Technological Literacy Courses in Pre-Service Teacher Education

By By Roger Skophammer and Philip A. Reed

ABSTRACT

The goal of this study was to determine to what extent technological literacy courses were required in K-12 teacher education. A documents review of the appropriate course catalogs for initial teacher preparation was conducted. The documents review identified general education requirements and options for technological literacy courses, as well as requirements and options for these courses for English, social studies, mathematics, and science education majors. For this study, technological literacy was defined as "the ability to use, manage, assess, and understand technology" (ITEA, 2000/2002/2007, p. 9). This definition of literacy is broader than technology literacy associated with computer use and instructional technology, as well as courses limited to the history or philosophy of technology. A finding from this study is that there is very little exposure to technological literacy courses for prospective K-12 teachers. This may be due in part to the confusion between instructional technology literacy and technological literacy.

Keywords: Technological Literacy, Technology Education, Teacher Education

INTRODUCTION

The increasing rate of technological change in the United States requires a technologically literate populace that can think critically and make informed decisions about technological developments. The International Technology and Engineering Educators Association (ITEEA), National Assessment Governing Board, and the National Academy of Engineering (NAE), along with other organizations, have called for a larger involvement in K-12 education for the development of technological literacy in students (ITEA, 1996; National Assessment Governing Board, 2013; Pearson & Young, 2002).

Technological literacy is defined as "the diverse collection of processes and knowledge that people use to extend human abilities and to satisfy human needs and wants" (ITEA, 2000, p. 2). A broad range of academic subjects encompass technological literacy; therefore, development of technological literacy for K-12 students necessitates that all K-12 teachers develop a level of technological competency. According to the NAE and the National Research Council, "the integration of technology content into other subject areas, such as science, mathematics, social studies, English, and art could greatly boost technological literacy" (Pearson &Young, 2002, p. 55). The purpose of this study was to investigate the development of technological literacy in accredited pre-service K-12 teacher education programs in the United States. To guide this study, the following research questions were developed:

1. Are technological literacy courses a part of general education requirements for K-12 education majors at 4-year, accredited institutions?
2. Are technological literacy courses used to fulfill program requirements for K-12 education majors at 4-year, accredited institutions?
3. Do the required technological literacy courses focus on the development of broad technological literacy awareness or is the focus on learning how to use instructional methods similar to those used in technology education activities?
4. What, if any, are the differences in K-12 education majors in requirements for technological literacy courses?

CONTEXT OF THE STUDY

For this study, a distinction was made between *technological literacy* as defined by the ITEEA and technology literacy as defined by the International Society for Technology in Education (ISTE). Technology literacy is concerned with student literacy in computer and information technologies as well as teacher abilities to use computer and information technologies for instruction (ISTE, 1998). Technological literacy is concerned with "how people modify the natural world to suit their

own purposes" (ITEA, 2002, p. 2). In reference to Research Question 3, technological literacy includes this definition as well as the relationship among technology, the sciences, and society.

Instructional methods that utilize technology education activities generally involve the design and development of a product, physical or virtual, as a means to improve learning of the subject content (Foster, 1995). These activities promote problem-solving skills essential in a complex society (Schwaller, 1995). Activities include the design process, but may or may not address additional technological literacy content.

The need for a technologically literate populace has been broadly recognized by the relationship between other academic fields and technology education. The National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) provided funding for the Technology for All Americans Project (TfAAP) (ITEA, 1996). Many other organizations supporting technological literacy include the National Research Council (NRC), the National Academy of Engineering (NAE), the National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS) Project 2061, and the National Council of Teachers of Mathematics (NCTM) (Dugger, 2005). Additionally, the disciplines of science, mathematics, and social studies have standards that address technological literacy (Achieve, 2014; Foster, 2005).

The NAE and NRC publication, *Tech Tally* (Garmire & Pearson, 2006), includes recommendations in the assessment of technological literacy relevant to this study. Primarily, the focus and recommendations suggest a strong need for teachers to develop technological literacy in K-12 pre-service education programs and to include technological literacy as part of the assessment of K-12 teachers and K-12 teacher education programs. An important step in meeting these recommendations is to develop an understanding of the current status of technological literacy, both in the extent to which coursework is required in K-12 teacher education as well as what aspects of technological literacy are covered in those courses.

