathematics, and science classes were quantified; and then the number of each STEM category of classes per student was calculated. The final step was to perform a comparison between the groups to see if there was a difference in the participation level and grade performance level between technology students and the general student population. The reported data have been rounded to the nearest ten to preserve confidentiality.

Study findings were achieved by the use of WesVar 5.1.17 and SPSS (Version 21). Excel (Version 2013) was also used to create some of the charts. WesVar was used to evaluate the correlation models, and SPSS was used to

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provide descriptive information such as frequencies and for the creation of charts.

Findings revealed that the overall GPAs differed between technology students and nontechnology students in all of the HSTS dataset years. This was also the case when looking at specific STEM categories with technology students, who earned significantly lower grades in mathematics and science courses (p= .05). Technology course enrollments represented in the sample appeared to decline between 1996 and 2005 and remain steady over the rest of the study period. The findings are addressed in the following paragraphs by research question.

With regard to Question 1 (What is the level of technology course taking per year for technology students?), there was a large increase in the number of technology courses taken per student each year from 2000–2005 and the level of participation was similar between the samples during the period 2001–2009. Table 5 illustrates the mean number of technology education courses per year as taken by technology students in each HSTS study. The progression of course enrollment was similar during the entire period of the study, with students tending to take a greater number of technology courses as they progressed through high school.

Table 5
Level of Technology Student Participation

Grade	2000	2005	2009
Nine	.14	0.55	0.47
Ten	.16	0.64	0.63
Eleven	.21	0.91	0.86
Twelve	.28	1.16	1.12

It is worth noting that although the participation rate per student increased, the number of students taking technology courses declined during this time frame. This might indicate that there is a cohort of students with a high interest, as indicated by the rate at which they enroll in technology courses, but overall the number of students enrolling in technology education classes is declining. It would also indicate fewer casual students, those who only enroll in one or two technology courses during high school, leaving only those with a strong interest in technology.

Regarding Question 2 (What is the mean level of mathematics participation achieved by technology students and how it compared with the overall secondary student population?), the trend reflected in the changes in technology enrollments also appears in the 2000–2009 data for mathematics, with a change in the enrollment level of mathematics courses between the 2000 study and the 2005 study, which then maintains the same general level for the 2009 data. It

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also would appear that the trend for enrollment by technology students changes from enrolling in fewer courses than the general population to enrolling in more mathematics courses than the general student population. This trend continues in the 2009 study, as indicated in Table 6.

Table 6
Mathematics Courses per Student 2000–2009

	2000		2005		2009	
	Overall	**Technology**	**Overall**	**Technology**	**Overall**	**Technology**
Grade 9	0.58	0.43	1.62	1.79	1.66	1.81
Grade 10	0.56	0.42	1.59	1.76	1.63	1.78
Grade 11	0.52	0.39	1.51	1.66	1.54	1.68
Grade 12	0.36	0.26	1.06	1.14	1.12	1.20
Total	2.06	1.53	5.89	6.47	6.11	6.64

In general, students were enrolling in a larger number of mathematics courses starting in 2005, with the overall mean level of courses per student rising to almost two mathematics courses per year. This trend was also reflected in the patterns of technology students with a mean level greater than the general student population, taking six to seven mathematics courses over the span of a high school career. This is about one half course more than the general population mean.

With regard to Question 3 (What is the mean level of science coursework achieved by the average technology student and how does it compare with the overall secondary student population?), a trend similar to enrollments in mathematics courses appears in the data for science courses. Although the overall enrollments in science courses declined over the time in high school, the students enrolling in science courses tended to take more than one course a year. This is also observed in technology students with the mean level tending slightly higher than the general population.

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Table 7
Science Courses per Student 2000–2009

	2000		2005		2009	
	General	**Technology**	**General**	**Technology**	**General**	**Technology**
Grade 9	0.50	0.37	1.39	1.55	1.45	1.59
Grade 10	0.54	0.40	1.45	1.60	1.53	1.67
Grade 11	0.47	0.35	1.36	1.48	1.46	1.57
Grade 12	0.29	0.21	0.88	0.92	0.95	1.00
Total	1.81	1.34	5.09	5.57	5.41	5.86

Overall, students tended to enroll in fewer science courses than mathematics courses and also tended to take fewer at a time than mathematics courses. Technology students followed a similar pattern, although they tended to enroll in slightly more science courses than the general population.

