Contents

Articles

Reports

Book Reviews

Miscellany

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,

Paul A. Asunda (pasunda@purdue.edu) is Assistant Professor in the Department of Technology Leadership & Innovation at Purdue University. Eun Sook Kim (ekim3@usf.edu) is Assistant Professor in the Department of Educational and Psychological Studies at the University of South Florida. Richard Westberry (westberr@lssc.edu) is Associate Dean of Workforce Programs at Lake Sumter State College.

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 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 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 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%	

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 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 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 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.

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 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 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.

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.

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	

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

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.

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 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.

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.

References

American Society of Civil Engineers. (2015). *Raise the bar*. Retrieved from http://www.asce.org/raise_the_bar/

American Society of Mechanical Engineers. (2015). *Certification and training*. Retrieved from https://www.asme.org/career-education/certification-and-training

Bradby, D., Pedroso, R., & Rogers, A. (2007). *Secondary school course classification system: School codes for the exchange of data (SCED)* (NCES 2007-341). Washington, DC: National Center for Education Statistics. Retrieved from https://nces.ed.gov/pubs2007/2007341.pdf

Brown, J. (2011). *NAEP high school transcript study 2009 restricted-use data file* [Data file]. Washington, DC: National Center for Educational Statistics.

Brown, J. (2008). *NAEP high school transcript study 2005 restricted-use data file* [Data file]. Washington, DC: National Center for Educational Statistics.

Brown, J. (2004). *2000 high school transcript study restricted-use data file* [Data file]. Washington DC: National Center for Educational Statistics.

Chen, X. (2009). *Students who study science, technology, engineering and mathematics (STEM) in postsecondary education* (NCES 2009-161). Washington, DC: National Center for Education Statistics. Retrieved from http://nces.ed.gov/pubs2009/2009161.pdf

Daugherty, M. K. (2009). The "t" and "e" in STEM. In International Technology Education Association, *The overlooked STEM imperatives: Technology and engineering K–12 education* (pp. 18–25). Reston, VA: Author.

Florida Department of Education. (2011). *2011–2012 course code directory and instructional personnel assignment*. Tallahassee, FL: Author.

Fox, M. A., & Hackerman, N. (Eds.). (2003). *Evaluating and improving undergraduate teaching in science, technology, engineering, and mathematics*. Washington, DC: National Academies Press.

Garet, M. S., & DeLany, B. (1988). Students, courses, and stratification. *Sociology of Education*, *61*(2), 61–77.

Hahs-Vaughn, D. L. (2005). A primer for using and understanding weights with national datasets. *The Journal of Experimental Education*, *73*(3) 221–248. doi:10.3200/JEXE.73.3.221-248

Hagedorn, L. S., & Kress, A. M. (2008). Using transcripts in analyses: Directions and opportunities. *New Directions for Community Colleges, 2008*(143), 7–17. doi:10.1002/cc.331

Havice, W. (2009). The power and promise of a STEM education: Thriving in a complex technological world. In International Technology Education Association, *The overlooked STEM imperatives: Technology and engineering K–12 education* (pp. 10–17). Reston, VA: Author.

Hudson, L., & Laird, J. (2009). New indicators of high school career/technical education coursetaking: Class of 2005 (NCES 2009-038). Washington, DC: National Center for Education Statistics. Retrieved from http://nces.ed.gov/pubs2009/2009038.pdf

Illinois State Board of Education. (2012). *Illinois State Board of Education secondary course catalog*. Springfield, IL: Author

International Technology Education Association. (2007). *Standards for technological literacy: Content for the study of technology* (3rd ed.). Reston, VA: Author.

International Technology Education Association. (2003). *Advancing excellence in technological literacy: Student assessment, professional development, and program standards*. Reston, VA: Author.

Locke, E. (2009). Proposed model for a streamlined, cohesive, and optimized K-12 STEM curriculum with a focus on engineering. *The Journal of Technology Studies*, *35*(2), 23–35. Retrieved from https://scholar.lib.vt.edu/ejournals/JOTS/v35/v35n2/pdf/locke.pdf

McComas, W. F., & McComas, K. K. (2009). The contributions of science and mathematics to STEM education: A view from beyond the disciplines of technology and engineering. In International Technology Education Association (Ed.), *The overlooked STEM imperatives: Technology and engineering K–12 education* (pp. 26–35). Reston, VA: Author.

National Academy of Sciences, National Academy of Engineering, & Institute of Medicine. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future.* Washington, DC: National Academies Press.

National Center for Educational Statistics. (2011). *The 2009 high school transcript study: Users guide* (NCES 2011-465). Washington, DC: Author. Retrieved from http://nces.ed.gov/nationsreportcard/pdf/studies/2011465.pdf

National Economic Council. (2011). *A strategy for American innovation: Driving towards sustainable growth and quality jobs*. Retrieved from http://www.whitehouse.gov/administration/eop/nec/StrategyforAmericanInnovation

New Mexico Public Education Department. (2011). *Student-Teacher Accountability Reporting System: Volume 2: Reference Materials*. Santa Fe, NM: Author. Retrieved from http://ped.state.nm.us/stars/dl11/SY2011%20STARS%20Manual%20Volume%202_Final%2020110218.pdf

Roey, S., Caldwell, N., Rust, K., Hicks, L., Lee, J., Perkins, R., & Brown, J. (2005). *The 2000 high school transcript study user's guide and technical report* (NCES 2005-483). Washington, DC: National Center for Education Statistics. Retrieved from http://nces.ed.gov/pubs2005/2005483.pdf

Rodgers, J. L. (1999). The bootstrap, the jackknife, and the randomization test: A sampling taxonomy. *Multivariate Behavioral Research*, *34*(4), 411–456. doi:10.1207/S15327906MBR3404_2

Scott, C. (2012). An investigation of science, technology, engineering and mathematics (STEM) focused high schools in the U.S. *Journal of STEM Education*, *13*(5), 30–39. Retrieved from http://ojs.jstem.org/index.php?journal=JSTEM&page=article&op=view&path%5B%5D=1629

Spence, J. T., Cotton, J. W., Underwood, B. J., & Duncan, C. P. (1983). *Elementary statistics* (4th ed.). Englewood Cliffs, NJ: Prentice Hall.

SPSS (Version 21) [Computer software]. Armonk, NY. IBM Corporation

Starkweather, K. N. (2011). Branding: Putting a little dent in the universe. *Technology & Engineering Teacher*, *70*(6), 36–40. Retrieved from http://www.iteea.org/Publications/TTT/mar11.pdf

State of New Jersey Department of Education. (2013). *NCES SCED course codes* [SCED Spreadsheet]. Trenton, NJ: Author.

Stone, R. J., III, & Aliaga, A. O. (2005). Career & technical education and school-to-work at the end of the 20th century: Participation and outcomes. *Journal of Career and Technical Education Research*, *30*(2), 125–144.

Sweeder, R. D., & Strong, P. E. (2012). Impact of a sophomore seminar on the desire of STEM majors to pursue a science career. *Journal of STEM Education, 13*(3), 52–61. Retrieved from http://ojs.jstem.org/index.php?journal=JSTEM&page=article&op=view&path[]=1623&path[]=1461

Wang, X. (2013). Why students choose STEM majors: Motivation, high school learning, and postsecondary context of support. *American Educational Research Journal*, *50*(5), 1081–1121. doi:10.3102/0002831213488622

WesVar (Version 5.1.17) [Computer software]. Rockland, MD: Westat.

Wolter, K. M. (2007). *Introduction to variance estimation* (2nd ed.). New York, NY: Springer. doi:10.1007/978-0-387-35099-8

Developing Instrumentation for Assessing Creativity in Engineering Design

Abstract

A perceived inability to assess creative attributes of students' work has often precluded creativity instruction in the classroom. The Consensual Assessment Technique (CAT) has shown promise in a variety of domains for its potential as a valid and reliable means of creativity assessment. Relying upon an operational definition of creativity and a group of raters experienced in a given domain, the CAT offers the field of engineering education an assessment method that has demonstrated discriminant validity for dimensions of creativity as well as for technical strength and aesthetic appeal. This paper reports on a web-based adaptation of the CAT for rating student projects developed during a weeklong engineering camp. Images of resulting scale models, technical drawings, and poster presentation materials were displayed on a website which was accessed by a team of seven independent raters. Online survey software featuring a series of Likert-type scales was used for ratings. The raters viewed project images on larger computer screens and used iPads to input their assessments. This effort extended the accessibility of the CAT to raters beyond limitations of geographic location.

Keywords: Engineering Design, Creativity, Consensual Assessment Technique

The need for promoting creative thinking and innovative problem solving in classrooms has been established in the literature (National Research Council, 2002; Todd & Shinzato, 1999). Not only is creativity seen as an essential component of human cognition, but its promotion is essential to a global economy and creating globally competitive citizens (Kaufman, Baer, Cole, & Sexton, 2008). It is vital that teachers are able to effectively impart 21st century skills to our students, including creative and innovative skills (Fatt, 2000; P21, 2010). The cultivation of our high school students as innovative and creative problem solvers for today's technological problems has become a focus for STEM education in the 21st century (Dede, 2010; Fatt, 2000; P21, 2010).

Cameron D. Denson (cddenson@ncsu.edu) is Assistant Professor of Technology, Engineering and Design Education; Jennifer K. Buelin (jkbuelin@iteea.org) is Director of Digital Initiatives Division at ITEEA; Matthew D. Lammi (matthew_lammi@ncsu.edu) is Assistant Professor of Technology, Engineering and Design Education in the Department of STEM Education; and Susan D'Amico (susan_damico@ncsu.edu) is Coordinator of Engineering K-12 Outreach Extension, in the College of Engineering at North Carolina State University.

Engineering and technology education classrooms are uniquely positioned to offer a potentially fertile environment for developing students' problem-solving abilities and creative behavior (Lewis, 2005). With an emphasis on problem-based learning and open-ended questions, instructors of technology, engineering, and science education can provide students with a milieu conducive to the promotion of creativity. This is especially true for informal environments in which teachers are not bound by the standards-based restrictions of formal classroom settings.

Though the need for promoting creativity has been established in the literature, the task of fostering creativity and creative problem-solving skills can prove challenging amidst the classroom expectations of explicit objectives and measurable outcomes (Buelin-Biesecker & Weibe, 2013). This is especially difficult within the current goal framework of the average K–12 public school classroom, a context in which engineering education is gaining traction with the release of the *Next Generation Science Standards* (NGSS Lead States, 2013). Part of the challenge is that teachers may view creative students as "inattentive and disruptive," tending to "wander away from the regular paths of thought" (Lau & Li, 1996, p. 348). Without effective measures of creativity and validated instruments for the assessment of creativity, the teaching of creativity will continue to face scrutiny amongst teachers. Much of this scrutiny can be attributed to a lack of research dedicated to developing strategies that help teachers identify creativity and assess creative attributes of student work (Lewis, 2005). It is the researchers' contention that the lack of validated assessment measures for creativity and a perceived inability to assess creative attributes of students' work has precluded the teaching and learning of creativity in STEM classrooms (Buelin-Biesecker & Weibe, 2013; Lewis, 2009).

Studies have shown, however, that the reliable assessment of creativity in students' design work is possible (Amabile, 1996; Hennessey, Amabile, & Mueller, 2011; Hickey, 2001). This paper highlights a novel approach to creative assessment of engineering design products in secondary classrooms. This paper reports on the results of using the Consensual Assessment Technique (CAT) for creativity assessment in an engineering design setting. CAT offers promise for the assessment of creativity in a myriad of different domains. Relying upon an operational definition of creativity, the CAT has proven to be a valid and reliable means of assessment. However, CAT's accessibility has been limited by the need for a group of expert raters experienced in a given domain to rate design products on site. To address this issue, this paper will report on a web-based adaptation of the CAT for rating student projects. If functional, the web-based version of the CAT offers the field of engineering education an assessment method that has demonstrated discriminant validity for dimensions of creativity as well as for technical and aesthetic appeal.

Background Literature

Creativity

When sorting through the profuse definitions and conceptual frameworks available for discussing the concept of creativity, it is useful to identify those most applicable to the task at hand; in this case, the topic of interest is the potential for fostering students' creativity in hands-on problem-solving activities in engineering design settings. Two types of definitions are useful to this discussion. Hennessey, Amabile, and Mueller (2011), whose work in creativity assessment has had tremendous influence upon the design of this study, offered the following:

> **Conceptual definition of creativity** A product is considered creative to the extent that it is both a novel and appropriate, useful, correct, or valuable response to an open-ended task. (p. 253)
>
> **Operational definition of creativity** A product or response is considered creative to the extent that appropriate observers independently agree that it is creative. Appropriate observers are those familiar with the domain in which the product was created or the response articulated. (p. 253)

Hennessey et al.'s (2011) conceptual definition is a useful guide for evaluating student products in technology and engineering education because student products and design processes will vary widely due to many factors and problems are often open ended. The definition assimilates many prior conceptual definitions (Cropley, 1999) and can be helpful in clarifying to students what is being asked of them when they are told that creativity is a part of their grades. The operational definition establishes the framework and justification for the use of Amabile's (1983) Consensual Assessment Technique (CAT) for evaluating creativity and other dimensions of student responses to open-ended design and problem-solving activities: If knowledgeable raters independently, and with an acceptable level of interrater reliability, determine that a student product is creative in its context, then by definition, it is. The creative outcomes sought in the engineering design curriculum will be assessed using this method for three major dimensions (creativity, technical strength, and aesthetic appeal) and for nine additional subdimensions (novel idea, novel use of materials, complexity, organization, neatness, effort evident, liking, pleasing use of shape or form, and pleasing use of color or value). Factor analysis reveals the CAT's discriminant validity, in effect revealing whether creativity was measured apart from other characteristics of students' work.

Consensual Assessment Technique (CAT)

The CAT is an evaluation tool used by creativity researchers for assessment of creative products by panels of raters. The method "is based on the assumption that a panel of independent raters familiar with the product domain, persons who have not had the opportunity to confer with one another and who have not been trained by the researcher, are best able to make such judgments" regarding "the nature of creative products and the conditions that facilitate the creation of those products" (Hennessey et al., 2011, p. 253).

Amabile (1996) describes consensual assessment as a technique of judging creativity based on an operational, rather than conceptual, definition of creativity. Amabile states that "'a product or response is creative to the extent that appropriate observers independently agree it is creative. Appropriate observers are those familiar with the domain in which the product was created or response articulated'" (Amabile, 1982; as cited in Amabile, 1983, p. 31). Recent studies have advanced Amabile's work by applying the CAT in different contexts, including assessing the creativity of children's musical compositions and nonparallel creative products (Baer, Smith, & Allen, 2004; Hickey, 2001).

The application of the CAT for making inferences about students' work, and subsequent inferences about pedagogical strategies used in producing that work, depends upon acceptance of an operational definition of creativity, which is described above. Interrater reliability "quantifies the closeness of scores assigned by a pool of raters to the same study participants. The closer the scores, the higher the reliability of the data collection method" (Gwet, 2008, p. 29). As Hennessey et al. (2011) explained,

> In the case of the consensual assessment technique, reliability is measured in terms of the degree of agreement among raters as to which products are more creative, or more technically well done, or more aesthetically pleasing than others. (p. 253)
> By definition, interjudge reliability in this method is equivalent to construct validity: if appropriate judges independently agree that a given product is highly creative, then it can and must be accepted as such. (p. 256)

In order to claim that creativity is being isolated and measured apart from other characteristics of students' work, it is essential to demonstrate an instrument's discriminant validity. Items related to creativity will ideally receive consistently different ratings from items related to categorically different types of items. Many studies using the CAT have followed Amabile's (1983) three clusters of dimension types (creativity, technical strength, and aesthetic appeal) and have included ratings of multiple related subdimensions (Buelin-Biesecker & Weibe, 2013). Figure 1 provides a list of subdimensions associated with each of the three major dimensions. Factor analysis determines the CAT's discriminant validity; optimally, items within each of those three clusters will consistently load together.

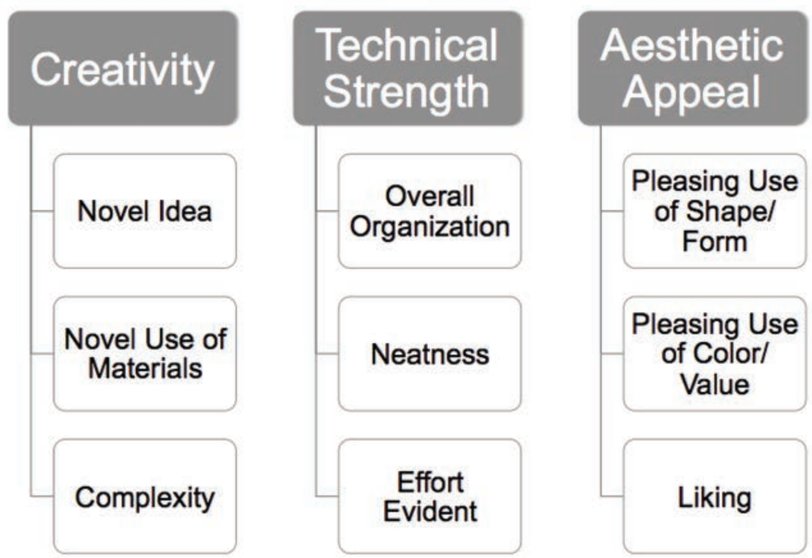


Figure 1. Subdimensions associated with each major dimension measured.

The rating instrument provided raters with a brief description of each subdimension. The creativity prompt was described this way: "Using your own subjective definition of creativity, the degree to which the design is creative." Those subdimensions associated with creativity throughout Amabile's body of work on the CAT include novel idea (the degree to which the design explores a unique and interesting idea), novel use of materials (the degree to which the use of materials is unique and interesting), and complexity (the level of complexity in the design).

The technical strength prompt was described this way: "The degree to which the work is good technically." Those subdimensions associated with technical strength throughout Amabile's body of work include overall organization (the degree to which the work shows good organization), neatness (the amount of neatness shown in the work), and effort evident (the amount of effort that is evident in the product).

The aesthetic appeal prompt was described this way: "In general, the degree to which the design is aesthetically appealing." Those subdimensions associated with aesthetic appeal throughout Amabile's body of work on the CAT include pleasing use of shape or form (the degree to which there is a pleasing use of shape or form in the design), pleasing use of color or value (the degree to which the design shows a pleasing use of color or value), and liking (your own subjective reaction to the design; the degree to which you like it).