METHODOLOGY AND RESEARCH DESIGN

The research design of the study was content analysis. Content analysis is "a detailed and systematic examination of the contents of a particular body of material for the purpose of identifying patterns, themes, or biases" (Leedy & Omrod, 2005, p. 142). For this study, a documents review of current undergraduate course catalogs was performed to address the research problem and the content analyzed in order to answer the research questions.

Population and Sample

The K-12 education programs reviewed in the study were randomly selected from the combined lists of education programs accredited through the National Council for Accreditation of Teacher Education (NCATE) and Teacher Education Accreditation Council (TEAC). A single list of 697 accredited education programs within the United States was created by entering the data, available online, into a spreadsheet. The sample size of 248 education programs was determined using a table based on the formula by Krejcie and Morgan (1970) (as cited in Patten, 2007) for a finite population at a 95% confidence level. The random sample was created using the random number generator and sort functions in the spreadsheet software. The sample size and random sample procedure allows for the sample to be proportionally representative of the NCATE and TEAC accredited education institutions in terms of geographic location in the United States, as well as the distribution among liberal arts colleges, regional institutions, and research universities. The education majors to be reviewed represent the academic areas that K-12 students are required to study.

Data Collection Methods

This study used a qualitative analysis of electronic sources of course titles and course descriptions. In a documents review, the researcher makes the judgment on how to code the appropriate data in the document (Creswell, 2007). The data were collected for the study by reviewing the appropriate catalogs for each institution of the 248 education programs in the sample. General education options and requirements as well as education program options and requirements were reviewed to identify courses that may have technological

literacy or engineering content. Potential courses were identified and course descriptions were reviewed to determine if they contained technology or engineering content. Additionally, a search was done of all courses offered at the institution using technology, technological, engineering and design. When a course was identified as having technological literacy or engineering content, it was checked against the courses listed in general education and education program options and requirements.

A spreadsheet was used to record data from each institution with categories for mathematics, science, English, social studies, and elementary education programs. Subcategories for elementary education majors included English, social studies, mathematics, and science content specializations. Categories for secondary subjects included a subcategory for middle school majors. Subcategories for secondary social studies included history, geography, economics, political science (including civics), and sociology. Subcategories for science included biology, chemistry, physics, and earth science. There were no content subcategories for mathematics or English.

In order to answer Research Question 1, the general education requirements at each university or college where the teacher education program resided were reviewed. Courses that were identified as developing technological literacy that were general education requirements were identified in one column and those that were an option in a separate column. When the general education courses were not intended for science majors they were coded with an E. Data for Research Question 2 were collected from the teacher education requirements in the undergraduate catalog for each of the education majors evaluated in this study. Where distinctions existed between middle school and high school majors, both sets of requirements were reviewed and recorded separately. Likewise, when differences in science education majors' course requirements existed, they were also recorded separately. Codes for courses are explained in Table 1, which follows. Courses that were identified as developing technological literacy that were teacher education requirements were coded R and those that were an option in teacher education requirements recorded as O. In order to address Research Question 3, the content focus of the required courses, TL or IM was added to the initial code. Courses that focused on instructional methods and technology education activities were coded IM, and courses that focused on technological literacy as content were recorded TL. Courses that addressed both were coded with TL-IM. Therefore, a course that was an education requirement for elementary teacher education that focused on technology education methods as well as content was coded R-TL-IM.

Course content was considered to focus on the development of technological literacy (TL) when the course title or course description indicated that the course curriculum promoted technological literacy as defined in *Technically Speaking* (2002) and *Tech Tally* (2006). *Tech Tally* provided a matrix of the cognitive dimensions of technological literacy and the content areas for technological literacy that were used as a rubric for determining whether a course promoted technological literacy (see Figure 1).

Course content was considered to be technology education instructional methods (IM) when

Table 1: *Codes and Descriptions for Teacher Education Programs*

Codes	Description
R	Required course
O	Optional course used to fulfill requirement
TL	Technological Literacy awareness
IM	Instructional Method using technology education activities

technological literacy courses included instructional methods or activities in the description or title of the course. For example, the course description that follows was an option for an elementary education track at the institution. It clearly describes technological literacy with terms such as systems, products, and technological design. The activities model an instructional method relevant to education majors by having students complete design projects using methods that would be similar and appropriate for the elementary classroom. There were not required courses that met the criteria at this institution, therefore this course is coded O-TL-IM for Optional, Technological Literacy, and Instructional Methods.

