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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).

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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?

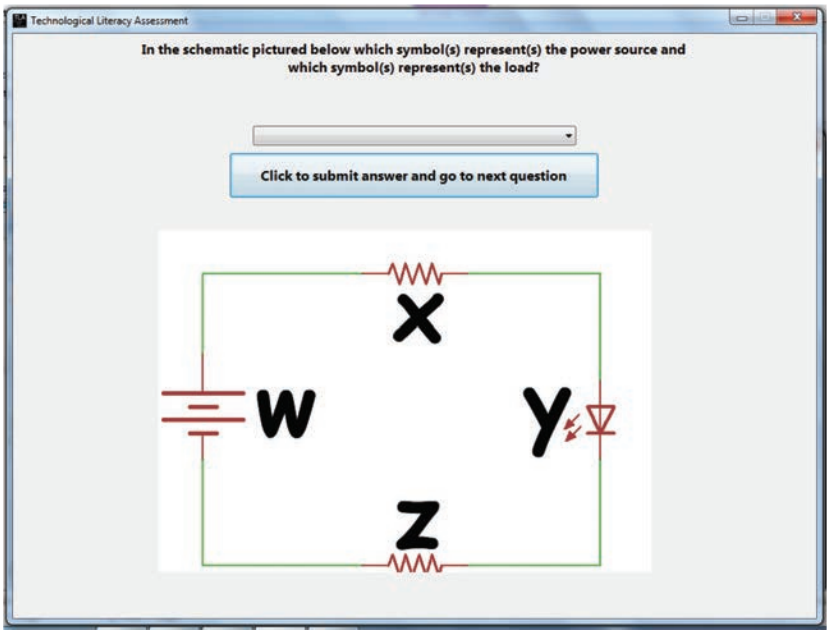
a) testing and evaluating the shoe tread prototypes
b) marketing the new shoes

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.



In the schematic pictured below which symbol(s) represent(s) the power source and which symbol(s) represent(s) the load?

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^{TM} 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^{TM}/blocks	7	Video games	5
Video games	5	Board games	4
Board games	4	Pretend play	2
Action figures/dolls	3	LEGOs^{TM}/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.

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