Informal Learning Environments

The informal learning environment framing the following study is classified as a programmed setting. Informal learning environments can be categorized into three major settings: (a) “everyday experiences,” (b) “designed settings,” and (c) “programmed settings” (Kotys-Schwartz, Besterfield-Sacre, & Shuman, 2011, p. 1). Programmed settings are characterized by “structures that emulate [or complement] formal school settings—planned curriculum, facilitators . . . , and a group of students who continuously participate in the program” (Kotys-Schwartz et al., 2011, p. 2). It is estimated that during the schooling years of students, 85% of their time will be spent outside of a classroom (Gerber, Cavallo, & Marek, 2001). This illustrates the importance of providing opportunities for learning that are outside of the traditional learning environment. Informal learning environments provide these opportunities and have been an integral part of education for years (Martin, 2004). The continued study of informal learning environments may provide insight into ways that the nation can address the issue of STEM education reform (Kuenzi, 2008). The merits of informal learning environments are known (Gerber et al., 2001), however little research is available that addresses their role in the cultivation of creativity. Informal environments were deemed appropriate for the exploration of creativity in this study because they are not bound by the standard-based restrictions of formal learning environments. However, it is argued that results from this study have implications for both informal and formal learning environments.

Description of the Innovation

Digital CAT interface

Creativity assessment conducted using the CAT has traditionally followed similar implementation processes: students create products that are collected by researchers, spread around a single physical space, and viewed and assessed in that space by one rater at a time until the ratings were completed. It may prove valuable to expand the accessibility of consensual assessment beyond the traditional method characterized by displaying student projects throughout a physical space and having raters complete the assessments in person. For this study, the researchers developed a web-based assessment interface consisting of (a) an overview video displaying all project images for raters to view prior to the rating session; (b) a website built for the display of project images and documentation; and (c) a web-based version of the consensual assessment instrument, accessed by raters via iPad while viewing the project website on desktop computers. The web-based version of the CAT consisted of images of modeled artifacts resulting from the engineering design challenge (see Figures 2 and 3).

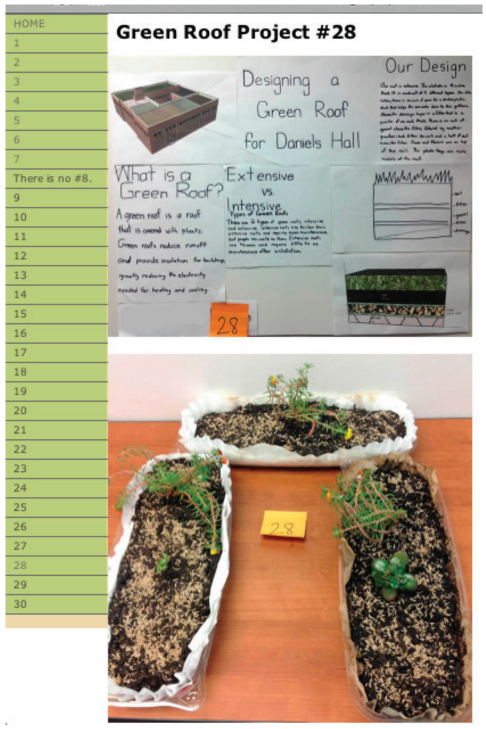


Figure 2. Green roof project website. This figure illustrates the website used by project raters for viewing each of the green roof projects. Photographs of presentation posters and physical models were included for each project.

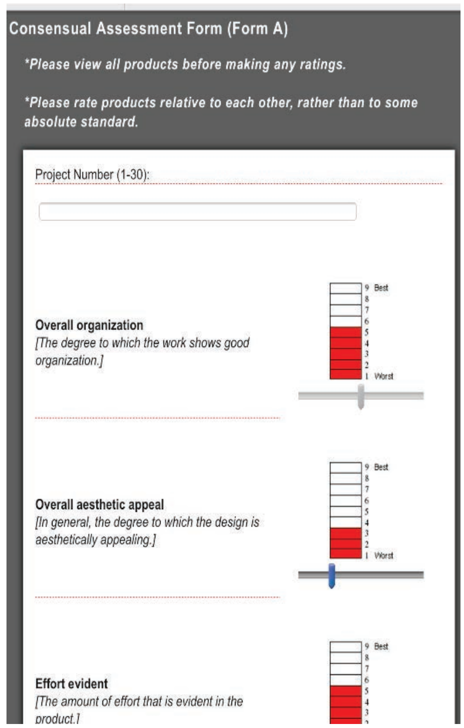


Figure 3. Consensual assessment instrument for iPad. This figure illustrates the interface used by project raters for making online consensual assessment ratings on 12 dimensions of students' projects.

Example Applications

For an example of the interface that the raters were using for assessment, please refer to the following URL: http://www4.ncsu.edu/~jkbuelin/index.html.

Please follow the link below for an example of the web-based version of the Consensual Assessment Technique (CAT) for the iPad: http://tinyurl.com/GreenRoofCAT.

Procedures

Engineering Summer Camp

Founded in 1999 as an extension of the Women in Engineering Program, the Engineering Summer Camps at North Carolina State University offers week-long day and residential engineering camps each summer for rising 3rd through 12th grade students' interested in experiencing engineering, science and technology. Participants for this study attended a multidisciplinary coed day camp session for rising 9th and 10th grade students. Student campers paid a fee to participate in the engineering summer camps; however, financial aid was available to those demonstrating need. Approximately 90 students were placed in design teams of three students, providing the study with 30 student groups. The demographic data for the participants were as follows: 63% male, 37% female, 53% Caucasian, 18% African American, 11% Asian, 4% Hispanic, 4% Native American, 6% other, and 3% didn't respond. Participants were not provided remuneration for their participation in this study.

Three secondary school educators, one middle school and two high school teachers with backgrounds in science or math were selected as instructors for the engineering summer camp. Instructors were responsible for 30 students each, equaling 10 student groups. The instructors provided guidance and instruction for the student teams while facilitating the engineering design experience. Six staff camp counselors, undergraduate engineering students, assisted the teacher team leads as mentors and role models to the participants. Six staff high school assistants also supported the engineering summer camp by providing materials and logistical support.

Throughout the week, a variety of hands-on activities were presented, providing a glimpse into the broad scope of opportunities available in engineering. The main weeklong project was the Green Roof Design Challenge, designing an intensive green roof for a campus building that would absorb rainwater, provide insulation for a building, and serve as a beautiful, natural green place that students, faculty, and visitors can enjoy. The project included three steps: (1) Create a very detailed design, complete with technical drawings; (2) create a working scale model of the final design; and 3) prepare a brief 3–5 minute presentation about the design.

In order to complete the project, the campers were provided with the following instructional guidance:

- Learn About Green Roofs
- Substrate Proof of Concept Design
- Test the Substrate Design
- Conceptual Model
- Mathematical Model
- Graphical Model
- Working Model
- Presentation

Fieldtrips to a local arboretum to view plant options and to a nearby building with a working green roof were included in the week of camp.

After receiving their team assignments and a brief introduction to the engineering summer camp, student teams received their green roof engineering design challenge on Day 1 of the 5-day camp. Each day throughout the week, teams participated in ancillary activities designed to promote critical-thinking and problem-solving skills. These activities included experimentation, analysis, mathematical modeling, and other engineering ways of thinking and doing.

In groups of three, each team was "responsible for defining, developing, and testing a design which takes into account all relevant specifications and constraints" for a proposed green roof on campus. Besides a rooftop schematic, the students were not given any more guidance on the design brief. The design challenge was left ambiguous for the student designers so that they could further formulate the problem, take deeper ownership of the design, engage in questioning, and express creativity.

Additionally, the teams were asked to produce a series of modeling artifacts as part of the design requirements. The models that the teams produced included a conceptual model, a mathematical model, a graphical model, and a working model illustrating their design solution (Lammi & Denson, 2013). The modeling artifacts gave the students something tangible to which they could work while giving the instructors and teaching assistants opportunities to offer concrete feedback and assessment. This design process culminated in team presentations to all camp participants, staff, and students' families on Day 5.

Following the presentations, photographs of students' working models and presentation materials were taken. Images were catalogued by project number on a website built for rater access. Once raters were contracted as participants they were given instructions via email as well as the project website URL, and each rater was given a unique CAT survey URL.

Methods

The primary research question for this study was whether the digital interface developed for this implementation of the Consensual Assessment Technique would yield strong (alpha > 0.75) interrater reliability among the seven raters for the 12 dimensions measured. A secondary question concerning the digital instrument's discriminant validity was also investigated because it is essential to determine whether raters are evaluating creativity apart from other dimensions of projects, such as technical strength and aesthetics.

To secure raters for this study, researchers developed an online solicitation, which explicitly detailed in the criteria that raters needed to be familiar with the engineering design process and experienced in teaching high school aged students. It was important that raters understood the nuances of assessing engineering design products while still understanding the quality of work to be expected from high school age students. Below is the solicitation that prospective raters received:

> STEM Education faculty at NCSU request the participation of project raters for an investigation into the assessment of creativity in high school students' engineering design projects.

> Raters should be familiar with engineering design processes and should have some knowledge of learners aged 14–17. It is not necessary for raters to have taught high school engineering design in a formal classroom setting.
>
> Ratings will be performed digitally, simultaneously using an iPad and a desktop or laptop computer connected to the Internet. No travel is required for participation; however, an equipped workspace will be provided on the NCSU campus if requested. Compensation of $50 will be provided for time spent conducting ratings. The estimated time for completion of ratings is approximately 1–2 hours.

The raters included a high school teacher currently teaching Project Lead the Way (PLTW) with over 9 years of teaching experience, a professor with joint appointments in engineering and technology education, a National Board certified science teacher with over 19 years teaching experience, a former engineer and current middle school assistant principal, a high school teacher who has taught at the summer engineering camp for five previous years, an engineering camp director with National Board certification as a science teacher, and a 6th grade science teacher with 13 years teaching experience.

Raters were asked to commit approximately 2 to 3 hours to a rating session during which they would evaluate student projects on dimensions such as creativity, aesthetic value, and technical strength. Raters were compensated with a $50 honorarium for their participation.

After the camp ended and documentation of student products was organized on the rater website, raters were provided with the URL for the website and a link to the rating form. They were given the following instructions:

> Please begin the rating process by reading the problem definition contained in the student's artifacts and viewing the short video on the project landing page. This video is an overview of the images you will find on the website. It serves as an introduction to the products created by the students, and it will give you a sense of the range of abilities represented in the sample. It is essential to our methodology that you look over all the products prior to rating any projects, and that you rate projects relative to each other rather than making ratings based on some absolute standard. In other words, consider what the camp students were able to do given time, instruction, supplies, etc., rather than what you think they should be able to do.

To ensure a consistent rating experience, raters were offered loaner iPads, laptops, and office space in which to conduct ratings if needed.

Assessment of Innovation

To test interrater reliability, Cronbach's alpha was calculated using adult raters' scores for the 12 separate dimensions rated. It can be seen in Table 1 that all 12 items have reliabilities greater than .70 and that ten of the 12 have reliabilities greater than .80. This includes creativity, with an interrater reliability of 0.86. According to the Landis and Koch (1977) scale, a reliability coefficient between 0.61 and 0.80 is "substantial," and agreement above 0.80 is "almost perfect" (p. 165).

Table 1
Cronbach's Alpha for 12 Dimensions Measured

Dimensions of Judgment	Cronbach's α
Creativity	0.8642
Aesthetic Appeal	0.8786
Technical Strength	0.7126
Complexity	0.7818
Liking	0.8557
Novel Idea	0.8453
Novel Use of Materials	0.8808
Shape/Form	0.8422
Color/Value	0.8914
Organization	0.8269
Neatness	0.8149
Effort Evident	0.8387

In order to evaluate the discriminant validity for this implementation of the CAT, factor analysis was conducted on the mean ratings of the 12 dimensions of judgment (promax rotation). Factor analysis suggested the emergence of three factors, as shown in Table 2, corresponding, albeit not perfectly, with Amabile's (1983) paradigm (Figure 1). Although only one factor emerged with an eigenvalue higher than 1.0, consideration of the scree plot (Figure 4) similarly suggests the emergence of three factors, indicated by the rate of change in magnitude of the eigenvalues for Factors 1–3. Factor 1 includes creativity and its three subjacent items: novel idea, novel use of materials, and complexity (as well as liking, effort evident, and technical strength). Factor 2 comprises overall aesthetic appeal and its three subjacent dimensions: pleasing use of color or value, pleasing use of shape or form, and liking (as well as novel use of materials and creativity). Factor 3 includes technical strength and two out of three of its subjacent dimensions: overall organization and neatness. This suggests that the raters were able to distinguish between the features of creativity, technical strength, and aesthetic appeal. The clusters as provided by the factor analysis align very closely with Amabile's (1983) three clusters of dimension types. This provides strong evidence that the raters were able to distinguish between creative characteristics of design and other characteristics (i.e., aesthetic appeal) of the students' green roof designs. It should be noted, however, that factor analysis is far more stable with larger sample sizes than that of this study; therefore, further testing would be necessary in order to make claims about this instrument's discriminant validity.

Table 2
Factor Loading of 12 Dimensions, Promax Rotation

Dimensions of Judgment	Factor 1: Creativity	Factor 2: Aesthetic Appeal	Factor 3: Technical Strength
Creativity	**0.61**	**0.43**	0.04
Aesthetic Appeal	0.12	**0.79**	0.18
Technical Strength	**0.79**	-0.23	**0.41**
Color/Value	-0.13	**1.02**	0.06
Complexity	**0.90**	0.01	0.08
Effort	**0.58**	0.21	0.33
Liking	**0.55**	**0.48**	0.07
Neatness	0.04	0.18	**0.83**
Novel Idea	**0.88**	0.22	-0.09
Novel Materials	**0.52**	**0.57**	-0.05
Organization	0.14	0.20	**0.72**
Shape/Form	0.19	**0.75**	0.14

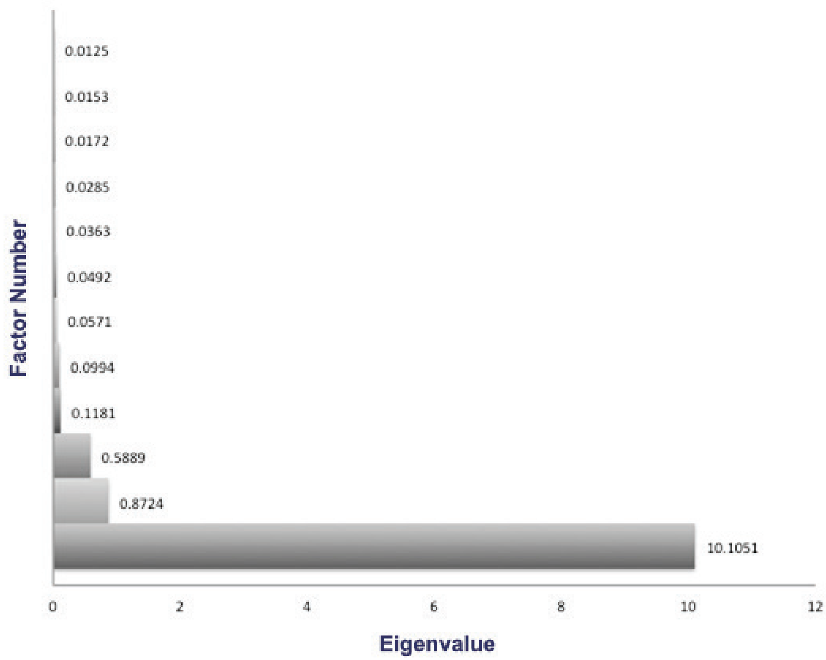


***Figure 4*.** Scree plot for the 12 dimensions measured. This figure illustrates the rate of change in magnitude of the eigenvalues for all 12 components. The slope flattens considerably beyond the third component, suggesting the retention of three factors.

Conclusion and Summary

Despite the skepticism that various stakeholders (e.g., teachers, students, parents, administrators) have been known to display, a growing body of research supports the assertion that creativity can be reliably recognized and assessed in a formal classroom setting. The Consensual Assessment Technique shows promise for the assessment of creativity in the domain of engineering design education. The web-based CAT tools used in this study allow instructors to bypass the limitations posed by implementing consensual assessment in a single physical location. The likelihood of obtaining well-qualified raters is improved, and logistical challenges such as displaying a large number of student projects simultaneously are ameliorated. Using the web-based version of the CAT still produced interrater reliability among the seven raters that was consistently high for all 12 dimensions of judgment measured in this study, and, despite its relative instability with a small sample size, factor analysis suggests that raters were able to recognize and assess creativity apart from other characteristics of student projects. These findings are important to discussions of how curricula and assessment methods might evolve in engineering design education.

A need for the promotion of creative thinking and innovative problem solving has been identified in the research literature (National Research Council, 2002; Todd & Shinzato, 1999), and the importance of creativity in engineering education has become well documented in recent years (Amato-Henderson, Kemppainen, & Hein, 2011). This study builds upon the work of Amabile (1996), Hennessey et al. (2011), Hickey (2001), and others in confirming that creativity can be recognized by raters who are knowledgeable in a domain and that it can be reliably assessed in the classroom. The promotion of engineering students' abilities to think creatively and to effectively communicate their innovative design ideas is fundamentally important. As these findings add to a research base that continues to show creativity can reliably be assessed, engineering instructors are encouraged to include creativity as an explicit objective in their design challenges.

Overview of Future Work

Further study is needed to develop practical classroom projects and assessment instruments for pre-engineering and engineering students and instructors that will spur students toward meeting their creative potential. One challenge for formal learning environments is that the current system can provide raw scores per dimension and project from the slider scale input. The user is required to download and manipulate raw data, and the mean score (between 1 and 9) does not directly translate to a reportable grade. The development of a streamlined software or website template would be beneficial because this method requires the time, resources, and ability to compile images into an accessible format that is not too cumbersome for raters and it requires familiarity and access to an online survey instrument. The promotion of creativity in engineering design settings still faces many logistical questions as well that has to be addressed. The time and planning needed to secure seven "expert" raters has to be considered. Unlike the researchers in this study, teachers may not have the latitude or budget to pay raters of student projects. In light of these challenges, researchers are encouraged by the preliminary results of assessing creativity in engineering design products.