> This is a foundational course that looks at the elements and principles of design as related to practical products, systems, and environments. It introduces students to the creative process practiced by artists, designers, and engineers, valuable to them as both future producers and consumers. Content includes thinking, drawing, and modeling skills commonly used by designers; development of a design vocabulary; the nature and evolution of technological design; the impacts of design on the individual, society, and the environment; patents and intellectual property; human factors; team design; and appropriate technology, risk analysis, and futuring techniques. Design problems are presented within real-world contexts, using field trips and outside speakers. Students complete a major design project, document their work through a design portfolio, and present their solutions before the class. Weekly critiques of class projects build fluency, confidence, and creativity. (College of New Jersey, 2008, p. 3).

CONTENT AREAS	COGNITIVE DIMENSIONS: KNOWLEDGE	CAPABILITIES	CRITICAL THINKING AND DECISION MAKING
TECHNOLOGY AND SOCIETY			
DESIGN			
PRODUCTS AND SYSTEMS			
CHARACTERISTICS, CORE CONCEPTS, AND CONNECTIONS			

Figure 1. Assessment matrix for technological literacy (Garmire & Pearson, 2006, p. 53).

Courses that were not included for this study are those that focused on information-technology literacy, computer literacy, or instructional technology as defined by the ISTE (1998) standards. Required courses that focus on these areas were not included in this study because several recent studies have been done in these areas (Baylor & Ritchie, 2002; Hinchlifee, 2003; Kelly & Haber, 2006; Garmire & Pearson, 2006; Sanny & Teale, 2008; Topper, 2004).

FINDINGS AND ANALYSIS

A general conclusion of this study is that there is very little exposure to technological literacy courses for prospective K-12 teachers. The review of literature suggested that this might be due in part to the confusion between instructional technology literacy and technological literacy (Dugger, 2007; Pearson & Young, 2002; Zuga, 2007). All teacher education programs require the acquisition of skills in computer use and instructional technology. This is in large part due to the inclusion of the International Society for Technology in Education (ISTE) National Educational Technology Standards in NCATE accreditation standards for all academic areas (Hinchliffe, 2003; Hofer, 2003). The following are the findings and analysis for each of the four research questions.

Research Question 1: Technological literacy as a part of general education for K-12 education majors

Data analysis identified technological literacy courses as being either a requirement of the institution or an option to fulfill a requirement of the institution. The review of the 248 course catalogs determined that 80 institutions included technological literacy courses as part of their general education requirements. Typical course titles included Science, Technology, and Society, Technology and Society, and Technology and Civilization. At a few of the institutions, these courses were part of a technology track or sequence that would include computer technology courses as well as industrial technology and design courses. Seventy-six of these institutions allowed a technological literacy course to fill a general education requirement, and four institutions required a technological literacy course as part of the general education requirements. Of the 76 institutions that offered a technological literacy course as an option for general education requirements, 42 excluded that course as an option for secondary science majors. Eight institutions identified a technological literacy course that was an option for general education as a requirement for the teacher education program (see Figure 2). The