Finally, regarding Question 4 (What is the mean overall GPA reported for technology students by year as compared to the overall population of secondary school students?), comparisons between the different study years were not performed because there were differences between the variable definitions and the data structures in each study sufficient to prohibit direct comparisons of the transcript data. The evaluation process was begun by performing mean calculations for both the general student population and the technology student cohort for the 2000, 2005, and 2009 HSTS. Then, the overall GPAs for the technology student population were compared with the general student population. Finally, the GPA results for mathematics and science courses for technology students were compared to the general student population. The results from each HSTS study are presented in the tables and text to allow the reader to compare results, but caution is advised in the interpretation of differences and similarities between the reported study years because there are differences in the numbers of subjects and because the precise definitions of variables may make easily observed conclusions questionable.

The overall GPA was calculated from the reported grades on the transcripts dataset and is listed in Table 8. The 2000 overall GPA was higher than both the 2005 and 2009 levels. There were some grades not reported in the data, which were included in the total count of courses but were treated as missing in the GPA calculations.

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Table 8
Calculated Mean from Reported Transcript Grades

	Mean	Std. Deviation	n (Courses)	Missing
2000	2.81	1.14	996,756	41,422
2005	2.63	1.15	1,309,325	45,205
2009	2.63	1.15	1,838,516	56,717

The results of a regression model as performed by WesVar Version 5.1.17 on the 2000 HSTS data are illustrated in Table 9. This process used the jackknife process to perform resampling based on the 62 replicate base weights included in the HSTS studies weights and compared students classified as technology students with the entire population of students based on GPA, as reported on their high school transcripts. The results indicated that there was a significant difference between technology students and the general student population. Similar results were observed in the 2005 and 2009 studies.

Table 9
Results of Regression: Technology Student: Transcript GPA

Number of replicates :	62	
Number of observations read :	23,520	
Weighted number of observations read	3,277,950,131,358	
	Degrees of Freedom = 60	(Rounded)
	t VALUE : 1.999	
Missing :	2532 (UNWEIGHTED)	
	255,534,686,732 (WEIGHTED)	
Non missing :	20990 (UNWEIGHTED)	
	3,022,415,444,626 (WEIGHTED)	
R_Square value:	0.017	
	PROB>|T|= 0.0	
Hypothesis Testing Results		
Test	F VALUE	DENOM. DF
Overall fit	90.945	60 (Rounded)
Techstudent	90.945	60 (Rounded)
	PROB>F= 0.0	

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Similar results were also observed when examining comparisons between STEM courses. The technology student GPAs were lower than the general student population. These comparisons for all three HSTS studies are illustrated in Tables 10–12.

Table 10
2000 Science and Mathematics GPA Comparison for Nontechnology vs Technology Student

2000 STEM GPA		Mean	Std. Deviation	N
Nontechnology Student	Science	2.6860	1.11716	42890
	Mathematics	2.4961	1.19214	48670
Technology Student	Science	2.5114	1.13892	70390
	Mathematics	2.3262	1.20487	80400

Table 11
2005 Science and Mathematics GPA Comparison for Nontechnology vs Technology Student

2005 STEM GPA		Mean	Std. Deviation	N
Nontechnology Student	Science	2.7430	1.08904	56020
	Mathematics	2.5746	1.16395	63840
Technology Student	Science	2.5725	1.12531	94750
	Mathematics	2.4222	1.17903	109280

Table 12
2009 Science and Mathematics GPA Comparison for Nontechnology vs Technology Student

2009 STEM GPA		Mean	Std. Deviation	N
Nontechnology Student	Science	2.6980	1.10650	85360
	Mathematics	2.5553	1.17312	96450
Technology Student	Science	2.5925	1.11263	133300
	Mathematics	2.4427	1.17801	151610

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Although the overall scores differed only slightly, they are significantly different at the .05 level, and this is observed in all three HSTS studies. The variability of these comparisons is much more acceptable with the standard error of the mean for the 2000 study (.04), for the 2005 (.03), and for the 2009 (.03), which would indicate that these samples conform more closely with the calculated mean GPA for each of the HSTS studies. Confirmative post hoc testing also found a significant difference with the Scheffe used as a conservative measure and the Dunnetts T used as a specific test of unequal variances in the compared samples. The results are illustrated in Tables 13–15 and show that even with a conservative measure; there is a difference between technology students and the other students.

Table 13
2000 Confirmatory Post Hoc Testing

2000 Post Hoc Results			**Mean Difference**	**Std. Error**
Scheffe	Technology Education	Science	.4550*	.00659
		Mathematics	.6422*	.00648
Dunnett t (2-sided)[a]	Technology Education	Mathematics	.6422*	.00648

Note. Based on observed means. The error term is Mean Square (Error) = 1.339.
[a] Dunnett t-tests treat one group as a control, and compare all other groups against it.
* The mean difference is significant at the .05 level.