Larger scale investigation could be useful in exploring potential benefits of self and peer evaluation to student achievement as well as to classroom creativity assessment. Additional investigation is needed into effective methods for training students to act as peer raters. Consistently high levels of interrater reliability found in preliminary cross-domain studies have laid a groundwork for pedagogical investigations comparing, for example, the effects of variables such as design processes, pedagogical strategies, and design prompts on engineering students' creative outcomes. Gender tendencies might also be of interest in similar future studies of larger samples because prior studies have intermittently shown girls receiving significantly higher creativity scores than boys (Amabile, 1983; Hennessey et al., 2011). Results of this study add to the body of literature on creative assessment through continued research with the engineering summer camp. A future study will investigate the reliability and validity of the digital interface CAT using 144 student participants, which formed 48 student groups. In addition, researchers will investigate students' creative self-efficacy and explore its relationship with creative outcomes as determined by the CAT.

Acknowledgements

We would like to thank Dr. Laura Bottomley for her tireless work, and we would also like to thank the Engineering Place for allowing us the opportunity to work with them on this project.

References

Amabile, T. M. (1983). *The social psychology of creativity*. New York, NY: Springer-Verlag. doi:10.1007/978-1-4612-5533-8

Amabile, T. M. (1996). *Creativity in context*. Boulder, CO: Westview Press.

Amato-Henderson, S., Kemppainen, A., & Hein, G. (2011). *Assessing creativity in engineering students*. Paper presented at the 41st ASEE/IEEE Frontiers in Education Conference, Rapid City, SD. Retrieved from http://fie-conference.org/fie2011/papers/1440.pdf

Baer, R. A., Smith, G. T., & Allen, K. B. (2004). Assessment of mindfulness by self-report: The Kentucky Inventory of Minfullness Skills. *Assessment, 11*, 191–206. doi:10.1177/1073191104268029

Buelin-Biesecker, J. K., & Weibe, E. N. (2013). *Can pedagogical strategies affect students' creativity? Testing a choice-based approach to design and problem-solving in technology, design, and engineering education.* Paper presented at the American Society for Engineering Education Annual Conference & Exposition, Atlanta, GA. Retrieved from http://www.asee.org/file_server/papers/attachment/file/0003/3381/PedagogicalStrategiesCreativity.pdf

Cropley, A. J. (1999). Definitions of creativity. In M. A. Runco & S. R. Pritzker (Eds.), *Encyclopedia of creativity* (Vol. 1, pp. 511–524). San Diego, CA: Academic Press.

Dede, C. (2010). Comparing frameworks for 21st century skills. In J. Bellanca & R. Brandt (Eds.), *21st century skills: Rethinking how students learn* (pp. 51–76). Bloominton, IN: Solution Tree Press.

Fatt, J. P. T. (2000). Fostering creativity in education. *Education, 120*(4), 744–757.

Gerber, B. L., Cavallo, A. M. L., & Marek, E. A. (2001). Relationships among informal learning environments, teaching procedures and scientific reasoning ability. *International Journal of Science Education, 23*(5), 535–549. doi:10.1080/09500690116971

Gwet, K. L. (2008). Intrarater reliability. In R. B. D'Agostino, L. Sullivan, & J. Massaro (Eds.), *Wiley encyclopedia of clinical trials* (pp. 1–13). Hoboken, NJ: Wiley. doi:10.1002/9780471462422.eoct631

Hennessey, B. A., Amabile, T. M., & Mueller, J. S. (2011). Consensual assessment. In M. A. Runco & S. R. Pritzker (Eds.), *Encyclopedia of creativity* (2nd ed., Vol. 1, pp. 253–260). San Diego, CA: Academic Press.

Hickey, M. (2001). An application of Amabile's consensual assessment technique for rating the creativity of children's musical compositions. *Journal of Research in Music Education, 49*(3), 234–249. doi:10.2307/3345709

Kaufman, J. C., Baer, J., Cole, J. C., & Sexton, J. D. (2008). A comparison of expert and nonexpert raters using the consensual assessment technique. *Creativity Research Journal, 20*(2), 171–178. doi:10.1080/10400410802059929

Kotys-Schwartz, D., Besterfield-Sacre, M., & Shuman, L. (2011). *Informal learning in engineering education: Where we are - where we need to go.* Paper presented at the 41st ASEE/IEEE Frontiers in Education Conference, Rapid City, SD. Retrieved from http://fie-conference.org/fie2011/papers/1235.pdf

Kuenzi, J. J. (2008). *Science, technology, engineering, and mathematics (STEM) education: Background, federal policy, and legislative action* (Congressional Research Service Report No. RL33434). Retrieved from http://www.fas.org/sgp/crs/misc/RL33434.pdf

Lammi, M., & Denson, C. D. (2013). *Pre-service teacher's modeling as a way of thinking in engineering design.* Paper presented at the 120th American Society for Engineering Education Annual Conference & Exhibition, Atlanta, GA. Retrieved from http://www.asee.org/public/conferences/20/papers/5867/download

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*(1) 159–174. doi:10.2307/2529310

Lau, S., & Li, W.-L. (1996). Peer status and the perceived creativity: Are popular children viewed by peers and teachers as creative? *Creativity Research Journal, 9*(4), 347–352. doi:10.1207/s15326934crj0904_6

Lewis, T. (2005). Creativity—A framework for the design/problem solving discourse in technology education. *Journal of Technology Education, 17*(1), 35–52. Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/v17n1/pdf/lewis.pdf

Martin, L. M. W. (2004). An emerging research framework for studying informal learning and schools. *Science Education, 88*(S1), S71–S82. doi:10.1002/sce.20020

National Research Council. (2002). Equipping the federal governemnt to counter terrorism.In National Research Council, *Making the nation safer:*

The role of science and technology in countering terrorism (pp. 335–356). Washington, DC: National Academies Press.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, DC: National Academies Press.

Partnerships for 21st Century Skills. (2010). *Partnerships for 21st century skills*.

Todd, S. M., & Shinzato, S. (1999). Thinking for the future: Developing higher-level thinking and creativity for students in Japan—and elsewhere. *Childhood Education, 75*(6), 342–345. doi:10.1080/00094056.1999.10522054

Perceptions About the Role of Race in the Job Acquisition Process: At the Nexus of Attributional Ambiguity and Aversive Racism in Technology and Engineering Education

Abstract

This study explored the role of race in the negative job acquisition outcomes of African American graduates of a federally funded multi-institution doctoral training program. Because the credentials of African American graduates were similar, equal to, and/or, in some cases, exceeded those of their white peers, qualifications were ruled out as contributing to negative job outcomes. Further examination indicated that among the likely factors accounting for job acquisition outcomes were: tokenism; aversive racism; microaggressions; and inadequate professional development for graduates entering a White-male-dominated field. Recommendations for practice suggest amending graduate programming to include anticipatory socialization relative to being a member of a historically underrepresented group in the field, and mentorship that can help diffuse the impacts of tokenism and facilitate career success in academia.

Keywords: Race, Gender, Tokenism, Professional Development

Twelve individuals—three African American, one non-U.S.-resident African, and eight White—completed the National Technology and Engineering Education Program (NTEEP, a pseudonym), a prestigious federally funded multi-institution doctoral training program. Two years post-graduation, the three African American program fellows were the only graduates who had not obtained permanently funded academic positions. Did the program fail these students in some way? Were they less prepared or less accomplished than their White colleagues? Was the outcome the result of racial bias in the field of technology and engineering education? In this paper, we explore answers to these complex questions through the perceptional lens of the program faculty and fellows and through the theoretical lens of tokenism.

Tokenism is a psychological state imposed upon persons from demographic groups that are rare within a work context (Kanter, 1977a; Niemann, 2003). More than numbers, tokenism is fueled and moderated by antecedents, including subordinated gender status within the context, placement of the demographic group on the social hierarchy, and perception of gender and race appropriateness

Yolanda Flores Niemann (Yolanda.Niemann@unt.edu), is Professor of Psychology and Nydia C. Sánchez (Nydia.Sanchez@unt.edu), is in the Department of Counseling and Higher Education at the University of North Texas.

for the occupation (Yoder, 1994; King, Hebl, George, & Matusik, 2009; Stichman, Hassell, & Archbold, 2010; Torchia, Calabro, & Huse, 2011). Consequences of tokenism are behavioral and perceptual and include feelings of isolation and loneliness, visibility and chronic distinctiveness (Pollak & Niemann, 1998), representativeness and role encapsulation, stereotyping and stereotype threat, racism, and attributional ambiguity (Niemann & Dovidio, 1998; Niemann, 2003; 2011).

Tokenism results from the context, not from the qualifications, accomplishments, or character of the tokenized person and not necessarily from intentional prejudices of persons in the workplace, whose biases may be unconscious. These contexts afford exaggeration of differences between tokens and persons who are members of dominant demographic groups within the environment (Kanter, 1977a). Observers in these contexts may: assimilate tokens to their preconceived notions about their group (Sekaquaptewa & Thompson, 2003); question their goodness of fit for a given environment, role, or occupation (Hewstone, Cairns, Voci, Hamberger, & Niens, 2006); or encapsulate group members into particular roles and occupations (King et al., 2009; Yoder, 1994). In addition, tokens may be evaluated under different, and more stringent, criteria than their dominant colleagues (Jones, Dovidio, & Vietze, 2014). For a non-dominant group member, tokenized contexts may trigger feelings of inadequacy (Kanter, 1977b), stigma (Niemann, 2003; 2012), inequity, and intensified attributional ambiguity (i.e., not knowing the intentions of the feedback or actions toward or against them). That is, the individuals perceived do not know if feedback and outcomes are grounded in a fair and equitable evaluation or based on racist or sexist biases.

Tokens may also experience the fear of proving true the stereotypes about one's group, also known as *stereotype threat* (Steele, 1997), which is more pervasive among members of historically underrepresented racial or ethnic groups than gender groups (Thompson & Sekaquaptewa, 2002). For instance, an individual's visibility may create more pressure to take or not take certain actions (Kanter, 1977b). Students and faculty from these groups identify feelings of isolation, expectations to conform, and negative stereotypes (Austin, 2010; Niemann & Dovidio, 1998; Niemann 2003, 2012). They often perceive an overall lack of academic fit (Schmitt, Oswald, Friede, Imus, & Merritt, 2008) and lack of support systems (Poirier, Tanenbaum, Storey, Kirshstein, & Rodriguez, 2009). The lack of critical mass impacts their willingness to speak up, which can be deemed risky for persons in non-dominant groups (Crosby, King, & Savitsky, 2014; Niemann, 2012). Further complicating the issue, research suggests individuals in the numerical minority may feel like imposters, which leads them to discount their achievement and ability and attribute successes to external factors, such as luck or charm (Sekaquaptewa, 2011).

Hiring decisions create tokenized contexts. Due to *aversive racism*, which refers to largely unconscious racial biases and preferences for the in-group

(Gaertner & Dovidio, 2014), it is likely that some of the hiring or decision-making faculty and leaders do not understand the role of race in their perceptions and ultimate decisions. However, there is strong empirical evidence that White persons judge Black persons using different standards than when judging other White persons in employment and other everyday situations. For instance, when Black persons are evaluated for hiring, annual reviews, or promotion, if their profile is short of perfect, inherent biases work against them. In contrast, White decision makers weigh the strongest credentials of White men most heavily in their decision making. That is, White men systematically shift their decision-making standards, depending upon the race of the candidate. For Black men, as well as for White women in White male-dominated professions, decision makers focus on the weakest aspects of their profiles. When they evaluate White men, the same decision makers focus on the strongest aspects of the profile. This process may be largely unconscious, leaving these decision makers to strongly deny that racism or sexism played any role in their evaluation of a candidate (Gaertner & Dovidio, 2014). Dismissal of candidates' credentials and downplaying of their potential contributions may result from decision makers' biases rather than from an objective evaluation of the individual (Niemann, 2012).

About the Study

At the time of this study, NTEEP was a multi-university collaborative network developed to "build research capacity within technology education through development of doctoral programs and students, to build capacity in K-12 technology education to teach engineering design and apply engineering design processes to solve technological problems, and increase diversity and leadership capacity in the field," according to one of the program's principal investigators (PIs). NTEEP doctoral fellows received formal training at their primary base university. The cohort model also brought the fellows together for various courses at one of the partner institutions as well as for conferences, symposia, and travel.

Upon realizing that none of the three African American fellows had obtained a full-time academic position two years after graduation, the NTEEP PIs engaged a consultant, the first author of this paper, to gain insight into these outcomes. Specifically, the consultant was to explore perceptions about whether experiences related to the fellows' membership in historically underrepresented groups within their field led to the unexpected job outcomes. In this qualitative study, the job acquisition process is understood through participants' experiential lens.

All 12 NTEEP fellows as well as program faculty were invited to participate in the assessment. Of the three female and nine male fellows, eight fellows self-identified as White, three as African American or Black, and one as African (non-U.S.-born). Interviews were designed to ascertain participants' perceptions of demographic factors in the program experience and job acquisition outcomes. Of the faculty members, five were White males, one was a White female who became part of the program after the program's conception and development, and one was a foreign-born African male who retired before the program ended.

Semi-structured, open-ended interviews were utilized to maximize flexibility and create room for the discussion of sensitive topics (Merriam, 2009). Interviews were conducted with nine of the 12 fellows. Two fellows elected not to participate, and one did not respond. All program faculty members participated in the interviews. To maintain the confidentiality of the small number of study participants, respondent quotes are only identified as either fellows or faculty.

An initial 30-minute interview was conducted with each of the nine fellows to begin relationship development between the consultant and fellows. During this interview, the consultant described the purpose of the assessment: to gain further knowledge about fellows' perceptions of socio-demographic factors in the job acquisition experiences. The initial questions verified program participation and completion, current job situations, and racial or ethnic identity. A 1-hour follow-up phone interview probed into fellows' individual experiences and perceptions about the program structure, faculty mentoring, and the perceived role of race, gender, and socioeconomic status in their experiences.

For member checking (Merriam, 2009) and to provide an additional feedback loop, the consultant developed an executive summary of the interview themes and disseminated it to participating fellows. All fellows concurred with the report content. The summary was then reviewed with program faculty via 1-hour semi-structured interviews to increase perception reliability and layered insights about the program and job outcomes. Further, the fellows' scholarly productivity that was publically posted on the NTEEP website was disaggregated according to one of three types: publication, presentation, or grant.

Perceptions About the Role of NTEEP in the Job Acquisition Process

As with most graduate training (Austin, 2010; Hailey, Erekson, Becker, & Thomas, 2005; Griffith, 2010; MacLachlan, 2006; Litzler, Lange, & Brainard, 2005; Malcom & Dowd, 2012), NTEEP's focus was on building students' capacity to conduct original research in their field. Program structure included significant exposure to funding agencies, small seed grants, and paper presentations at program-sponsored symposia, university site visits, and networking with established scholars in the field. All faculty members expressed satisfaction that the program goals had been fulfilled. Fellows also expressed gratitude for the opportunities afforded them by the program:

- “I knew it was important to understand how meaningful research is conducted; [NTEEP] did that well. It gave us the DNA of the research process.”
- “I am so grateful for [NTEEP], and the taxpayer who made this possible, and for the faculty and support staff. I don’t think I’d have a job without [NTEEP].”

The program’s cohort model afforded networking, peer collaboration, and the potential for developing mentoring relationships with faculty members from various universities. Consistent with research indicating that mentoring expectations depend on multiple variables, including faculty or student role, age, experience, and cultural differences, the extent to which fellows availed themselves to networking opportunities varied (Crisp & Cruz, 2009; Savage, Carp, & Logue, 2004). Some fellows believed that respect for and deference to the faculty required that the faculty take the initiative for extending professional relationships beyond the formal requirements of the classroom. Other fellows believed that the success of networking and professional relationship building was their responsibility and incumbent upon their own initiative.

- “[The program] faculty were very professional. They were all concerned with our well-being, but not about collegiality. They made it clear they were the faculty and we were the students.”
- “It’s each man or woman for him or herself, but the men seem to more naturally form networks and friendship groups that women are left out of.”
- “The vehicle was [NTEEP] but I was the engine. I got to drive the sports car but it requires someone to take initiative.”

Although faculty members agreed with the importance of networking for success in the field, the development of those skills was not specifically addressed in the curriculum, nor was there an assumption that it should have been a formal part of the program.

- “I’ll respond when they come into my office under stress, I’ll listen, but it’s not my job to be buddy-buddy with them.”
- “Some in the [NTEEP] network were narrow minded. About half of the faculty were open minded about working with minorities outside of those they advised, others were content with the status quo.”
- “Networking has to do with maturity and personality. It’s available to everyone.”
- “The area of technology education is that way. Professors are called ‘doctor.’”

Fellows across demographic groups, including White males, indicated that a discussion of the impact of race or gender in the workplace and in their careers and how to navigate these challenges when they are experienced might have served them well as researchers and as future leaders in their field. The program’s structure has proven particularly disadvantageous for persons from historically underrepresented groups, who may face additional obstacles in fitting in at institutions that lack diversity (Gaffe & Pruitt-Logan, 1998; Smith 2000). This research-based model often fails to address many of the nuances that entail success in academia (Gaffe & Pruitt-Logan, 1998; Poirier, Tanenbaum, Storey, Kirshstein, & Rodriguez, 2009; Smith, 2000).

- "My major Faculty was honest about the difficulties I would encounter, but it was never brought up in class or during conferences or seminars."

Faculty members expressed varying levels of concern that a lack of discussion on race or ethnicity and gender seemed to have such a negative impact on some fellows' experiences. Race concerns were simply not part of their awareness. A few expressed hesitancy and discomfort with the idea that race might matter in the job acquisition process.

- "Two years ago, they had a research symposium at [a partner campus]. One panel dealt with diversity issues; all three African American [fellows] were on that panel. It became uncomfortable. Panel members got into the issues and got no response."
- "I guess we could have done better but it's a challenge with the state of the field, mostly White male, and with lack of knowledge of faculty in this area."
- "Race/gender was not a factor in jobs. There were issues in getting a job but they were related to the economy, not race or gender. It was very competitive."
- "I wouldn't know how to give female or minority guidance but I agree that it's difficult for minorities and women to survive in that world."

The Perceived Role of Biases in the Job Acquisition Process

All respondents were directly asked to speculate about what role, if any, race may have played in the job acquisition outcome. They suspected that race may have been a factor in the lack of success in the job search process, but one that was subtle, covert, difficult to document, and very difficult to know how to navigate.

- "I don't know if race or gender mattered, but my department is mostly White male and there's lots of talk around the university of needing to improve diversity."
- "It would be naïve to say that being a White male didn't make a difference in getting my job and my success in my environment, but it's hard to articulate and prove."