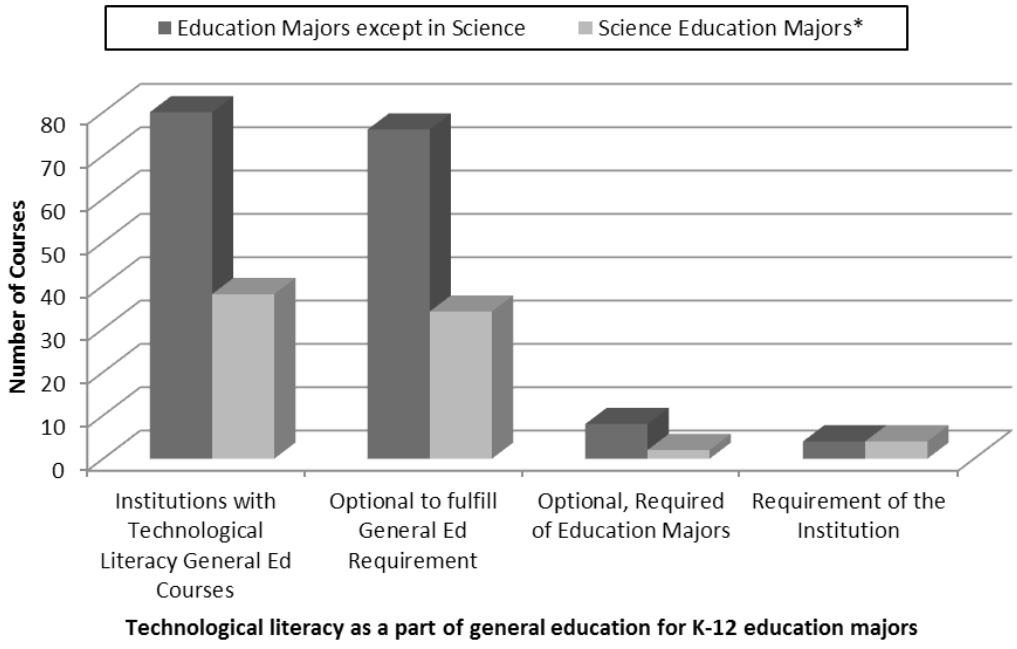

Figure 2. Technological literacy general education courses (* Including elementary science specialization).

narrow understanding of technological literacy as computer literacy may lead some to believe the technological literacy is being addressed in the general education curriculum. A study by Rose (2007) found that administrators in higher education generally believe that science, technology, engineering, and mathematics (STEM) initiatives are addressing technological literacy through computer and digital communication coursework.

Research Question 2: Technological literacy courses used as program requirements for K-12 education majors

For this question, technological literacy courses were identified as either an option or a requirement for the education majors at the institution. Forty-six institutions included technological literacy courses to fulfill program requirements for K-12 education majors. Twenty-seven institutions included technological literacy courses in elementary education; 19 required courses, and eight were optional. For secondary education majors, 29 institutions used technological literacy courses to fulfill program requirements. In addition to the course titles found for general education, some of the course titles required for education majors included Critical Literacies in Childhood Education, Teaching Mathematics, Science and Technology, and Science and Technology. Table 2 shows whether the technological literacy courses were used as a requirement or an option for each of the education majors included in the study. The total number of courses listed in Table 2 does not equal the number of institutions because an institution may have had more than one major with a technological literacy course requirement or option.

Table 2: *Technological Literacy Courses in Teacher Education Institutions, N* = 248

	Required		Option to Fulfill Requirements		Totals	
	#	%	#	%	#	%
Institutions with courses in both elementary and secondary majors	6	2.42%	2	0.81%	8	3.23%
All majors	2	0.81%	1*	0.40%	3	1.21%
Specific majors	4	1.61%	1*	0.40%	5	2.02%
Just elementary majors	12	4.84%	6	2.42%	18	7.26%
Generalist	10	4.03%	6	2.42%	16	7.26%
Specialists	2	0.81%	0	0.00%	2	0.81%
Just secondary majors	14	5.65%	6	2.42%	20	8.06%
All majors	4	1.61%	1	0.40%	5	2.02%
Specific majors	10	4.03%	5*	2.02%	15	6.05%
Totals	32	12.90%	14	5.65%	46	18.55%

* Institutions that had a major with a requirement and a major with an option were included in the option column.

Research Question 3: Technological literacy awareness or instructional methods

The analysis for this question differentiates between technological literacy courses that focus on the nature of technology and/or the relationship of technology and the subject content referred to here as technological literacy awareness. Technological literacy courses that focused on the use of technology education activities as an instructional strategy are referred to as instructional methods. Technological literacy awareness courses were more likely to be found as part of the requirements for secondary education majors, while the distribution between technological literacy awareness and instructional methods was evenly represented in elementary education. Of the 46 institutions identified as having technological literacy courses as part of the requirements for the K-12 education majors, 34 required broad technological literacy awareness courses such as Science, Technology, and Society. Sixteen institutions included broad technological literacy awareness courses as an option. Instructional methods courses, such as Methods for Teaching Math, Science, and Technology, or course descriptions for methods courses that included "the use of robots," "creating maps," and "building models" were required by 19 institutions and were options at three institutions. The total of these is greater than 46 because there were 11 institutions that required courses that address both technological literacy awareness and instructional methods. Most often, these were a single course for elementary education majors such as Critical Literacies in Childhood Education or Elementary Education taught by a technology education department.