Table 14
2005 Confirmatory Post Hoc Testing

2005 Post Hoc Results			**Mean Difference**	**Std. Error**
Scheffe	Technology Education	Science	.4882*	.00560
		Mathematics	.6457*	.00550
Dunnett t (2-sided)[a]	Science	Technology Education	-.4882*	.00560
	Mathematics	Technology Education	-.6457*	.00550

Note. Based on observed means. The error term is Mean Square (Error) = 1.274.
[a] Dunnett t-tests treat one group as a control, and compare all other groups against it.
*. The mean difference is significant at the .05 level.

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Table 15
2009 Confirmatory Post Hoc Testing

2009 Post Hoc Results			Mean Difference	Std. Error
Scheffe	Technology Education	Science	.5585*	.00487
		Math	.7057*	.00480
Dunnett t (2-sided)[a]	Science	Technology Education	-.5585*	.00487
	Math	Technology Education	-.7057*	.00480

Note. Based on observed means. The error term is Mean Square (Error) = 1.271.
[a] Dunnett t-tests treat one group as a control, and compare all other groups against it.
*. The mean difference is significant at the .05 level.

One additional concern raised during the analysis of the data was based on the working definition of a technology student. The working definition used for this study was any student who had enrolled in one or more technology classes. The issue was the concern that this definition might prove to be too inclusive, with some states mandating enrollment in technology courses as part of revised graduation requirements. This also introduced a concern that as a student proceeded through multiple STEM courses, they may demonstrate higher grading levels as they become more familiar with STEM concepts in general, and this might provide them with an advantage unrelated to the specific content of the course. The method used to address this concern was to compare the GPA of technology students based on the number of courses in each STEM discipline. Using a linear regression, modeling the influence of the number of mathematics courses on mathematics GPA and the same process on science and technology courses, there was no significant difference in specific STEM GPA between students enrolled in one or more courses.

Conclusions

There was a significant difference in overall GPA between technology students, as defined in this study, and the general student population of the data set, with technology students earning a lower overall GPA. There was also a significant difference in GPAs between technology students and general student population in STEM courses, also with technology students earning a lower GPA. Additionally there was a slight decline in enrollment for technology courses and large increase in science and mathematics course enrollments over the study period. It would appear that technology students differ from the majority of the student population, as indicated by this study. This may have

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implications for postsecondary admissions in selective programs such as engineering as the engineering profession is undergoing changes to make the profession more selective and to require greater credentials for licensure. An example of this if the "Raise the Bar" initiative from the American Society of Civil Engineers (ASCE, 2015), which calls for increased educational credentials for the licensure of civil engineers, and the American Society of Mechanical Engineers' (2015) push for increasing certifications in the engineering profession, which will raise the requirements for both entering and continuing engineering education.

Limitations

The primary limitations of this study are limitations imposed by the data collection used in the HSTS studies. These studies were designed for more generic analysis and were not focused on technology education. As a result the classification of courses, while conforming to the CSSC system, will require an assumption of content in terms of the actual curriculum. Technology education has been in a state of transition with some programs retaining more traditional content and others using a more progressive approach, yet both are classified as the same course offering. This may require some additional validation of the course correlations at a later date. One additional limitation is the necessary translation of course descriptor codes required by the use of SCED course codes for contemporary course descriptions in defining technology education course, and the CSSC codes used in the HSTS studies.

Recommendations

One of the major limitations in the study was the lack of consistent data regarding historical high school records. Although the data provided by the NCES were of great value, consistent data structures, labels, and valuation would make comparisons between different high school cohorts easier and of greater value to researchers. It would appear that the collection of comprehensive, systematically unchanging high school data for use in longitudinal and aged cross sectional analysis would be a great tool. Additional research in this area will be hindered by a lack of consistent agreement on STEM course definitions, and this is an area that ITEEA should consider. Perhaps ITEEA could continue providing guidance and policy recommendations through state affiliations, state and local directors, publications, and other professional efforts. At the point of composing this study, there was no method of comparison between states (and in many cases districts) for technology and engineering courses and no standards for defining them. While the Standards for Technological Literacy move in the right direction, there is a lack of concrete standards and this makes direct comparison of curriculum and courses impossible. One additional recommendation would be continuing research on the postsecondary educational destinations followed by technology students.

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The original hope for these data was that a comparison of educational indicators such as test scores and postgraduation data might be available, but this was not possible using the HSTS data. Research in this direction would also be of great benefit in designing curriculum for best fit with the student population.

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