Fellows' quantity and quality of scholarly productivity was not sufficient to account for different job acquisition outcomes. As indicated in Table 1, scholarship outcomes, indicated by publications, presentations, and grants, varied within each racial group. Table 1 shows scholarly activity aggregated according to type—publications, presentations, or grants—with each item being awarded 3, 2, and 1 points, respectively. These points were awarded in order to take into account the importance of each activity type in the competitive application process for tenure-track positions.

Table 1
Fellows' Scholarly Productivity Scores

Race	Research Interest	Score	Position at Time of Study
White	Professional Development	74	Tenure Track
African American	Mentoring, HS, Race, Gender	34	Research Consultant
African	Metacognition	26	Tenure Track
White	HS, Systems Thinking	15	Tenure Track
White	Creativity	14	Tenure Track
African American	Meta-cognition	10	Adjunct Faculty
African American	HS, Self Efficacy, Race	6	Post-Doctoral Fellowship
White	Student Learning	5	Community College Director
White	HS, Engineering	0	Tenure Track

As reflected in the range of productivity scores, some fellows structured their scholarly activity in ways that maximized perceptions on productivity. A closer examination of the publications, especially those who had an exceptionally high number, revealed that some were very short (1–2 pages) essays or articles, theme papers that were divided into multiple publications, and some were in non-peer-reviewed venues. However, it is important to also note that perhaps some of these fellows were not consistent with making the full spectrum of their scholarly activity publically available through the NTEEP website.

Overall, fellows did not definitely know, nor could they prove or disprove, the role of biases in the decision compared to the role of their demonstrated competencies. They were left with lingering suspicions and attributional ambiguity that race mattered in the decision or evaluation (Crocker, Voekl, Testa, & Major, 1991; Niemann, 2003, 2012).

- "Racism is still an issue, but I don't know if it affected my job search. Race matters in society but not for me personally."
- "I don't know if race/gender matter, but I've been in much more diverse universities. Experience plays a more important role than gender. I don't know about race."
- "I don't think race mattered; some of the adjuncts are Asian and African American, but all my colleagues [tenure-track professors] are male, so gender might matter."

Faculty members had varying theories about the job acquisition outcomes. Some speculated that African American males and females across race or ethnicity, due to their paucity in the field, may have a higher bar than White peers to prove their qualifications and fit for an academic position. They conjectured that African American students might have to go out of their way to demonstrate their good personality, "team player" attitudes, and collegiality before they could get an interview. Tacit in their comments was the idea that these attributes may be taken for granted for White males but unknown or questioned about students of color. Other faculty members speculated that African American fellows might have to apply for more positions than their White male colleagues to have a chance for an interview. They would then need to engage in more interviews than their White male colleagues to eventually be perceived as a good fit for the hiring department.

- "Being minority in the field is not a barrier as long as they're productive and visible at national conferences and writing. They'll be okay."
- "Being Black was a factor for those who didn't get jobs; they were just as qualified and motivated as those who did get jobs. The field is White-male dominated with people who are only comfortable around people who look and think like them."
- "Race plays no role; people don't care about background. In fact, people might look more kindly upon Blacks/Hispanics/women due to lack of their groups in the field."
- "Students were given all the skills they need to get a job; and it's up to them to put those skills to use. If they don't get a job it's because of their lack of skill and/or motivation, and not about bias in the workplace."

Fellows were also asked to indicate what, if any, role they believe gender played in this process. Again, responses reflected the complexity of the question and subjective perceptions.

- "I don't believe that race has any impact on the work environment, though gender might matter because all of my colleagues are male and the department has been talking about the need to hire females to be role models."
- "Snide comments are made. It's a systemic issue. It's a very political culture."
- "I think my experience played more of a role than being male (in getting a job). I was told I was a very good fit for the job."

Other fellows noticed *microaggressions* in the workplace and program. "Racial microaggressions are the brief and commonplace daily verbal, behavioral, and environmental indignities, whether intentional or unintentional, that communicate hostile, derogatory, or negative racial, gender, sexual-orientation, and religious slights and insults to the target person or group" (Sue et al., 2007, p. 273). For instance, one program faculty member reportedly told students, "We're supposed to address gender, so for this project, the motorcycle will be pink." Faculty members were disturbed but not necessarily surprised by the occurrence of insensitive remarks.

- "The pink motorcycle comment doesn't surprise me, because it's a group [the Faculty] that hasn't thought much about race or gender."

- “I’m disgusted by the pink motorcycle comment. It makes me sick that they said that.”

Recommendations for Practice

When it comes to entry into the academic job market for faculty of color, race matters (Law, Phillips & Turney, 2004; Rai & Critzer, 2000; Stanley, 2006; Turner & Myers, 2000). Although the numbers of White women and people of color in the field are growing, they are still entering a White-male-dominated field. As such, even the most well regarded programs can be unprepared to address the challenges of students from underrepresented groups. The perceptions and suspicions of some program students and faculty cannot disregard the student demographics, especially in a field dominated by White male faculty. In many ways, perception is reality (Bem, 1972). Superficial attention to and silences about matters of race or ethnicity and gender are inconsistent with recommendations from research literature (Tochluk, 2010). For example, in a study on tokenism, researchers found that the perceptions of the field can influence perceptions of climate (King et al., 2009). When students make comments such as “I didn’t want to have the burden or responsibility of speaking for all females” or “snide comments are made. It’s a systemic issue,” it is an indicator about the need to change.

For the field of technology and engineering education, and even generally for STEM fields, to be accessible to members of historically underrepresented groups, graduate education will benefit from restructuring professional development curricula and programming (Austin, 2010) to include meaningful mentoring with anticipatory socialization that will better prepare persons entering a White-male-dominated field by helping them navigate the politics of racism and sexism (Heilman, Block & Stathatos, 1997; Stanley, 2006; Sue, 2010; Vargas, 2002).

NTEEP faculty, however well intentioned, may not have understood the unique preparatory needs of White women or of men and women of color. The proactive engagement of faculty with these topics can instill confidence in students and, if done knowledgeably, can prepare students to engage environments in which they will have solo or token status. Mentoring and professional development may be especially critical to persons who are underrepresented within a field. As visible minorities in their field, they need confidence that they will fit and be respected and welcomed in these environments. Such comments, when spoken by a faculty member, can impact the climate and feelings of belonging in the field. Specific recommendations for practice include the following.

First, discuss the possibility of experiencing the collective psychological effects of tokenism, including how to navigate the situation. Students need to know that tokenized situations exist in the workplace and that consequences are a function of the context not their competence. Faculty need to rankly discuss issues of racial and gender biases in the field. For instance, faculty might discuss conscious and unconscious biases in the field that may impact the perception of students' fit for a position, which is oftentimes synonymous with hiring committees preferring candidates with similar ethnic, racial, cultural, and gender backgrounds (Heilman, Block, & Stathatos, 1997; Rai & Critzer, 2000; Niemann, 2012; Sue, 2010; Vargas, 2002).

Second, faculty should seek to develop trusting relationships that can diffuse issues of attributional ambiguity. Not knowing whether feedback is genuine or is related to prejudice makes it difficult to gauge one's skills and abilities and what actions one needs to take to improve. It can stop professional development, halt career trajectories, and undermine self-confidence (Crocker et al., 1989; Niemann & Dovidio, 1998; Niemann, 2011). Knowing can help diffuse the impact of conscious and unconscious bias and stereotypical beliefs (Steele, 1997, 2010).

Third, address stereotype threat, which is defined as the fear of proving true the stereotype about one's group (Steele, 1997, 2010). Strategies that can diffuse this identity threat include becoming "alert to how the features of a setting affect people and change them so that they don't disadvantage certain groups" (Steele, 2010, p. 183–184) and helping people understand the safety that they do have in a given setting (Steele, 2010).

Fourth, prepare students for the possibility that they will experience daily microaggressions based on their race or gender. Such discussions may facilitate anticipatory socialization, which refers to the ways that student's academic and career aspirations can be influenced by institutional policies and practices (Hurtado, Newman, Tran, & Chang, 2010). Such socialization may also anticipate best interview strategies and presentation of qualifications of members of historically underrepresented groups in the field, thereby increasing the likelihood of success in the job acquisition process.

Conclusion

The job acquisition outcomes for the African American candidates was not inevitable. To be sure, responsibility for ensuring equitable opportunity during the job acquisition process is to be shared amongst program faculty, hiring faculty, and the fellows themselves. Nevertheless, the case of NTEEP can be interpreted as a story of successful recruitment and retention of members of historically underrepresented groups within the technology and engineering education fields but as a failure of adequate professional development for graduates entering a White-male-dominated field. The findings and recommendations in this paper are consistent with those in the National Research Council (2013) report, *Research Universities and the Future of America: Ten Breakthrough Actions Vital to Our Nation's Prosperity and Security*. The report states that increasing the numbers of historically underrepresented groups in STEM fields is especially urgent for the United

States to remain globally competitive in the economic market. The future of STEM fields, including technology and engineering education, may depend upon the interest and success of persons who have been historically underrepresented in these fields (White, Altschuld, & Lee, 2006). Both may be facilitated by enhanced professional development within graduate programs. Graduate programming that includes professional development will benefit all students. Clear expectations and mission statements about the role of race or gender in the program may increase sensitivity and awareness.

In many ways, men and women of color may be canaries in the academic coal mine warning us of the toxic academic environment for members of historically underrepresented groups within the field (Torres & Guinier, 2003). We need to engage in meaningful, yet difficult, conversations and anticipatory socialization about the likelihood that White women and men and women of color may be working in White male-dominated academic contexts. As one faculty member stated, the African American fellows not getting permanent positions "is an indictment of [NTEEP]. In hindsight, we should have provided [professional development]. This could be a weakness of graduate preparation in other disciplines, as well." Conversations about tokenism, attributional ambiguity, and aversive racism can encourage trusting, mentoring relationships and prepare students to navigate the political and psychological consequences of tokenized academic contexts. When leaders consider the role that White male dominance has played, everyone, but especially those most vulnerable, can benefit.

References

Austin, A. E. (2010). Reform efforts in STEM doctoral education: Strengthening preparation for scholarly careers. In J. C. Smart (Ed.), *Higher Education: Handbook of Theory and Research* (Vol. 25, pp. 91–128). Dordrecht, the Netherlands: Springer. doi:10.1007/978-90-481-8598-6_3

Bem, D. J. (1972). Self-perception theory. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 6, pp. 1–62). New York, NY: Academic Press. doi:10.1016/S0065-2601(08)60024-6

Crisp, G., & Cruz, I. (2009). Mentoring college students: A critical review of the literature between 1990 and 2007. *Research in Higher Education, 50*(6), 525–545. doi:10.1007/s11162-009-9130-2

Crocker, J., Voelkl, K., Testa, M., & Major, B. (1991). Social stigma: The affective consequences of attributional ambiguity. *Journal of Personality and Social Psychology, 60*(2), 218–228. doi:10.1037/0022-3514.60.2.218

Crosby, J. R., King, M., & Savitsky, K. (2014). The minority spotlight effect. *Social Psychological and Personality Science, 5*(7), 743–750. doi:10.1177/1948550614527625

Gaertner, S. L., & Dovidio, J. F. (2014). *Reducing intergroup bias: The common ingroup identity model*. Philadelphia, PA: Psychology Press.

Gaffe, J. G., & Pruitt-Logan, A. S. (1998). Preparing college faculty. *New Directions for Higher Education, 1998*(101), 77–86. doi:10.1002/he.10107

Griffith, A. L. (2010). Persistence of women and minorities in STEM field majors: Is it the school that matters? *Economics of Education Review, 29*(6), 911–922. doi:10.1016/j.econedurev.2010.06.010

Hailey, C. E., Erekson, T., Becker, K., & Thomas, M. (2005). National center for engineering and technology education. *The Technology Teacher, 64*(5), 23–26. Retrieved from http://www.iteea.org/Publications/TTT/feb05.pdf

Heilman, M. E., Block, C. J., & Stathatos, P. (1997). The affirmative action stigma of incompetence: Effects of performance information ambiguity. *Academy of Management Journal, 40*(3), 603–625. doi:10.2307/257055

Hewstone, M., Cairns, E., Voci, A., Hamberger, J., & Niens, U. (2006). Intergroup contact, forgiveness, and experience of "The Troubles" in Northern Ireland. *Journal of Social Issues, 62*(1), 99–120. doi:10.1111/j.1540-4560.2006.00441.x

Hurtado, S., Newman, C. B., Tran, M. C., & Chang, M. J. (2010). Improving the rate of success for underrepresented racial minorities in STEM fields: Insights from a national project. *New Directions for Institutional Research, 2010*(148), 5–15. doi:10.1002/ir.357

Jones, J. M., Dovidio, J. F., & Vietze, D. L. (2013). *The psychology of diversity: beyond prejudice and racism*. Chichester, West Sussex, United Kingdom: Wiley-Blackwell.

Kanter, R. M. (1977a). *Men and women of the corporation*. New York, NY: Basic Books.

Kanter, R. M. (1977b). Some effects of proportions on group life: Skewed sex ratios and responses to token women. *American Journal of Sociology, 82*(5), 965–990.

King, E. B., Hebl, M. R., George, J. M., & Matusik, S. F. (2009). Understanding tokenism: Antecedents and consequences of a psychological climate of gender inequity. *Journal of Management, 36*(2), 482–510. doi:10.1177/0149206308328508

Law, I., Phillips, D., & Turney, L. (Eds.). (2004). *Institutional racism in higher education*. Stoke on Trent, Staffordshire, England: Trentham Books.

Litzler, E., Lange, S. E., & Brainard, S. G. (2005, June). Climate for graduate students in science and engineering departments. *Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition*. Retrieved from https://peer.asee.org/14279

MacLachlan, A. J. (2006). *Developing graduate students of color for the professoriate in science, technology, engineering, and mathematics (STEM)* (Research & Occasional Paper Series: CSHE.6.06). Retrieved from http://www.cshe.berkeley.edu/publications/developing-graduate-students-color-professoriate-science-technology-engineering-and-0

Malcom, L. E., & Dowd, A. C. (2012). The impact of undergraduate debt on the graduate school enrollment of STEM baccalaureates. *The Review of Higher Education, 35*(2), 265–305. doi:10.1353/rhe.2012.0007

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation* (2nd ed.). San Francisco, CA: Jossey-Bass.

National Research Council. (2013). *Research universities and the future of America: Ten breakthrough actions vital to our nation's prosperity and security*. Washington, DC: National Academies Press.

Niemann, Y. F. (2003). The psychology of tokenism: Psychosocial reality of faculty of color. In G. Bernal, J. E. Trimble, A. K. Burlew, & F. T. L. Leong (Eds.), *Handbook of racial and ethnic minority psychology* (pp. 100–188). Thousand Oaks, CA: Sage Publications.

Niemann, Y. F. (2011). Diffusing the impact of tokenism on faculty of color. In J. E. Miller, & J. E. Groccia (Eds.), *To improve the academy: Resources for faculty, instructional, and organizational development* (pp. 216–229). San Francisco, CA: Jossey-Bass.

Niemann, Y. F. (2012). Lessons from the experiences of women of color working in academia. In G. Gutiérrez y Muhs, Y. F. Niemann, C. González, & A. Harris, (Eds.), *Presumed incompetent: The intersections of race and class for women in academia* (pp. 446–500). Boulder, CO: University Press of Colorado.

Niemann, Y. F., & Dovidio, J. F. (1998). Relationship of solo status, academic rank, and perceived distinctiveness to job satisfaction of racial/ethnic minorities. *Journal of Applied Psychology, 83*(1), 55–71.

Poirier, J. M., Tanenbaum, C., Storey, C., Kirshstein, R., & Rodriguez, C. (2009). *The road to the STEM professoriate for underrepresented minorities: A review of the literature*. Washington, DC: American Institutes for Research. Retrieved from http://www.air.org/sites/default/files/downloads/report/AGEP_Lit_Review_10-26-09_0.pdf

Pollak, K. I., & Niemann, Y. F. (1998). Black and White tokens in academia: A difference of chronic versus acute distinctiveness. *Journal of Applied Social Psychology, 28*(11), 954–972. doi:10.1111/j.1559-1816.1998.tb01662.x

Rai, K. B., & Critzer, J. W. (2000). *Affirmative action and the university: Race, ethnicity and gender in higher education employment*. Lincoln, NB: University of Nebraska Press.

Savage, H. E., Karp, R. S., & Logue, R. (2004). Faculty mentorship at colleges and universities. *College Teaching, 52*(1), 21–24. doi:10.3200/CTCH.52.1.21-24

Schmitt, N., Oswald, F. L., Friede, A., Imus, A., & Merritt, S. (2008). Perceived fit with an academic environment: Attitudinal and behavioral outcomes. *Journal of Vocational Behavior, 72*(3), 317–335. doi:10.1016/j.jvb.2007.10.007

Sekaquaptewa, D. (2011). Discounting their own success: A case for the role of implicit stereotypic attribution bias in women's STEM outcomes. *Psychological Inquiry, 22*(4), 291–295.

Smith D. G. (2000). How to diversify the faculty. *Academe, 86*(5), 48–52. doi: 10.2307/40251921

Stanley, C. A. (Ed.). (2006). *Faculty of color: Teaching in predominantly White colleges and universities*. Boston, MA: Anker.

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist. 52*(6), 613–629. doi:10.1037/0003-066X.52.6.613

Steele, C. M. (2010). *Whistling Vivaldi: And other clues to how stereotypes affect us*. New York, NY: W. W. Norton & Company.

Stichman, A. J., Hassell, K. D., & Archbold, C. A. (2010). Strength in numbers? A test of Kanter's theory of tokenism. *Journal of Criminal Justice, 38*(4), 633–639. doi:10.1016/j.jcrimjus.2010.04.036

Sue, D. W. (2010). *Microaggressions in everyday life: Race, gender, and sexual orientation*. Hoboken, NJ: John Wiley & Sons.

Sue, D. W., Capodilupo, C. M., Torino, G. C., Bucceri, J. M., Holder, A. M. B., Nadal, K. L., & Esquilin, M. (2007). Racial microaggressions in everyday life: Implications for clinical practice. *American Psychologist, 62*(4), 271–286. doi:10.1037/0003-066X.62.4.271

Thompson, M., & Sekaquaptewa, D. (2002). When being different is detrimental: Solo status and the performance of women and racial minorities. *Analyses of Social Issues and Public Policy, 2*(1), 183–203. doi: 10.1111/j.1530-2415.2002.00037.x

Tochluk, S. (2010). *Witnessing whiteness: The need to talk about race and how to do it*. Plymouth, United Kingdom: Rowman &Littlefield Education.