Table 3: *Types of Technological Literacy Courses*

	Technological Literacy Awareness		Instructional Methods		Both	
	#	%	#	%	#	%
Required	**23**	**9.27%**	**8**	**3.23%**	**11**	**4.44%**
Elementary Programs	6	2.42%	4	1.61%	8	3.23%
All majors	4	1.61%	4	1.61%	7	2.82%
Specific majors	2	0.81%	0	0.00%	1	0.40%
Secondary Programs	17	6.85%	4	1.61%	3	1.21%
All Majors	3	1.21%	1	0.40%	0	0.00%
Specific Majors	14	5.65%	3	1.21%	3	1.21%
Optional	**14**	**5.65%**	**1**	**0.40%**	**2**	**0.81%**
Elementary Programs	7	2.82%	1	0.40%	2	0.81%
All Majors	7	2.82%	1	0.40%	2	0.81%
Specific Majors	0	0.00%	0	0.00%	0	0.00%
Secondary Programs	9	3.63%	0	0.00%	0	0.00%
All majors	1	0.40%	0	0.00%	0	0.00%
Specific majors	8	3.23%	0	0.00%	0	0.00%
Total Institutions	30	12.10%	6	2.42%	10	4.03%

The findings for elementary education suggest there is a growing understanding of the value of technology education activities for integrating other subjects, as well as the need to develop technological literacy in elementary education. Linnell (2000) identified five programs in the United States that required elementary education majors to take technological literacy courses and 10 institutions that provided these courses as on option. This study, using a sample that is approximately 1/3 of the population, found 18 institutions that required these types of courses for elementary education majors and 10 that provided them as options. Table 3 shows the number of programs that had either required or optional courses for each of the three variables (Technological Literacy Awareness, Instructional Methods, or both).

Research Question 4: Technological literacy course differences in K-12 education majors.

The focus of this question was to determine if there were differences between the education majors of elementary education, English, social studies, mathematics, and science for required or optional technological literacy courses. Technological literacy course requirements were found primarily in elementary education, with secondary science majors having the most courses requirements for secondary education majors.

Table 4: *Comparison of Technological Literacy Courses by Education Major*

	Required		Option		Totals	
	#	%	#	%	#	%
Elementary Education	**19**	**7.66%**	**8**	**3.23%**	**27**	**10.89%**
Generalist	16	6.45%	8	3.23%	24	9.68%
English		0.00%		0.00%	0	0.00%
Social Studies		0.00%		0.00%	0	0.00%
Mathematics		0.00%		0.00%	0	0.00%
Science	3	1.21%		0.00%	3	1.21%
Secondary Majors	**9**	**3.63%**	**5**	**2.02%**	**14**	**5.65%**
All Secondary Subjects*	4	1.61%	1	0.40%	5	2.02%
English		0.00%		0.00%	0	0.00%
Social Studies	3	1.21%	4	1.61%	7	2.82%
Mathematics	2	0.81%		0.00%	2	0.81%
Science Majors	**15**	**6.05%**	**6**	**2.42%**	**21**	**8.47%**
All Sciences Majors	13	5.24%	4	1.61%	17	6.85%
Biology		0.00%		0.00%	0	0.00%
Chemistry		0.00%		0.00%	0	0.00%
Physics	2	0.81%	1	0.40%	3	1.21%
Earth Science		0.00%	1	0.40%	1	0.40%
Total	**43**	**17.34%**	**19**	**7.66%**	**54**	**21.77%**

Note: The findings for middle school and high school are identical, therefore are reported under "Secondary". There were no differences between social studies majors, therefore social studies are listed as one category. *Includes science majors.

Elementary education had the largest number of programs with required or optional technological literacy course requirements; this included 19 required courses and eight optional courses.