Torchia, M., Calabrò, A., & Huse, M. (2011). Women directors on corporate boards: From tokenism to critical mass. *Journal of Business Ethics, 102*(2), 299–317. doi: 10.1007/s10551-011-0815-z

Torres, G., & Guinier, L. (2003). The miner's canary. *Yes! Magazine*, (24), 28–31.

Turner, C. S. V., & Myers, S. L., Jr. (2000). *Faculty of color in academe: Bittersweet success*. Boston, MA: Allyn and Bacon

Vargas, L. (Ed.). (2002). *Women faculty of color in the White classroom*. New York, NY: Peter Lang Publishing.

White, J. L., Altschuld, J. W., & Lee, Y-F. (2006). Persistence of interest in science, technology, engineering, and mathematics: A minority retention study. *Journal of Women and Minorities in Science and Engineering, 12*(1), 47–64. doi:10.1615/JWomenMinorScienEng.v12.i1.40

Yoder, J. D. (1994). Looking beyond numbers: The effects of gender status, job prestige, and occupational gender-typing on tokenism processes. *Social Psychology Quarterly, 57*(2), 150–159. doi:10.2307/2786708

Measuring the Influences That Affect Technological Literacy in Rhode Island High Schools

Abstract

This study sampled the current state of technological literacy in Rhode Island high schools using a new instrument, the Technological Literacy Assessment, which was developed for this study. Gender inequalities in technological literacy were discovered, and possible causes and solutions are presented. This study suggests possible next steps for technology teachers, teacher educators, curriculum developers, and policy makers to move technology education forward and lays the groundwork for further studies of technological literacy. The *Standards for Technological Literacy* (International Technology Education Association [ITEA], 2007) were used as the benchmarks measured in this study.

Keywords: Technological Literacy, Gender

Problem Statement

The lack of common assessment in the area of technology education has left a gap in our knowledge about the success of technology programs in their aim to meet the benchmarks set by the *Standards for Technological Literacy* (ITEA, 2007). It would be helpful for teachers, curriculum makers, policy makers, and teacher preparation institutions to know the level of technological proficiency that their students are attaining. If there are gender or other biases in the curriculum, then curriculum changes, instructional strategies, or other interventions may be necessary to fix such problems. An instrument designed to measure technological literacy might be used to measure the success of new or existing technology curriculums at increasing technological literacy.

Significance

Since the evolution of technology education as a content area around 1985, technology teachers have been working to produce technologically literate students through hands-on problem-based activities (Foster, 1994, 1997; Sanders, 2001). The *Standards for Technological Literacy* define the content for the study of technology. The Rhode Island Department of Education has adopted their own frameworks for the study of technology, which are based on the standards (Rhode Island Department of Education [RIDE], 2011). Technology education programs should be structured and implemented to best serve the general population of students in American high schools while raising their technological knowledge (ITEA, 2007).

Michael Walach (Michael.Walach@eku.edu) is Assistant Professor in Applied Engineering and Technology at Eastern Kentucky University.

Purpose

The goal of this study was to answer the following questions about Rhode Island public high school students (14–18 years old).

1. Are there statistically significant group differences using a measure of technological literacy based on gender, race, or socio-economic status?
2. What factors are common among the highest scoring technologically literate students?
3. What common factors exist among students who struggle to achieve technological literacy?

Literature Review

Technological Literacy in the United States

This literature review will examine the implementation of the *Standards for Technological Literacy* (STL), and the state of technological literacy in the United States since the introduction of these standards. Gender differences were the most significant finding in this study, therefore, evidence of a possible gender divide in technological literacy will then be explored.

As the complexity of our technological world increases, technology curriculum will need to be structured in such a way as to facilitate lifelong learners and problem solvers (ITEA, 2007). The STL define what a technologically literate students should know and be able to do.

The STL, which were originally published in 2000, were the product of the Technology for All Americans Project (TFAAP), which was funded by the National Science Foundation (NSF), International Technology Education Association (ITEA), and the National Aeronautics and Space Administration (NASA). The focus for the TFAAP came from concern that the United States has become dependent on technology; however, many people have little understanding of how most of such technology actually works (ITEA, 2007). The goal of the STL and the TFAAP was to make sure that all Americans would become technologically literate (ITEA, 2007). The authors of the STL believe that technology education teachers are the ones to lead the way; however, they believe that technological literacy can be taught in any subject area (ITEA, 2007). The STL document does not spell out a specific curriculum to be taught or how subject matter should be taught. It is intentionally vague so that curriculum makers and other professionals can adapt the standards as they see fit. ITEA's release of standards set in motion a call for systematic change in the instruction of technology, with the goal of a paradigm shift from the trade and skill training era of manual arts at the turn of the 20th century and the tools, materials, and processes era of industrial arts through the 1950s until the mid-1980s.

A Gallup poll measuring the public's understanding of technology was conducted in 2001 just after the release of the STL (L. C. Rose & Dugger, 2002) and repeated again in 2003 (L. C. Rose, Gallup, Dugger, & Starkweather, 2004). The three most important findings from these polls remained unchanged:

- Almost all participants felt technological literacy was an important goal for all Americans.
- Americans view technology narrowly, thinking mostly of computers and the internet.
- Most Americans agree that technology should be part of the public school curriculum.

In 2001, two thirds of the people polled considered themselves able to use and understand technology. Seventy-five percent of the public reported that they wanted to know more about technology and how it works. Only 24% stated that they did not care how technology works, as long as it works. Most people surveyed (92%) thought that schools should increase technological literacy and (97%) that technological literacy should be included in the curriculum. Half of the participants thought that technology should be a required subject in high school, and 61% thought that technological literacy should be a high school graduation requirement. L. C. Rose, Gallup, Dugger, and Starkweather (2004) found that 98% of people surveyed viewed technological literacy as important, with 38% stating that it is very important and 48% somewhat important. People reported that they wanted to know about how technology (that directly affects them) works. Technology and engineering were seen as the same thing by more than half of the respondents. Younger people felt more prepared to use technology (90% of 18-29 years olds), whereas only about half of the older respondents (57% of 50+ years) felt the same way.

The inclusion of the *Standards for Technological Literacy* in state frameworks has increased over the last 10–14 years (Dugger, 2007; Moye, Dugger, & Starkweather, 2012; Newberry, 2001). Moye, Dugger, and Starkweather (2012) found that 93% of US states (out of the 42 that responded to the survey) included technology education in their state frameworks. Dugger (2007) found that only 87% of states included technology education in their frameworks, and Newberry (2001) found a mere 76% of states included technology education in their state frameworks. These studies show that there has been a positive trend to include the STL in state frameworks; however, the implementation from state to state varies.

Newberry (2001) examined technology education across the United States and found a fair amount a variation in the requirements for technology. Technology education was a requirement in Massachusetts and Tennessee for Grades 5–8 and in Colorado for Grades 7–9. In Maryland, one technology credit was required for graduation. In Virginia and West Virginia, there was a requirement for graduation that technology education could (but wasn't required) to fulfill. In Texas and Nevada, technology was encouraged in Grades 6-8; however, technology was required in Nevada by 8th grade. In Rhode Island, technology education was required in the high schools by the Rhode Island Department of Education's Basic Education Program, but it was up to each district to decide if it would be a graduation requirement (Rhode Island Board of Regent for Elementary and Secondary Education, 2009). At the elementary school level, 50% of states offered some form of technology education (Moye et al., 2012), although only one school in Rhode Island, the Henry Barnard School, offered technology education as a separate course in the elementary grades.

The National Academy of Engineering and the National Research Council (2006) examined approaches to assessing technological literacy. Some of the key recommendations that they made were: that the National Assessment Governing Board should authorize studies of technological literacy, that the U.S. Department of Education should encourage the Trend in Mathematics and Science Study to include technological literacy, that the National Science Foundation should fund small studies of technological literacy, and that preservice and in-service teachers should be tested on technological literacy. The National Assessment of Academic Progress measured technological literacy in 2014, but, as of this publication, the results have still not been released National Assessment Governing Board. (2013).

Technological Literacy Gender Divide

In a second Gallup poll about "how Americans think about technology," L. C. Rose et al. (2004) found that in most areas, men were more interested in fixing, assessing, or analyzing technology than women. Fixing a light switch or household product, diagnosing technology, determining whether to fix or throw away broken technology, and programming a VCR were all more important to men than women. When asked a question about the risk of electrocution from dropping a cordless phone in the bath tub, 37% of men answered correctly to only 24% of women. Men were more interested in the construction of homes, robotics, and programming a VCR. Women, however, were more interested in plant modification and the food supply (29% women vs. 24% men) and space exploration (39% vs. 35%), and more women answered a question correctly about the use of antibiotics and viruses than men (38% women vs. 32% men).

The Deficiencies in the Literature

The Gallup poll research shows that the American public supports technology education and views technological literacy as important (L. C. Rose & Dugger, 2002; L. C. Rose et al., 2004). However, very little research in measuring technological literacy has been done. Research conducted shortly after the standards were released (Sanders, 2001; Russell, 2005) has found that some technology teachers either believe that traditional industrial arts curriculum is just as valuable as technology education or that the *Standards for Technological Literacy* can be met with traditional methods. However, there has been very little data collected to directly measure technological literacy. In New

England, for instance, only one of six states, Massachusetts, is assessing technological literacy on its state assessment (Massachusetts Department of Elementary and Secondary Education, 2009).

Rhode Island has only relatively recently adopted a technology framework, the Engineering and Technology Grade Span Expectations (RIDE, 2011). It is unclear at this time what impact if any this framework will have. Many of the studies presented here (Akmal, 2002; Daugherty, 2005; Dugger, 2007; Gray & Daugherty, 2004; Hill, 2006; Lewis, 1999, 2004; Moye et al., 2012; National Academy of Engineering & National Research Council, 2006; Newberry, 2001; Rogers, 2005; Rogers & Rogers, 2005; L. C. Rose & Dugger, 2002, L. C. Rose et al., 2004; M. A. Rose, 2007; Sanders, 2001; Schmitt & Pelley, 1966; Williams, 2000) only collected self-reported survey data about classroom practice or methods or conducted limited interviews with teachers or other experts. Very little research has been done with K-12 student populations, and even less research has been done on actual measures of technological literacy.

In order to understand the complexities and the factors that lead to technological literacy or possible differences among at risk populations, a measure of technological literacy and an analysis of the students tested is necessary. By understanding what factors help promote technological literacy or determining where biases exist, technology teachers can better plan lessons, and develop more effective curriculum. Teacher preparation programs can put courses in place that better prepare teachers for the technology education classroom.

The purpose of this study was to measure technological literacy and try to uncover what might influence a person's level of technological literacy. The literature review presented in this paper has demonstrated that technological literacy is the end goal of technology education. Therefore, rather than examining classroom practice, curriculum, or school environment, the focus of this study was on student outcomes. By uncovering what leads a student to technological proficiency, more effective programs, curricula, and technology lessons can then be developed. Some of the research (L. C. Rose et al., 2004; Weber & Custer, 2005) presented in this paper has shown that females are underrepresented in technology classrooms, so they have been compared to their male counterparts in this study to see if there is a difference in their level of technological literacy.

Method

Participants

Rhode Island high school students (ages 14–18 years) were selected for this study because they have had more opportunities for instruction in technology than students in the lower grades, and therefore have had the most time to develop technological literacy. There are 37 school districts in the State of

Rhode Island, and all district superintendents were contacted and access was requested. There was a strong resistance by superintendents to subject students to more testing and remove students from instruction for the purpose of testing, and at least one district did not allow outside researchers into the schools. Only four of the 37 districts granted access, so the sample is not representative of the state, and the reader should keep such limitations in mind. One urban, two suburban, and one rural school district participated. Random sampling was requested at each site, but building principals refused the researcher's request. Existing classrooms were the only option, and technology classes were the preference of the researcher because these classes would have students that had been exposed to technology courses. In one school (a suburban school), the technology classes were not available for study, but a science class was. Although the researcher can't be certain that the science students had technology in high school, it should be noted that technology education is a requirement in all Rhode Island schools (Rhode Island Board of Regent for Elementary and Secondary Education, 2009) and all Rhode Island students in this particular district are exposed to at least one technology course in middle school. In Rhode Island high schools, students have the option to take technology education as an elective. No student records were allowed (per individual school policies) to be accessed by the researcher; therefore, no history of number of technology classes, grade point average, or other background information was available for comparison or analysis.

Once permission had been granted to test student's at all four schools, Institutional Review Board approval was applied for and granted. Informed consent forms were given to the cooperating teachers at each test site for distribution to all participants. Student participants were given a written explanation of their rights and privacy approved by the University of Rhode Island Institutional Review Board. Students and their parent or legal guardian were required to provide written consent. The researcher retained written consent from all 90 participants and their legal guardians.

Instrument

A new instrument, the Technology Literacy Assessment (TLA) was designed by the researcher for this study. The TLA is a multiple-choice test containing questions about topics contained in the STL.

A panel of nine technology education teachers who are also members of the Rhode Island Technology and Engineering Education Association served as a review team to critique and edit the assessment. Curriculum experts from the Boston Museum of Science Teacher Resource Center also reviewed the assessment. Only questions that the entire group agreed upon were included in the study. A matrix was generated to align each question with the standard it was intended to measure. The final document was sent to the entire review team for a final review and was determined by the team to be a fair assessment of technological literacy.

The assessment measured Standards 8, 9, 10, 14, 15, 16, 17, 18, 19, and 20. These standards represent design and the designed world (ITEA, 2007). The instrument did not assess the nature of technology, technology in society, or abilities for a technological world. A test instrument to measure all the standards would have been much longer. There was concern by the researcher that students would have been less likely to volunteer to take a longer assessment. Therefore, it should be noted that not all standards in the STL were assessed, and any conclusions drawn from these data should reflect such limitations.

Internal Test Validity

A small sample (n = 25) of students from the target population were interviewed before the test questions were finalized. Each of the 25 students read approximately 10–15 questions, provided an answer choice, and explained why they picked the answer they chose. Each question was reviewed at least five times by separate students. Poor questions were reworded and reviewed again or removed. Good questions were determined using the following criteria: The student answered question correctly and knew the correct answer, or the student answered the question incorrectly and did not know the correct answer. Poor questions were determined using the following criteria: The student answered question correctly and did not know the correct answer, or student answered the question incorrectly and did know the correct answer. Students' understanding of each question was determined through their explanation of the answer that they chose. Students had to supply an answer before they saw the multiple-choice options then had a chance to refine their answer after they saw the options. They had to explain their answer choses. Only questions that were determined "good" by five reviewers were used. If a question failed to meet that criterion, the question was rejected or rewritten and retested.

Sample Questions from the Technological Literacy Assessment (TLA)

Which of the following communication systems has both a transmitter and a receiver?

a) cell phone
b) television
c) radio
d) newspaper

A manufacturer has developed new shoe treads. These treads are designed for runners. The manufacturer has produced several prototypes. Which of the following is the next step in the engineering design process?

a) testing and evaluating the shoe tread prototypes
b) marketing the new shoes

c) redesigning the shoe treads on the prototype shoes
d) developing new shoe treads

An engineer is designing a new toy boat and has machined her boat on a CNC machine using machinable wax. The actual toy boat will be made from plastic. The wax model is an example of a ________________________?
a) prototype
b) design brief
c) isometric
d) static

Test Software

Software for delivering the test as well as scoring and collating data was created by this researcher for this study. The testing software presented the text for each question as well as a picture if appropriate. A drop-down menu with answer choices was located under each question (see Figure 1). The test software was located on a USB drive. Students had to enter in a unique username and pin to access the test.

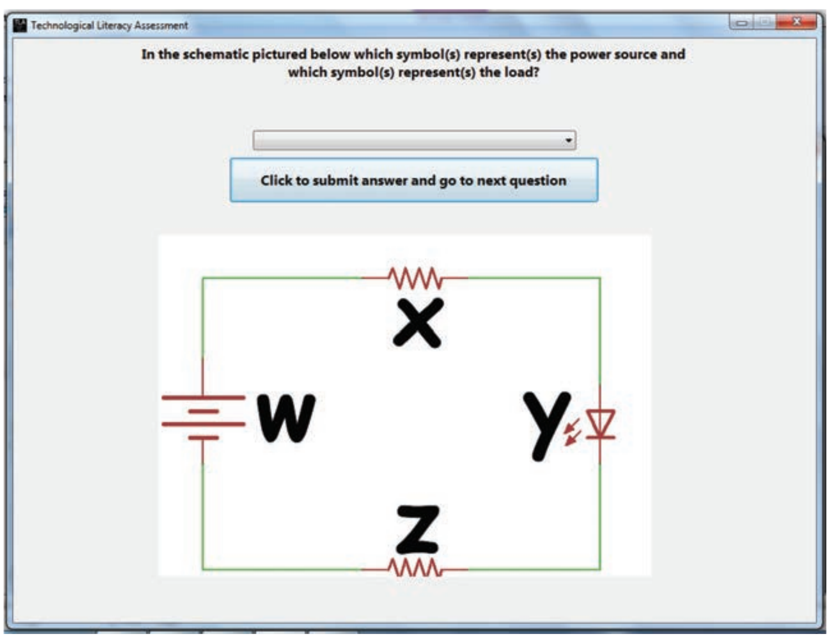


Figure 1. TLA Screen shot.

Data Analysis

Student data from all TLA participants (*n* = 90) were analyzed using SPSS statistical analysis software. All participants were Rhode Island public high school students (14–18 years old).

Gender

An analysis of variance (ANOVA) was used to compare the mean scores of students using score as the dependent variable and gender as the factor (see Table 1).

Table 1
TLA ANOVA by Gender

	Male (*n* = 49)		Female (*n* = 41)		F	*p*
	M	*SD*	*M*	*SD*		
TLA Raw Score	60.3782	13.76619	50.6246	13.30025	11.555	.001

The male students had a mean score of 60.38, and the female students had a mean score of 50.62. The standard deviation for both males and females was approximately 13 points. The mean score difference between male and female students is statistically significant at the 0.001 level.

Minority vs. Nonminority

Because of the small number of minorities represented in this sample, an analysis of variance was run grouping all minority students (non-White) into one variable and all whites into another. An ANOVA was used to compare the mean score of minority verses nonminority students (see Table 2).

Table 2
TLA ANOVA by Minority vs. Nonminority

	Non-minority (*n* = 79)		Minority (*n* = 11)		F	*p*
	M	*SD*	*M*	*SD*		
TLA Raw Score	56.8385	14.15876	49.4455	14.59914	2.614	.110

The nonminority group scored slightly higher (56.84) than the minority group (49.45); however, the differences were not statistically significant. It should be noted that minority students only made up 11 of the 90 students in the sample.

Socioeconomic Status

Next, an ANOVA was run using score as the dependent variable and socioeconomic status as a factor (see Table 3). SES was determined as low if a student reported that they qualify for free or reduced-price lunch and high if they did not qualify.

Table 3

TLA ANOVA by SES

	Low SES (*n* = 14)		High SES (*n* = 76)		*F*	*p*
	M	*SD*	*M*	*SD*		
TLA Raw Score	57.4921	15.23940	55.6480	14.25318	.194	.661

Although the low SES group had a slightly higher mean score, the differences were not statistically significant. It should also be noted that SES status was determined by students' self-reporting of free and reduced-price lunch qualification. It is possible students could have been embarrassed to answer truthfully or may not have known whether they qualified or not.

Father's Education

Next, an ANOVA was run using score as a dependent variable and father's education as a factor (see Table 4). The student's father's education level was reported by the student on the TLA. The students were asked, "What is the highest level of education your father/male guardian has completed?" Students had the option of selecting "no father/male guardian." Because none of the students tested selected that as an option, it is not listed in the data analysis.

Table 4

TLA ANOVA by Father's Education

Father's Education	*n*	*M*	*SD*
Did not graduate HS	7	49.1286	19.27673
HS diploma	25	59.7084	14.29359
Trade/tech. training	7	47.0386	6.40885
Military	4	58.5375	9.34014
Associate degree	7	56.4457	11.90232
Bachelor degree	24	54.6742	15.11948
Masters	11	57.4264	13.68225
PhD/MD/Law	5	59.0240	18.03745
F = .951		***p* = .473**	

The lowest scoring group were students whose fathers had technical or trade training. The mean score of students whose fathers had only a high school diploma were almost identical to the mean score of those whose fathers had a PhD, MD, or law degree. However, there were no statistically significant differences in a student's technological proficiency based on his or her father's education.

Father's education by larger subgroups. A second analysis of variance was run on father's education by creating three larger subgroups (see Table 5). Group one consisted of students whose fathers had a high school diploma or less. Group two was comprised of students whose fathers had some undergraduate college, trade, military, or other training. Group three consisted of students whose fathers had a master's degree or higher.

Table 5
TLA ANOVA by Father's Education with Larger Subgroups

Father's Education	*n*	*M*	*SD*
High school or less	32	57.3941	15.80633
Some college	42	54.0648	13.15026
Masters or higher	16	57.9256	14.56528
F = .672		***p* = .513**	

There was little difference in the significance of mean score differences based on father's education by creating larger subgroups. The significance level was weaker with an increase from 0.473 to 0.513 with the larger subgroups.

Mother's Education

The next analysis was an ANOVA using score as a dependent variable and the students' mothers' education as a factor (see Table 6). The student's mother's education level was reported by the student on the TLA. The students were asked "What is the highest level of education your mother/female guardian has completed?" Students had the option of selecting "no mother/female guardian." Because none of the students tested selected that as an option, it is not listed in the data analysis.

Table 6
TLA ANOVA by Mother's Education

Mother's Education	***n***	***M***	***SD***
Did not graduate HS	3	49.5933	9.86114
HS diploma	26	54.7846	14.17647
Trade/tech. training	6	54.0650	19.72018
Associate degree	7	54.3557	16.28347
Bachelor degree	31	58.3787	14.68618
Masters	12	52.4392	13.57922
PhD/MD/Law	5	63.4140	7.71121
F = .637		***p* = .701**	

There was a slight increase in score as the mother's education increases, with the exception of a slight dip for the master's category. However, the differences in mean score between students based on their mothers' education were not statistically significant.

Mother's education by larger subgroups. A second analysis of variance was run on mother's education by creating three larger subgroups (see Table 7). Group one consisted of students whose mothers had a high school diploma or less. Group two was comprised of students whose mothers had some undergraduate college, trade, military, or other training. Group three consisted of students whose mothers had a master's degree or higher.

Table 7
TLA ANOVA by Mother's Education with Larger Subgroups

Mother's Education	***n***	***M***	***SD***
High School or Less	29	54.25	13.75
Some College	44	57.15	15.37
Masters or Higher	17	55.67	12.97
F = .357		***p* = .701**	

The second analysis of student score based on mother's education using larger subgroups made no statistical difference compared to many subgroups. The significance level was exactly the same value of 0.701.

Parent Education Regression Analysis

A regression analysis was also run on student score and parent education (see Table 8). The findings, as with the ANOVA, were not statistically significant. Student score was the independent variable, and father's education and mother's education were the dependent variables. A linear regression analysis was run using the whole group, just the females, and just the males. In all cases, there was a negative correlation between father's education and student score and a positive correlation between mother's education and student score regardless of the gender of the student. None of the differences were statistically significant however.

Table 8
Parent Education Regression Analysis

Sample	Dependent Variables	t-value	*p*
Whole Sample	Father's education	-0.245	0.807
	Mother's education	0.627	0.534
Males only	Father's education	-0.473	0.642
	Mother's education	1.339	0.196
Females only	Father's education	-0.114	0.910
	Mother's education	0.873	0.390

Performance by Grade Level

The next analysis compared the freshman students to upperclassmen (see Table 9). Upperclassmen consisted of 10th, 11th, and 12th grade students (16–18 years olds), and freshmen were the 9th grade students (14 years old). At all schools in the test sample, all middle school students have equal exposure to technology education classes, but students have the option to take or not take technology courses at the high school level. The purpose of this analysis was to see if there was a drop in mean score as students progressed through high school.

Table 9
TLA ANOVA by Freshmen vs. Upperclassmen

Freshmen/Upperclassmen	*n*	*M*	*SD*
Freshmen	63	54.59	13.28
Upperclassmen	27	59.08	16.39
F = 1.872		***p*** = .175	

The mean score of upperclassmen was slightly higher than the freshman group, although the differences are not statistically significant. It should be noted that the researcher could not control for the amount of exposure to technology courses in the test subjects.

Standards Performance by Gender

The next analysis compares the mean scores of males and females based on each of the standards that were assessed in this study (see Tables 10 and 11). Students were measured on nine of the 20 standards in the STL.

Table 10
Mean Score by Standards

Standards	Gender	*n*	*M*	*SD*
STL 8 - Attributes of Design	Male	49	57.14	31.91
	Female	41	46.34	20.91
STL 9 - Engineering Design	Male	49	85.71	27.00
	Female	41	80.49	27.11
STL 14 - Medical	Male	49	66.34	35.92
	Female	41	63.41	35.40
STL 15 - Biotech	Male	49	63.27	31.36
	Female	41	57.72	31.64
STL 16 - Energy/Power	Male	49	58.93	20.73
	Female	41	49.09	16.86
STL 17 - Communication	Male	49	53.94	21.48
	Female	41	44.95	17.07
STL 18 - Transportation	Male	49	78.23	38.82
	Female	41	56.91	33.54
STL 19 - Manufacturing	Male	49	59.77	16.41
	Female	41	46.69	22.59
STL 20 - Construction	Male	49	61.63	23.39
	Female	41	54.15	23.77

Table 11
TLA ANOVA by Standards

Standard	F	*p*
STL 8 - Attributes of Design	3.45	.067
STL 9 - Engineering Design	.833	.364
STL 14 - Medical	.149	.701
STL 15 - Biotech	.691	.408
STL 16 - Energy/Power	5.948	.017
STL 17 - Communication	4.696	.033
STL 18 - Transportation	7.611	.007
STL 19 - Manufacturing	10.074	.002
STL 20 - Construction	2.253	.137

Males performed better than females in all areas; however, differences were not statistically significant for all areas. In attributes of design, power and energy, information and communication, transportation, and manufacturing, the males mean scores were statistically significantly higher than the females. The mean score for males on construction was strong but not significant with a significance value of 0.137. The group differences were much less significant in the areas of medical technology, agriculture and related biotechnology, and engineering design. The area with the weakest statistical significance was in medical technology. The researcher did not have access to data about the number of technology classes taken by students.

Childhood Toys

The purpose of these data was to inform technology teachers in the selection of activities that they choose to use with their students. Although smash and crash activities using cars, planes, and bridges might appeal to boys, they might not be as likely to engage the bulk of the female population.

Students were asked the open ended question "What types of toys did you play with as a child?" during the TLA. Students could type as much as they wanted, and several students listed multiple toys, games, and other interests. The student responses were coded using HyperResearch software, and a frequency report was generated. Table 12 shows the frequency of each activity as listed by the top 20 scoring students and the lowest 20 scoring students. The toy or activity most common among high scoring students was playing with toy cars and trucks, with building blocks or LEGOs™ coming in a close second. Sports and pretend play were the least reported activities among the top 20 scorers. The lowest scoring students reported playing with dolls or action figures more than any other toy or activity. Video games and board games came in third and fourth place. Sports and making music were the least reported activities among the lowest 20 scoring students. None of the students in the bottom 20 reported playing with toy cars and trucks. Most of the highest scoring students (17 out of 20) were males, and most of the lowest scoring students (13 out of 20) were females, which may account for the types of toys played with.

Table 12
Toys Played With by Top and Bottom Scorers

Top 20 scores STL (17 male 3 female)	Frequency	Bottom 20 Scores STL (7 male 13 female)	Frequency
Trucks/cars	8	Action figures/dolls	16
LEGOs™/blocks	7	Video games	5
Video games	5	Board games	4
Board games	4	Pretend play	2
Action figures/dolls	3	LEGOs™/blocks	2
Sports	2	Sports	1
Pretend play	1	Made music	1

Conclusions

Are there statistically significant group differences on a measure of technological literacy based on gender, race, or socio-economic status? In this study, these data suggest that gender is the largest factor in achieving technological literacy, and gender was the only statistically significant group difference. Male students who participated in the TLA had about a 10-point advantage over their female counterparts.

The gender bias found in this study is consistent with the bias seen in postsecondary degree choices by gender. Women are underrepresented in many technology careers (National Center for Education Statistics, 2010). Only 16% of the total degrees in engineering in 2008/2009 went to female graduates, with a mere 11% of females in the areas of mechanical and electrical engineering. In construction trades, mechanics, and other repair service careers, women only make up 10% of new graduates. In healthcare, however, the tables are turned, with males making up only 15% of the new workers while females make up 85%. As shown in the data analysis section, the female students in this study were more interested in medical technology and biotech activities than their male counterparts at statistically significant levels.

Although male students had higher mean scores than females in all areas, the areas with the smallest gaps were in medical technology, agricultural and related biotechnology, and engineering design. All but one of the schools visited in this study have a biotechnology program. This researcher was unable to find any other biotechnology programs or any public high school medical technology programs in the state.

What factors are common among the highest scoring technologically literate students? The students with the highest scores on the TLA (top 45) answered more questions about transportation and engineering design correctly than any other category. The students with the lowest scores on the TLA (bottom 45) answered more questions correctly about engineering and medical technology than any other category. In both groups, engineering was one of the strongest areas of technological literacy. Table 13 shows the average scores for students in the top 50% and bottom 50% as well as the average score for all test participants based on the standards measured.

Table 13
Highest Scoring Standards

Entire sample		Top 45 (33 male, 12 female)		Low 45 (16 male, 29 female)	
Standard measured	**Mean**	**Standard measured**	**Mean**	**Standard measured**	**Mean**
Engineering	83.33	Transportation	91.85	Engineering	76.67
Transportation	68.52	Engineering	90	Medical	56.67
Medical	65.00	Bio-tech	79.26	Construction	47.56
Bio-tech	60.74	Medical	73.33	Power & Energy	45.83
Construction	58.22	Construction	68.89	Transportation	45.19
Power & Energy	54.44	Design	66.67	Manufacturing	43.17
Manufacturing	53.81	Manufacturing	64.44	Bio-tech	42.22
Design	52.22	Power & Energy	63.06	Communication	38.73
Communication	49.84	Communication	60.95	Design	37.78

The education or occupation of the students' parents seemed to have no effect on student performance. When student scores were compared based on father's education level, the scores were not statistically significant (0.473 level), and the significance level was even weaker when comparing the education level of the students' mothers (0.701 level). Students in this sample who were of minority status (n = 11) and students of low SES (n = 14) did not perform at statistically significantly different levels than their nonminority or high SES counterparts. The regression analysis that compared parent education to student achievement did not yield statistically significant results; however, the strength of the mothers education on males' scores (0.196) may be worth further study with a larger test sample.

What common factors exist among students who struggle to achieve technological literacy? The lowest scoring students answered more questions correctly about engineering design and medical technology than questions on any other standards measured on the TLA. Engineering design is an area of strength among both low and high scoring students. It may be possible to try using engineering design as the vehicle in which to teach all other areas of technology. Table 14 shows the mean scores for males and females on questions related to the Engineering and Design standards that were assessed on the TLA.

Table 14
Mean Score for Engineering Design by Gender

Male	Female	*p*
85.71	80.48	0.364

Note. While the males scored about 5 points higher than the females, the difference was not statistically significant.

Rather than designing activities that involve testing the strength of components by testing projects to the failure point, teachers might consider activities that encourage students to design solutions to problems that help society. Having a finished product that is used for a real purpose may be more appealing to both male and female students.

The gaps in performance measured in this study were smallest in the areas of medical technology and biotechnology, and yet this is one of the most ignored areas of the technology standards. Table 15 shows that the weakest statistical differences in score based on content standards were 0.701 in medical technology and 0.408 in biotechnology. Engineering design also had a weak significant level of 0.364. Perhaps medical technology, biotechnology, and engineering are more gender friendly technology areas; however, further study would have to be conducted.

Table 15
Medical Technology and Biotechnology Mean Scores

Standard	F	*p*
Medical	.149	.701
Bio-tech	.691	.408

Recommendations

Data examined in this study suggest that gender bias exists and is impeding the development of technological literacy among female students. There is some indication, however, that medical technology and biotechnology may be avenues to engage and excite female students. The findings in this study suggest that female students might be more inclined to take technology courses if they focused on these two areas. In order to prepare technology teachers to teach courses in medical technology and biotechnology, colleges that train technology teachers will have to develop courses in these two areas. Technology teachers currently in the public schools will need to reach out to their colleagues in science and math and draw on the resources and expertise of their school nurses. There are peer reviewed, research-based curriculums in existence for medical technology (Daugherty & Custer, 2006b) and biotechnology (Daugherty & Custer, 2006a) in ITEEA's Engineering by Design curriculum. Engineering by Design (EbD) curriculum guides provide day-by-day projects, activities, and discussion topics as well as material lists for the projects in the guide. There are

EbD guides for courses covering all of the content standards measured in this study, including construction, manufacturing, information and communication, transportation, and power and energy.

Although it is the recommendation of this researcher to develop and establish more medical technology and biotechnology programs that are likely to interest both male and female students, it is equally important to address the issue of female underrepresentation and performance in the other areas of technology. Data uncovered in this study suggest that technology teachers need to not only recognize the biases they have in their classrooms and activities but need to make strides to create activities that are appealing to both genders. Using engineering design as a vehicle for instructing the content of transportation, manufacturing, and construction may help make these areas more interesting to female students. Design problems, however, should focus more on problems that affect people and society rather than on hardware and machines. Instead of students making the fastest Co^2 powered car, they could design a car seat for a driver who is wheelchair bound or a prosthetic limb for a person or wounded animal. Rather than building sheds in a construction class, students could design a home that is environmentally friendly or makes use of ergonomic design. In the area of robotics, students often build robots that can compete in a completion; an alternative may involve using automation technology to grow and harvest produce in a hydroponics system.

Areas for Further Research

More testing in a variety of settings should be conducted to see if the results here can be reproduced. The sample size in this study was small, (n = 90) and minority (n = 11) and low SES (n = 14) subgroups were also small. This study only measured standards 8, 9, and 14–20. A much larger assessment that measures all 20 content standards may provide even more insight.

Case studies of classrooms that implement the recommendations of this study could provide more data as to the effectiveness of medical technology and biotechnology in attracting more female students. Are female students more engaged when activities are more social and involve helping people, animals, or society?

Why have medical technology and biotechnology become so ignored by technology teachers? Why are colleges not offering courses in medical technology or biotechnology to their students? A survey of technology teachers and technology teacher preparation programs could analyze the roots of this lack of support for such an area of need.

This study was not designed to measure the impact technology courses have on affecting technological literacy. A new study that measures technological literacy while accounting for the number and type of technology courses the participants have taken could be helpful for developing more effective technology programs.

The field of technology education will continue to grow and change in ways that this researcher cannot predict. This study has uncovered some possible gender issues in technological literacy. Technology will continue to advance and become more and more a part of our lives, whether we wish it to or not. If female students are not graduating high school with the same understanding of technology that their male counterparts are, they are at risk of having difficulties advancing in an ever-increasing technological workplace creating a further gender divide in engineering and technology career fields. It is the responsibility of technology educators to stay current with technology, adapt, and constantly improve the ways in which they teach children about the technological world in which they live. Excellent technology education teachers will produce technologically literate citizens of every gender, race, and socioeconomic status who will be able to use, manage, assess, and understand technology.

References

Akmal, T., Oaks, M. M., & Barker, R. (2002). The status of technology education: A national report on the state of the profession. *Journal of Industrial Teacher Education, 39*(4), 6–25. Retrieved from http://scholar.lib.vt.edu/ejournals/JITE/v39n4/akmal.html

Daugherty, M. K. (2005). A changing role for technology teacher education. *Journal of Industrial Teacher Education*, *42*(1), 41–58. http://scholar.lib.vt.edu/ejournals/JITE/v42n1/daugherty.html

Daugherty, M. K., & Custer, R. (Eds.). (2006a). *Agriculture and related biotechnologies*. Reston, VA: International Technology Education Association, Center for the Advancement of Technology and Science.

Daugherty, M. K., & Custer, R. (Eds.). (2006b). Medical technologies. Reston, VA: International Technology Education Association, Center for the Advancement of Technology and Science.