The analysis of the data obtained from the documents review showed differences between the secondary education majors that reflect the literature and standards for these academic areas. Secondary science had 21 programs that include technological literacy courses as part of the requirements with 15 required courses and six optional courses. The rest of the secondary education majors had 14 programs that included technological literacy courses as part of the requirements. This includes the four institutions that required technological literacy courses in all other secondary education programs (including science) and the one institution that provided a technological literacy course as an option in their requirements. Secondary English, except when required by all secondary education majors, did not include programs with requirements for technological literacy courses. There were no differences for the course titles that addressed broad technological literacy in the secondary education majors with titles such as Science, Technology, and Society, and Technology and Society common throughout. The instructional methods course titles included Teaching Math, Science, and Technology, or a description in the methods course that addressed technology education activities. See Table 4 for the complete analysis of the number of programs with required or optional technological literacy course requirements.

The differences between the secondary education majors suggests that the relationship between technology and science is better understood at teacher preparation institutions than the relationship between technology and social studies, and that the relationship between technology and mathematics or English is very poorly understood. These findings are consistent with the literature (AAAS, 1993/2008; Foster, 2005; IRA & NCTE, 1996; NAS & NRC, 1996; NCSS, 2008; NCTM 2000; Newberry & Hallenbeck, 2002; NSTA, 2003).

The standards for science teacher education clearly identify technological literacy as important and include the study of technology and the relationship with science (NSTA, 2003). This is also reflected in *Benchmarks for Science Literacy* chapter on "The Nature of Technology" (AAAS, 1993, pp. 49-52) as well as in *Next Generation Science Standards* (Achieve, 2014). There were 17 institutions that identified technological literacy courses such as Science, Technology, and Society as an option or a requirement for all science education majors.

The standards in social studies also discuss the importance of understanding the relationship between technology and society (NCSS, 1994; Foster, 2005). "Students will develop an understanding of the cultural, social, economic, and clinical effects of technology" and "Students will develop an understanding of the role of society in the development and use of technology," are two examples from the curriculum standards (Foster, 2005, p. 55). Seven institutions included technological literacy courses as a part of the requirements.

The NCATE/NCTM standards for mathematics teachers describe the role of technology as a tool for teaching and understanding mathematics as opposed to the role of mathematics and technological literacy. Standard 6: Knowledge of Technology states, "Use knowledge of mathematics to select and use appropriate technological tools, such as but not limited to, spreadsheets, dynamic graphing tools, computer algebra systems, dynamic statistical packages, graphing calculators, data-collection devices, and presentation software" (NCTM, 2003, p. 2). The findings from the review reflect this—only two institutions require technological literacy coursework.

The National Council of Teachers of English standards lists technology as a tool for research and writing. The standard, "Develop proficiency with the tools of technology" (NCTE, 2008, p. 1) does not distinguish between the broader technology literacy and the ISTE definition, but the supporting literature focuses primarily on the use of computers and the Internet (IRA & NCTE, 1996). There were no institutions, except for the four that required it for all secondary education majors requiring technological literacy coursework for secondary English majors. The professional standards in relation to technological literacy for all these academic areas were reflected in the findings of this study.

RECOMMENDATIONS FOR FURTHER RESEARCH

The inclusion of technological literacy in the Next Generation Science Standards (Achieve, 2014) and National Science Teachers Association's Standards (NSTA, 2003) is reflected in many state standards. This study suggests that there is a discrepancy between the state standards and science teacher education curriculum based on course titles and course descriptions reviewed in this study. State-level studies that identify discrepancies between the state standards and the science teacher education curriculum are needed. These studies could also explore in greater depth the extent of which technological literacy is included in the teacher education curricula through a documents review of course material and data collected from science teacher educators.

Studies by Foster (1997, 2005), Park (2004), Holland (2004), and others have identified the value of elementary school technology education. These qualitative studies show how technology education activities promote learning in an integrated curriculum that is consistent with constructivist learning theory. The value of elementary school technology education has a growing acceptance that is reflected in the number of technological literacy course requirements for elementary teachers. Similar qualitative studies are needed at the middle school and high school levels to show how using technology education instructional methods improve learning in an integrated curriculum.