Dugger, W. E., Jr. (2007). The status of technology education in the United States: A triennial report of the findings from the states. *The Technology Teacher, 67*(1), 14–21. Retrieved from http://www.iteea.org/Publications/TTT/sept07.pdf

Foster, P. N. (1994). Technology education: AKA industrial arts. *Journal of Technology Education*, *5*(2), 15–30. Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/v5n2/foster.jte-v5n2.html

Foster, P. N. (1997). Lessons from history: Industrial arts/technology education as a case. *Journal of Vocational and Technical Education*, *13*(2), 5–15. Retrieved from http://scholar.lib.vt.edu/ejournals/JVTE/v13n2/Foster.html

Gray, M., & Daugherty, M. (2004). Factors that influence students to enroll in technology education programs. *Journal of Technology Education*, *15*(2), 5–19. Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/v15n2/pdf/gray.pdf

Hill, R. B. (2006). New perspectives: Technology teacher education and engineering design. *Journal of Industrial Teacher Education*, *43*(3), 45–63. Retrieved from http://scholar.lib.vt.edu/ejournals/JITE/v43n3/pdf/hill.pdf

International Technology Education Association. (2007). *Standards for technological literacy: Content for the study of technology* (3rd ed.). Reston, VA: Author.

Lewis, T. (1999). Content or process as approaches to technology curriculum: Does it matter come Monday morning? *Journal of Technology Education*, *11*(1), 45–59. Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/v11n1/pdf/lewis.pdf

Lewis, T. (2004). A turn to engineering: The continuing struggle of technology education for legitimization as a school subject. *Journal of Technology Education*, *16*(1), 21–39. Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/v16n1/pdf/lewis.pdf

Massachusetts Department of Elementary and Secondary Education. (2009). *Release of spring 2009 MCAS test items.* Malden, MA: Author.

Moye, J. J., Dugger, W. E., Jr., & Starkweather, K. N. (2012). The status of technology and engineering education in the United States: A fourth report of the findings from the states (2011–12). *Technology and Engineering Teacher, 71*(8), 25–31. Retrieved from http://www.iteea.org/Publications/TTT/mayjun12.pdf

National Academy of Engineering & National Research Council. (2006). *Tech tally: Approaches to assessing technological literacy*. Washington, DC: National Academies Press.

National Assessment Governing Board. (2013). Technology and engineering literacy framework for the 2014 National Assessment of Educational Progress. Washington, DC: Author. Retrieved from https://www.nagb.org/content/nagb/assets/documents/publications/frameworks/technology/2014-technology-framework.pdf

National Center for Education Statistics. (2010). *Table 286. Bachelor's, master's, and doctor's degrees conferred by degree-granting institutions, by sex of student and discipline division: 2008–09*. Retrieved from http://nces.ed.gov/programs/digest/d10/tables/dt10_286.asp

Newberry, P. B. (2001). Technology education in the U.S.: A status report. *The Technology Teacher, 61*(1), 8–12. Retrieved from http://www.iteea.org/Publications/TTT/sept01.pdf

Rhode Island Board of Regent for Elementary and Secondary Education. (2009). *Basic Education Program Regulations*. Providence, RI: Author. Retrieved from http://www.ride.ri.gov/Portals/0/Uploads/Documents/Inside-RIDE/Legal/BEP.pdf

Rhode Island Department of Education. (2011). Rhode Island K–12 grade span expectations in engineering and technology. Providence, RI: Author. Retrieved from http://www.ride.ri.gov/Portals/0/Uploads/Documents/Instruction-and-

Assessment-World-Class-Standards/Science/E-T-GSEs-final.pdf
Rogers, G. E. (2005). Pre-engineering's place in technology education and its effect on technological literacy as perceived by technology education teachers. *Journal of Industrial Teacher Education*, *42*(3), 6–22. Retrieved from http://scholar.lib.vt.edu/ejournals/JITE/v42n3/pdf/grogers.pdf
Rogers, S., & Rogers, G. E. (2005). Technology education benefits from the inclusion of pre-engineering education. *Journal of Industrial Teacher Education*, *42*(3), 88–95. Retrieved from http://scholar.lib.vt.edu/ejournals/JITE/v42n3/pdf/srogers.pdf
Rose, L. C., & Dugger, W. E., Jr. (2002). ITEA/Gallup poll reveals what Americans think about technology: A report of the survey conducted by the Gallup Organization for the International Technology Education Association. *The Technology Teacher, 61*(6), 1–8 (Insert). Retrieved from http://www.iteaconnect.org/TAA/PDFs/Gallupreport.pdf
Rose, L. C., Gallup, A. M., Dugger, W. E., Jr., & Starkweather, K. N. (2004). The second installment of the ITEA/Gallup poll and what it reveals as to how Americans think about technology: A report of the second survey by the Gallup Organization for the International Technology Education Association. *The Technology Teacher, 64*(1), 1–12 (Insert). Retrieved from http://www.iteea.org/TAA/PDFs/GallupPoll2004.pdf
Rose, M. A. (2007). Perceptions of *technological literacy* among science, technology, engineering, and mathematics leaders. *Journal of Technology Education, 19*(1), 35–52. Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/v19n1/pdf/rose.pdf
Russell, J. F. (2005). Evidence related to awareness, adoption, and implementation of the standards for technological literacy: Content for the study of technology. *The Journal of Technology Studies, 31*(1), 30–38. Retrieved from http://scholar.lib.vt.edu/ejournals/JOTS/v31/v31n1/pdf/russell.pdf
Sanders, M. (2001). New paradigm or old wine? The status of technology education practice in the United States. *Journal of Technology Education, 12*(2), 35–55. Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/v12n2/pdf/sanders.pdf
Weber, K., & Custer, R. (2005). Gender-based preferences toward technology education content, activities, and instructional methods. *Journal of Technology Education, 16*(2), 55–71. Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/v16n2/pdf/weber.pdf
Williams, P. J. (2000). Design: The only methodology of technology? *Journal of Technology Education, 11*(2), 48–60. Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/v11n2/pdf/williams.pdf

Pearson–Praxis Assessments Review Teacher Certification Assessment Technology Education: A Report for the Council on Technology and Engineering Teacher Education

Objectives

1. Study and prepare a short report on Pearson and its implications for accreditation standards;
2. Disclose the primary areas of study topics for TE teachers; and
3. Describe the Pearson process and its relationship to Praxis.

Praxis

The Praxis Series, developed by Educational Testing Services (ETS), has been the long standing assessment for teacher licensure. It is comprised of three separate skills examinations:

- Praxis Core Academic Skills for Educators (Core)
    - Tests designed to measure academic skills in reading, writing, and mathematics.
    - Attempting to measure content knowledge of candidates entering teacher preparation programs.
- Praxis I Pre-Professional Skills Tests (PPST)
    - Tests measure basic skills in reading, writing, and mathematics.
    - Tests are often used to qualify candidates for entry into a teacher education program.
- Praxis II Subject Assessments
    - Tests measure subject-specific content knowledge, as well as general and subject-specific teaching skills, deemed necessary for beginning teaching. (Educational Testing Service [ETS], 2014a)

The Praxis Core and I Assessments attempt to measure educational skill sets deemed imperative to candidate teachers. They focus primarily on mathematical, reading, and writing skills. The Praxis II Subject Assessment is based on the content area specific to perspective teachers' chosen area of specialty. This assessment is usually taken toward the end of a candidate teachers' collegiate preparation. As of 2014, the Praxis II Subject Assessment for Technology Education (Praxis II) was provided in 29 states and U.S. territories (see Table 1; ETS, 2014b).

Mark P. Mahoney (Mark_Mahoney@berea.edu), is Associate Professor and Technology and Applied Design Chairperson at Berea College.

Table 1
Praxis II Subject Assessments

Technology Education—State List							
Alabama	Arkansas	Connecticut	Delaware	Hawaii	Idaho	Iowa	Kansas
Kentucky	Louisiana	Maine	Maryland	Mississippi	Missouri	Nebraska	Nevada
New Jersey	North Carolina	North Dakota	Oregon	Pennsylvania	Rhode Island	South Carolina	South Dakota
Tennessee	Utah	Virginia	West Virginia	Wisconsin			

Note. Adapted from Educational Testing Service (2014b).

The domains associated with the Praxis II assessments are standardized and replicated in all participating states. The domains are broken down into six areas (see Table 2). Within each of the six domains are a variety of subareas that are derived from the *Standards for Technological Literacy* (STL) from the International Technology and Engineering Education Association and the *National Educational Technology Standards for Teachers* (NETS-T) from the Society for Technology in Education. The product is a 120 question multiple-choice assessment that is administered over a 2 hour examination period. It is currently available in both paper and computer-based format and requires a test fee of $115 from the candidate teacher (ETS, 2014c).

Table 2
Praxis II: Technology Education Assessment Domains

Domains	Exam Percentage
• Technology and Society	15%
• Engineering or Technological Design and Problem Solving	20%
• Energy, Power, and Transportation	15%
• Information and Communication Technologies	15%
• Manufacturing and Construction Technologies	15%
• Pedagogical and Professional Studies	20%

Note. Adapted from *The Praxis Study Companion: Technology Education* (Educational Testing Service, 2014d).

Pearson

Since the early 2000s, Pearson Education began offering a series of updated teacher certification assessments. Pearson Education currently offers three categories of assessment tools for candidate teachers. These include the following:

- National Evaluation Series (NES)
    - Entry-level assessment that attempts to reflect contemporary teacher knowledge and skill sets
- Custom Programs (CP)
    - Assessments designed for specific content and reflect individual state needs
    - edTPA (formerly the Teacher Performance Assessment developed at Stanford University) Performance-based assessment protocols developed to evaluate candidate teachers level of classroom preparation
    - Still owned and authored by Stanford University. (Pearson Education, 2014a)

The NES is similar to the Praxis Core and I assessments in that all attempt to measure candidate teacher basic skill sets prior to entrance into an education preparatory program. On the other hand, edTPA is a performance-based assessment (in the form of a portfolio) developed for candidate teachers whom are close to the end of their formal education. It was developed by Stanford University faculty and staff at the Stanford Center for Assessment, Learning, and Equity (SCALE). Institutions can elect to utilize the Pearson ePortfolio system, or they may utilize their own portfolio requirements. In either case, candidates can have their documentation reviewed and scored by edTPA. If institutions were to opt for the Pearson ePortfolio (integrated) approach, the faculty would have access to the candidates portfolios and would be able to provide feedback (edTPA, 2015). Because edTPA is not a Pearson product, universities, programs, and individuals may self-submit their work for review and ranking through edTPA. The individual fee for a portfolio assessment is $300 (etTPA, 2015).

Historically, this type of assessment was performed by the supervising educational program and their assigned faculty, with the end product being that of a course grade and student teacher portfolio after the required number of teaching hours was achieved. This relatively new assessment intends to aid educational programs by providing candidate teachers with multiple-measure assessments that reflect state and national standards in addition to current teacher necessities. The hopeful products are capable and equipped classroom teachers prepared for the contemporary classroom (Pearson Education, 2014).

Lastly, the Pearson CP (henceforth, Pearson TE) addresses specific content areas as individual states require. Unlike the Praxis II assessment, the Pearson TE is not standardized. Each state develops domains from which the specific content assessment is drafted. The identified domains do suggest that national standards are reflected but also highlight specific areas that may or may not be of equal importance in other states or nationally. The Pearson TE variance is not only reflected in the domains of the assessment but also the formats and associated fees. Appendix A provides some evidence for the variance that is currently identified. Looking through the list, it is apparent that most states do possess similar domains (or topics within those domains). It also should be evident that some domains are exclusive to the state and reflect possible local educational objectives. As of today, 24 states are using Pearson Education assessment tools, 13 of which assess for technology education teacher certification (Pearson Education, 2014).

Comparison

Based upon this peripheral review, both the Pearson TE and the Praxis II – TE assessments share a majority of domains and topics with regard to assessment. The only discernable differences were presented in some of the state-specific domains on the individual Pearson TE assessments. Appendix B displays a frequency chart that depicts the occurrence of certain terms that were common in domain language. Thirteen terms were prevalent in both Praxis II and Pearson domains, appearing 30 times or more. The remaining accessory terms were associated with some of the variance in state-specific language and state-specific domains associated with the Pearson TE model.

The two assessment brands varied to a greater degree with regard to consistency. The Praxis II assessments were standardized and identical regardless of state or territory. They possessed the exact same number of items (120 multiple-choice questions), cost ($115), and were available in in both paper and computer-based formats. The Pearson TE currently offers both paper and computer-based formats like the Praxis II assessment. However, after reviewing several associated state websites, Pearson TE is transitioning to a fully computer-based format with online accessibility. The rationale for this transition is to improve transferability and communication of assessment scores between states. However, the Pearson TE assessment varies in format and cost (as depicted earlier in Table 1.2). Though most of the Pearson TE assessments share the basic constructs emulated within the STL and on the Praxis II assessments, the variance between states could present some difficulty when attempting to accredit various educational programs on a national scale or allow teachers to transfer to different states without having to retake local certification assessments.

It would also appear that the Praxis II assessment still retains the majority interest from states seeking teacher certification assessments for TE. Interestingly, after reviewing the current influence of the Pearson assessment system, there may be an upcoming shift in majority interest. As stated earlier, the Praxis II assessment is currently employed in 29 states, whereas the Pearson TE is only employed in the 13. Of the current 13 states, all had utilized the Praxis II prior to transitioning to the state specific version of the Pearson TE.

Additionally, there are currently 11 other states that are utilizing Pearson Education assessments for fields other than TE; seven of those states currently utilize the Praxis II (four do not currently possess a TE assessment under either Pearson or Praxis, see Figure 1). To further clarify the weight of this possible shift, a color-coded map of the United States was developed to better communicate the distribution of assessments (see Figure 2). All of the researched areas are represented on the map, with the exception of the District of Columbia, Guam, and the U.S. Virgin Islands (all of which fall under the "Neither" category with regard to TE assessment).

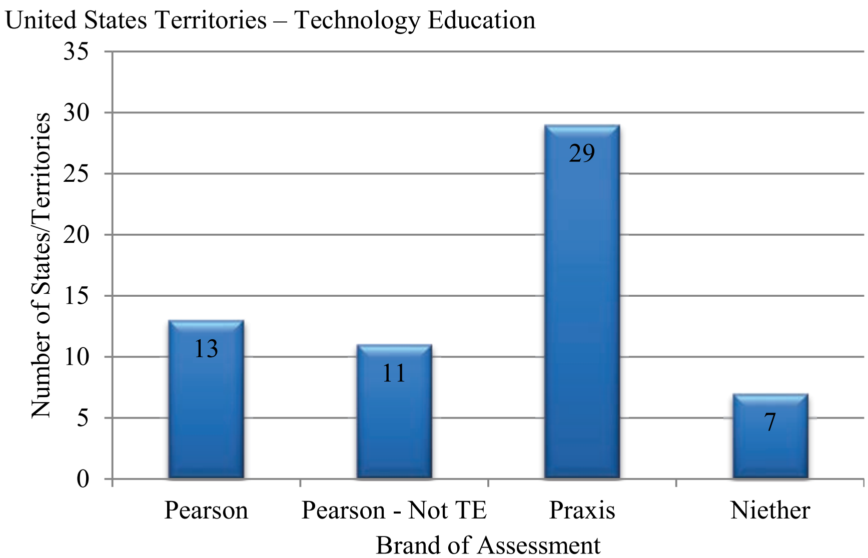


Figure 1. Teacher certification assessment brand distribution. Territories include the following: District of Columbia, Guam, and the U.S. Virgin Islands.

At this time, four possible rationales have been formulated that may explain the possible transition from the Praxis II assessment to the Pearson TE assessment. They are as follows:

1. Pearson Education is the first assessment brand to align with the Common Core standards.
2. Pearson Education is the first assessment to move to fully computerized, online assessment format.
3. Pearson Education possesses a more robust, action-based assessment component (edTPA) that the Praxis assessment series does not possess.

4. Pearson Education is the only teacher certification assessment that includes individual state standards in addition to state selected national standards. (Pearson Education, 2014)

Provided these four rationales, it may only be a matter of years before the Praxis Series assessments are replaced by the Pearson Education assessments. However, issues regarding non-standardized format, cost, and content may prolong, if not prevent, a full transition. Also, the ETS is in the process of developing its own version of the edTPA (Praxis Pre-Service Portfolio) to be provided along with the rest of their current assessment structure. As of 2013, 16 states had signed on to work with ETS in the development of their candidate performance-based, portfolio assessment system (ETS, 2013).

United States Territories—Technology Education

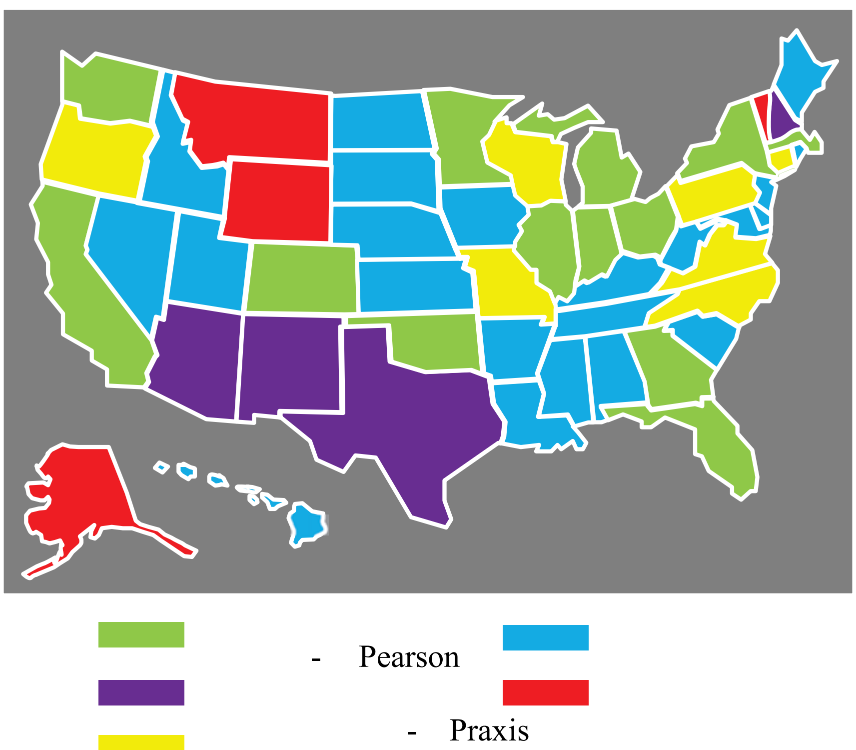


Figure 2. Teacher certification assessment brand distribution. Territories include the following: District of Columbia, Guam, and the U.S. Virgin Islands.

Accreditation

The U.S. Department of Education provides a list of requirements for basic accreditation eligibility (Subpart B) within categories 602.10–602.28. Each category addresses a specific aspect of the criteria that must be addressed prior to agency recognition. The categories include areas such as geographic scope, accrediting experience, and administrative and fiscal responsibilities. With regard to the previously detailed assessments, the sections that following the heading “Required Standards and Their Application” (sections 602.16–602.21) are of particular interest and may directly frame the candidacy for the Council on Technology and Engineering Teacher Education (CTETE) to become an accrediting agency (U.S Department of Education, 2014). These sections outline the need for rigorous agency accreditation standards that address the quality of a given teacher preparation institution. Also included are categories that address decision making, evaluation, and enforcement. As an example, areas of the teacher preparation institution or program that will be of interest include but are not limited to: student success, curricula, faculty, facilities, and equipment (U.S. Department of Education, 2014).

Each of the areas listed in the document do offer a certain amount of ambiguity to purposefully allow the agency leniency in assessing the institution or program. For instance, student success may include a variety of different elements that reflect institutional, state, or national standards. Additionally, student performance can be measured through course completion, job placement, or state licensing examinations (U.S. Department of Education, 2014). Therefore, if the CTETE were to become an accrediting agency for technology and engineering education, it could utilize either the Praxis II or Pearson TE assessments as evidence toward measuring student success. However, this would only be acceptable if the CTETE were to develop its own standards for teacher preparation institutions that account for the two assessment tools and their unique perspectives on student success. It is within areas like this example that the variances between the Praxis II and Pearson TE could provide some apprehension.

Conclusion and Recommendation

It is the recommendation of this researcher that the CTETE consider further investigation into becoming an accrediting agency for teacher certification institutions or programs in technology and engineering education. Though the variance between Praxis II and Pearson TE (and between state versions of Pearson TE) do present some challenges, it would be up to the purview of the CTETE as to how and to what degree the council wished to address the variance. In other words, the CTETE would have to decide the degree of accreditation that they wish to address—national, state, or a combination of the two. Also, as outlined in the accreditation requirements, the CTETE must establish a history of accreditation practices prior to applying for recognition.

Although no timeframe is clearly provided for what constitutes an appropriate history, if the CTETE were to seriously entertain the possibility of becoming an accrediting agency in the near future, it must attempt to be recognized as such an authority. Partnering with other organizations (e.g., the International Technology and Engineering Educators Association, the American Society for Engineering Education, and the Association for Career and Technical Education) may provide a more comprehensive and secure foundation from which to build an accrediting agency.

References

edTPA. (2015). *About edTPA.* Retrieved from http://www.edtpa.com/PageView.aspx?f=GEN_AboutEdTPA.html

Educational Testing Service. (2013). *ETS - Newsroom: ETS developing national pre-service assessment for teacher candidates.* Retrieved from https://www.ets.org/newsroom/news_releases/developing_national_pre-service_assessment

Educational Testing Service. (2014a). *ETS Praxis: About the Praxis Series tests.* Retrieved from https://www.ets.org/praxis/about?WT.ac=praxishome_about_121126

Educational Testing Service. (2014b). *ETS Praxis: State requirements.* Retrieved from https://www.ets.org/praxis/states

Educational Testing Service. (2014c). *ETS Praxis: Test and service fees.* Retrieved from https://www.ets.org/praxis/about/fees/

Educational Testing Service. (2014d). *The Praxis study companion: Technology education*. Retrieved from https://www.ets.org/s/praxis/pdf/5051.pdf

Pearson Education. (2014a). *Teacher licensure testing and performance assessment: Custom programs.* Retrieved from http://www.pearsonassessments.com/teacherlicensure/custom-programs.html

Pearson Education. (2014b). *Teacher licensure testing and performance assessment: edTPA.* Retrieved from http://www.pearsonassessments.com/teacherlicensure/edtpa.html

Pearson Education. (2014c). *Teacher licensure testing and performance assessment: National evaluation series (NES).* Retrieved from http://www.pearsonassessments.com/teacherlicensure/nes-national-evaluation-series-.html

Pearson Education. (2014d). *Teacher licensure testing and performance assessment: Study products.* Retrieved from http://www.pearsonassessments.com/teacherlicensure/study-products.html

U.S. Department of Education. (2014). *Accreditation in the United States: Subpart B – The criteria for recognition: Basic eligibility requirements.* Retrieved from http://www2.ed.gov/admins/finaid/accred/accreditation_pg13.html

Appendix A
Technology Education: Custom Program

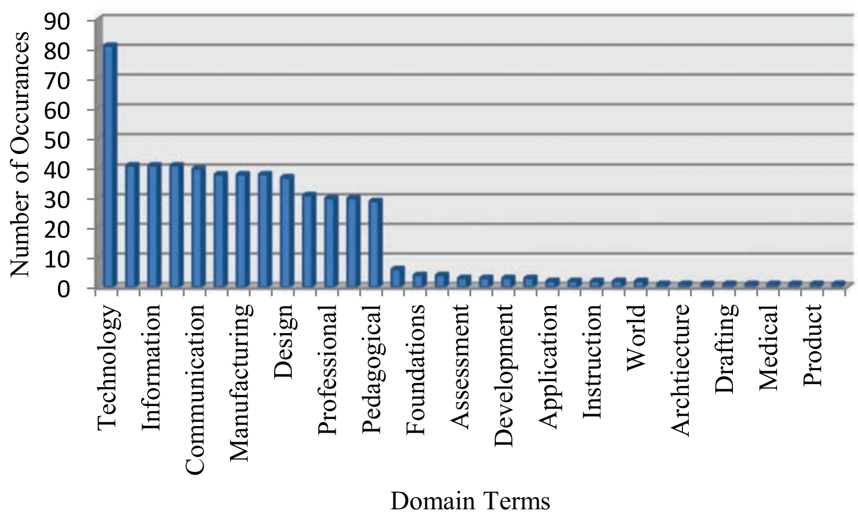
State	Domains	Tests	Items	Cost
California	• Nature of Technology • Energy, Power, and Transportation • Information and Communication • Project and Product Development	2	Multiple Choice (MC), Constructed Response (CR)	$267
Colorado	• Fundamentals of Technology • Communication and Information Systems • Energy, Power, and Transportation Systems • Production and Construction Systems • Technology Education Programs	2	MC	$155
Florida	• Nature and Impacts of Technology • Principles of Drafting • Principles of Engineering • Energy and Power Technologies • Information and Communication Technologies • Transportation Technologies • Manufacturing Technologies • Construction Technologies • Laboratory Management and Safety • Technology Education, Professional Development, and Standards-based Instruction and Assessment	1	MC	$200
Georgia	• Technology and Society • Abilities for a Technological World • Professional Development • The Nature of Technology • Design • The Designed World	2	MC	$193
Illinois	• History and Nature of Technology	1	MC	$86

	• Design, Development, Management, and Assessment • Information, Energy, and Physical Technologies			
Indiana	• Foundations of Engineering and Technology • Energy, Power, and Communication Systems • Manufacturing and Construction Systems • Transportation, Biotechnology, and Medical Systems • Instruction and Assessment	1	MC	$114
Massachusetts	• Foundations and Engineering Design • Energy and Power Systems • Construction Technologies • Manufacturing Technologies • Communication Technologies • Transportation Technologies	1	MC, CR	$130
Michigan	• Concepts and Applications of Technology • Physical Technology • Information Technology • Bio-Related Technology	1	MC	$130
Minnesota	• Fundamentals of Technology • Energy and Power Technology • Transportation Technology • Communication Technology • Manufacturing and Biotechnology • Construction Technology	2	MC	$120
New York	• Fundamentals of Technology • Communication Systems • Power and Energy Systems • Manufacturing and Construction Systems • Transportation Systems • Bio-related Systems	1	MC, CR	$79

Ohio	• Nature of Technology • Energy, Power, and Transportation • Information and Communication • Manufacturing and Construction	2	MC, CR	$105
Oklahoma	• Fundamentals of Technology • Arts/AV, Communications, and Information Technologies • Architecture and Construction • Manufacturing • Transportation, Distribution, and Logistics	1	MC, CR	$130
Washington	• Foundations and Design • Energy and Power Technology • Information and Communication Technology • Transportation Technology • Manufacturing Technology • Construction Technology	1	MC	$155

Note. Adapted from Pearson Education (2014a).

Appendix B
Teacher Certification Assessment Domains: Common Terms



Book Review

Healthcare and Biomedical Technology in the 21st Century: An Introduction for Non-science Majors

Baran, G. R., Kiani, M. F., & Samuel, S. P. (2013). Healthcare and biomedical technology in the 21st century: An introduction for non-science majors. New York, NY: Springer. ISBN: 978-1-4614-8540-7, $89.99 (Paperback); ISBN: 978-1-4614-8541-4, $69.99 (eBook), 503 pages.

Science education for nonscience majors in university settings has generally been focused on teaching basic science courses (e.g., physics, chemistry, biology) with the expectation that students will retain and internalize these concepts in the long run. However, student responses to these courses have often been less than enthusiastic, and a number of universities have begun to develop general education curricula focused more on applied science, technology, and engineering covering current topics of interest. As a professor in a community college dealing with a large number of students, majoring both in sciences and nonscience areas, I have been impressed with how Healthcare and Biomedical Technology in the 21st Century successfully covers and presents the state of the art in medical technologies and related issues. Professors Baran, Kiani, and Samuel are recognized experts in many of the fields covered in this book and have used their personal experience of teaching this material for several years to a large number of students (Fagette, Chen, Baran, Samuel, & Kiani, 2013) to assemble an excellent textbook. Although the subtitle of the book claims it to be "an introduction for non-science majors," this textbook is certainly appropriate for science majors in an introductory or review course on medical technology. Furthermore, this book has excellent background material for even engineering students who may be interested in reviewing the state of the art and possible problems that individuals in this field face. In particular, many insightful discussions and practical examples in the book on how advances in medical technology have impacted social change and clinical care provide excellent context for understanding biomedical technology. This book is written in a "continuing education" style, beginning each chapter with a summary and presenting the material in a didactic manner, including questions that would allow the reader to evaluate their understanding of the material. Most chapters are generously scattered with helpful diagrams, photographs, tables, and practical examples to illustrate the content. In general, the text is well laid out, clear, and appropriate. Each chapter ends with a very useful listing of foundational concepts that summarize the material covered in the chapter and a

M.Z. Hooshdaran (mziba09@yahoo.com) is an Instructor of Life Sciences at Southwest Tennessee Community College.

list of references.

The book is divided into two overall segments. In the first four chapters of the book, the authors introduce healthcare policy and the ethical and legal aspects of technology-centered healthcare in the modern world and discuss the scientific method in the context of how scientists and engineers develop new ideas and technologies. Chapter 1 delves into the controversies surrounding the delivery and cost of healthcare in the United States and does not shy away from addressing controversial topics such as how the healthcare system and outcomes in the United States differ from other industrialized countries. Nevertheless, these controversies are presented in a way to encourage debate and discussion in class and allow for students to form their own opinions on the subjects. Chapter 2 presents the scientific method and provides much practical insight on how students can use the scientific method in their daily decision making. Chapters 3 and 4 present a very accessible introduction on the legal and ethical issues arising from the applications of technology in healthcare covering topics such as animal and human experimentation, regulatory concerns for drugs and medical devices, and end of life decisions. Very interesting examples of a scientific grant proposal, a patent application, and an informed consent form are included in the appendices at the end of the book. Overall, this portion of the book provides the students with a solid understanding of the central role of technology in modern healthcare.

The second segment of the book, Chapters 5 through 14, covers a significant part of the modern technology that is at the center of modern healthcare in very simple yet comprehensive language. These chapters, although complementary, are written in a way that allows instructors the flexibility to choose topics of interest to their students or of special interest to the instructor, without necessarily having to cover all chapters in a serial fashion. Furthermore, the breath of material in each chapter allows the instructor to adjust the depth of presentation depending on the background of the students. Chapter 5 covers medical diagnostic and bioimaging technologies and presents many of their applications through examples that should be familiar to many students. Chapter 6 presents a discussion of how different tissues in the body interact with various materials and provides a basic understanding of issues such as transplant rejection. Chapters 7 and 8 present an in depth discussion of biomaterials and their applications not only in medical devices but also in any material that may come into contact with the human body. The technology behind cardiac devices such as stents, pacemakers, and artificial hearts, as well as their applications, is introduced in Chapter 9. Chapter 10 provides an interesting discussion of how modern drugs are formulated with many examples that even a younger student population should be able to find in their medicine cabinets. Chapters 11 and 12 cover the very hot topics of genetic and tissue engineering, including gene therapy and stem cell technology. Chapters 13 and 14 are very applied in tone and cover the applications of technology in dentistry and rehabilitation engineering. The variety of topics and the amount of material covered in this book is probably too much for a typical one semester science course, but it also gives instructors considerable flexibility because most chapters could stand alone.

In summary, this is a well-organized textbook that covers an emerging area of general education. For STEM (science, technology, engineering, and mathematics) educators, this will provide an excellent textbook for teaching applied science courses to nonscience majors, particularly because the topic of medical technology involves anyone who has ever been a patient or has a family member who has interacted with the healthcare system. This text seeks to demystify many of the medical diagnoses and treatments encountered by patients. The book may also be useful for teaching an introductory course to science majors on the applications of modern technology in healthcare. There is a shortage of appropriate textbooks in these areas, and Healthcare and Biomedical Technology in the 21st Century is a very welcome addition to the field.

References

Fagette, P., Chen, S.-J., Baran, G. R., Samuel, S. P., & Kiani, M. F. (2013). Engineering a general education program: Designing mechanical engineering general education courses. Innovative Higher Education, 38(2),117–128. doi:10.1007/s10755-012-9231-2

Scope of the JTE

The *Journal of Technology Education* provides a forum for scholarly discussion on topics relating to technology and engineering-related education. Manuscripts should focus on technology and engineering-related education research, philosophy, and theory. In addition, the *Journal* publishes book reviews, editorials, guest articles, comprehensive literature reviews, and reactions to previously published articles.

Editorial/Review Process

Manuscripts that appear in the *Articles* section have been subjected to a blind review by three or more members of the Editorial Board. This process generally takes from six to eight weeks, at which time authors are promptly notified of the status of their manuscript. Book reviews, editorials, and reactions are reviewed by the Editor.

Manuscript Submission Guidelines

One paper copy of each manuscript and an electronic version in Microsoft Word format on a CD or other electronic media should be submitted to:

Chris Merrill, JTE Editor
Department of Technology
Illinois State University
215 Turner Hall
Normal, IL 61790-5100

1. Overseas submissions in Microsoft Word format may be sent electronically via the Internet (to cpmerri@ilstu.edu) to expedite the review process.
2. All manuscripts must be double-spaced and must adhere to the guidelines published in *Publication Guidelines of the American Psychological Association* (6th Edition). **Tables and figures, however, should be imbedded within the text itself rather than at the end of the document.**
3. **All figures and artwork must be scalable to fit within the JTE page size (4.5” x 7.25” column width and length) and included electronically within the document.**
4. Line drawings and graphs must be editable within Microsoft products and in vector rather than raster format when possible.
5. **Shading should not be used as a background for illustrations or graphs and within bar graphs.** If needed, fill patterns consisting of lines should be used.
6. Manuscripts for articles should generally be 15-20 pages (22,000-36,000 characters in length, with 36,000 characters an absolute maximum). Book reviews, editorials, and reactions should be approximately four to eight manuscript pages (approx. 6,000-12,000 characters).

7. Authors for whom English is not the primary language must enlist a native English editor for the manuscript prior to submission. This person and his/her email address must be identified on the title page of the manuscript.

Subscription Information

The *Journal of Technology Education* is published twice annually (Fall and Spring issues). New and renewing subscribers should copy and mail the form below:

Name (please print) ____

Mailing Address (please print) __________________________________

____

Email address: ______________________________Fax: _________________

☐New Subscription ☐ Renewal Subscription

Make checks payable to: *Journal of Technology Education*. All checks *must* be drawn on a US bank.

Regular (USA): $20
Regular (Canada/Overseas): $30
Library (USA): $30
Library (Canada/Overseas): $40
Individual Back Issues (USA): $10 each
Individual Back Issues (Canada/Overseas): $15 each

Return remittance along with this form to:

Chris Merrill, JTE Editor
Department of Technology
Illinois State University
215 Turner Hall
Normal, IL 61790-5100

JTE Co-Sponsors & Membership Information

The International Technology and Engineering Educators Association (ITEEA) is a non-profit educational association concerned with advancing technological literacy. The Association functions at many levels – from international to local – in responding to member concerns. The Council on Technology and Engineering Teacher Education (CTETE), affiliated with the ITEEA, is concerned primarily with technology teacher education issues and activities. For membership information, contact: ITEEA, 1914 Association Drive, Reston, VA 22091 (703) 860-2100.

Journal of Technology Education

Editor
Chris Merrill, Illinois State University

Technical Editor
Amanda Fain, Illinois State University

Previous Editors
Mark Sanders, Virginia Polytechnic Institute and State University (1989-1997)
James LaPorte, Virginia Polytechnic Institute and State University (1997-2010)

Editorial Review Board
Vincent Childress, North Carolina Agricultural and Technical University

Rodney Custer, Black Hills State University

Jenny Daugherty, Purdue University

Marc deVries, Delft University of Technology, The Netherlands

Patrick Foster, Central Connecticut State University

W. Tad Foster, Indiana State University

Brenda Gustafson, University of Alberta, Canada

Ronald Hansen, University of Western Ontario, Canada

Christine Hailey, Utah State University

Oenardi Lawanto, Utah State University

Theodore Lewis, University of Trinidad and Tobago

Stephen Petrina, University of British Columbia, Canada

Philip Reed, Old Dominion University

Mary Annette Rose, Ball State University

Kay Stables, Goldsmiths University of London, England

Ken Volk, Masdar Institute of Science and Technology, Abu Dhabi

John Wells, Virginia Polytechnic Institute and State University

John Williams, University of Waikato, Hamilton, New Zealand

Electronic Access to the JTE
All issues of the *Journal of Technology Education* may be accessed on the World Wide Web at: http://scholar.lib.vt.edu/ejournals/JTE/ (Note: this URL *is* case sensitive).

The views expressed in this publication are not necessarily those of the Editor or the Editorial Review Board, or the officers of the Council on Technology and Engineering Teacher Education and the International Technology and Engineering Educators Association.