Studies by Dyer, Reed, and Berry (2006), Culbertson, Daugherty, and Merril (2004), and Satchwell and Loepp (2002) have shown a relationship between student academic achievement and participation in technology education courses. Further research is needed to better understand this relationship. These studies need to address more than the value of technology education for the development of technological literacy; they also should consider the relationship of the development of technological literacy and academic performance in other subject areas.

Finally, this study infers technological literacy of teachers by assessing the extent to which technological literacy courses are included in teacher preparation. Further understanding of the technological literacy of teachers should be addressed through the direct assessment of K-12 teachers through an inventory or survey instrument.

Roger Skophammer is Associate Director for Curriculum and Instruction at the STEM*Center for Teaching and Learning, International Technology and Engineering Educators Association, Reston, VA.

Philip A. Reed is Associate Professor in the Department of STEM Education and Professional Studies at Old Dominion University, Norfolk, VA. He is a member of the Beta Chi Chapter of Epsilon Pi Tau.

REFERENCES

Achieve, Inc. (2014). *The Next Generation Science Standards*. Washington, DC: Author.

American Association for the Advancement of Science, Project 2061. [AAAS]. (1993). *Benchmarks for science literacy.* New York: Oxford University Press.

American Association for the Advancement of Science. [AAAS]. (2008). Project 2061. Retrieved October 26, 2008 from http://www.project2061.org/.

Baylor, A. L., & Ritchie, D. (2002). What factors facilitate teacher skill, teacher morale, and perceived student learning in technology-using classrooms? *Computers & Education, 39*(4), 395.

College of New Jersey. (2008). *2008-2009 Undergraduate Bulletin*. Retrieved September 30, 2014 from http://www.tcnj.edu/~bulletin/archive/08-09/current/TechStudies.pdf.

Creswell, J. (2007) *Qualitative Inquiry & Research Design: Choosing Among Five Approaches.* Thousand Oaks, CA: Sage.

Culbertson, C., Daugherty, M., & Merrill, C. (2004). Effects of modular technology education on junior high students' achievement scores. *Journal of Technology Education, 16*(1), 7-20.

Dugger, W. E. (2005). A historical perspective of *ITEA's technology for all Americans project*. Retrieved June 13, 2008 from http://www.iteaconnect.org/ TAA/History/TAA_ History.html.

Dugger, W. E. (2007). Standards for Technological Literacy (ITEA) and National Educational Technology Standards (ISTE): Compare and contrast. Ruidoso, NM: Presentation at the New Mexico Technology Education Conference.

Dyer, R., Reed, P. A., & Berry, R. Q. (2006). Investigating the relationship between High school technology education and test scores for algebra 1 and geometry. *Journal of Technology Education, 17*(2), 6-16.

Foster, P. (1995, March). What makes an activity a technology activity? *Tech Directions, 54*(8), 28.

Foster, P. N. (1997). The benefits of elementary school technology education to children. Ph.D. dissertation, University of Missouri—Columbia, United States—Missouri. ProQuest Digital Dissertations database. (Publication No. AAT 9841141).

Foster, P. N. (2005). Technology in the standards of other school subjects. *The Technology Teacher, 65*(3), 17-167.

Garmire, E., & Pearson, G. (Eds.). (2006). *Tech tally: Approaches to assessing technological literacy* (Executive summary) [Electronic version]. Washington, DC: The National Academies Press.

Hinchliffe, L. J. (2003). Technology and the concept of information literacy for pre-service teachers. *Behavioral & Social Sciences Librarian, 22*(1), 7-18.

Hofer, M. J. (2003). ISTE educational technology standards: Implementation in award-winning teacher education programs. Unpublished Ph.D., University of Virginia, United States.

Holland, S. M. (2004). Attitudes toward technology and development of technological literacy of gifted and talented elementary school students. *DAI, 66*(01A), 271.

International Reading Association & National Council of Teachers of English. [IRA & NCTE]. (1996). *Standards for English language arts.* Urbana, IL: National Council of Teachers of English.

International Society for Technology in Education. [ISTE]. (1998). National educational technology standards. Retrieved October 26, 2008 from http://www.iste.org.

International Technology Education Association. [ITEA]. (1996). *Technology for all Americans: A rationale and structure for the study of technology*. Reston, VA: Author.

International Technology Education Association. [ITEA]. (2006). *Technology for all: A rationale and structure for the study of technology* (2nd ed.). Reston, VA: Author.

International Technology Education Association.[ITEA]. (2000/2002/2007). *Standards for*

technological literacy: Content for the study of technology. Reston, VA: Author.

Kelly, M. G., & Haber, J. (2006). Chapter 1: Assessing the technology literacy of K-12 students. In *national educational technology standards for students: Resources for Student Assessment* (pp. 3-25): International Society for Technology in Education.

Leedy, P. D., & Ormrod, J. E. (2005). *Practical Research: Planning and Design*. (8th ed.). Upper Saddle River, N.J: Pearson/Merrill/Prentice.

Linnell, C. (2000). Identifying institutions that prepare elementary teachers to teach technology education: Promoting ESTE awareness. *Journal of Industrial Teacher Education, 38*(1), 91.

National Academy of Sciences, & National Research Council. [NAS & NRC]. (1996/2008). *National Science Education Standards*. 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.

National Council for the Social Studies. [NCSS]. (1994) *Expectations of excellence: Curriculum standards for social studies*. Washington, DC: Author.

National Council for the Social Studies. [NCSS]. (2008). About NCSS. Retrieved November 1, 2008 from http://www.socialstudies.org/about

National Council of Teachers of English. [NCTE]. (2008). The NCTE definition of 21st-century literacies. Retrieved November 2, 2008 from http://www.ncte.org /announce/ 129117.htm.

National Council of Teachers of Mathematics. [NCTM]. (2000). *Principles & standards for school mathematics.* Retrieved November 1, 2008 from http://standards.nctm. org/document/index.htm.

National Council of Teachers of Mathematics. [NCTM]. (2003). *NCATE/NCTM Programs for initiation preparation of mathematics teachers*; Standards for secondary mathematics teachers. Retrieved November 1, 2008 from http://www.nctm.org/ uploadedFiles/Math_Standards/ NCTMSECONStandards.pdf

National Science Teachers Association. [NSTA]. (2003). *Standards for science teacher preparation*. Retrieved October 26, 2008 from http://www.nsta.org/ preservice?lid=tnav.

Newberry, P., & Hallenbeck L. S. (2002). Role of standards in difference subject areas. In J. M. Ritz, W. E. Dugger, & E. N. Israel (Eds.) *Standards for Technological Literacy the Role of Teacher Education*, 11-46. Peoria, IL: Glencoe/McGraw Hill.

Park, K. (2004). The value of technology education to elementary school students' learning of technology concepts and processes: A qualitative investigation of a constructivist perspective. *DAI, 65*(09A), 284.

Patten, M. L. (2007). *Understanding research methods*. Glendale, CA: Pyrcak Publishing.

Pearson, G., & Young, A. T. (Eds.). (2002). *Technically speaking: Why all Americans need to know more about technology*. Washington D.C: National Academy Press.

Rose, M. A. (2007). Perceptions of technological literacy among science, technology, engineering, and mathematics leaders. *Journal of Technology Education, 19*(1), 35-52.

Sanny, R., & Teale, W. H. (2008). Using multimedia anchored instruction cases in literacy methods courses: Lessons learned from pre-service teachers. *Journal of Literacy & Technology, 9*(1), 2-35.

Satchwell, R. E., & Loepp, F. L. (2002). Designing and implementing an integrated mathematics, science, and technology curriculum for the middle school. *Journal of Industrial Teacher Education, 39*(3). 41-66.

Schwaller, A. E. (1995). Instructional strategies for technology education. In G. E. Martin (Ed.), *Foundations of technology education: 44th yearbook, Council on Technology Teacher Education*, 29-43. Peoria, IL: Glencoe/McGraw Hill.

Topper, A. (2004). How are we doing? Using self-assessment to measure changing teacher technology literacy within a graduate educational technology program. *Journal of Technology & Teacher*

Education, 12(3), 303-317.

Zuga, K. (2007). STEM and technology education. Retrieved October 24, 2008 from http://www.iteaconnect.org/mbrsonly/Library/WhitePapers/STEM (Zuga).pdf.