Understanding Technology Literacy:

A Framework for Evaluating Educational Technology Integration

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"Learners must become aware of the available technology and its basic purpose, then implement and practice it in authentic situations if they are to reach the higher levels of technology literacy."

Abstract

Federal legislation in the United States currently mandates that technology be integrated into school curricula because of the popular belief that learning is enhanced through the use of technology. The challenge for educators is to understand how best to teach with technology while developing the technological expertise of their students. This article outlines a framework of technological literacy designed to help educators understand, evaluate, and promote effective and appropriate technology integration.

Keywords: Technology Integration; Technology Literacy; Educational Technology

It is hard not to be excited about technology. *What's not to like?* Technology makes our lives better. For some the thought of not using technology as much as possible is sacrilege. Still, it is important for us as educational technologists to step back and consider our ways. Given the trend in philosophy of science which persuasively argues that all methods are limited and so must be critically examined for their appropriateness (Burgess-Limerick, Abernathy, & Limerick, 1994), it is important to critically analyze technology literacy and how we evaluate successful integration of technology into instructional situations.

The purpose of this article is to outline a framework for understanding and assessing the technology literacy of teachers and students. Such a framework is required for understanding and properly evaluating technology integration efforts in the teaching and learning process. The proposed hierarchy, adapted from taxonomies of educational learning objectives, is based on observations from a five-year evaluation project which integrated learning technologies into sixth grade science classrooms utilizing a problem-based learning approach (Davies, Sprague, & New, 2008b). This article also draws on a recent study by the author exploring attitude differences in teaching candidates and classroom teachers towards integrating technology in teaching situations (Davies & Linton , 2008a).

The proposed framework for understanding technological literacy involves three levels: (1) awareness, (2) praxis (i.e., training), and (3) phronesis (i.e., practical competence and practical wisdom). These levels are most accurately represented as a continuum that involves a cycle of continual reeducation. Just as higher levels of cognitive development require some level of proficiency at lower levels, the highest levels of technological literacy require students to move through the lower levels. Learners must become aware of the available technology and

its basic purpose, then implement and practice it in authentic situations if they are to reach the higher levels of technology literacy. This framework of technological literacy was designed to help educators understand, evaluate, and promote effective technology integration.

A Background to Establish Context

Federal legislation mandates an emphasis on technology integration in all areas of K-12 education (U.S. Department of Education, 2002). Under this mandate, education leaders at the state and local levels are expected to develop plans to effectively utilize educational technologies in the classroom. In addition, the education system is expected to produce technologically literate students. The directive to integrate instructional technology into the teaching and learning equation results from the following fundamental beliefs: (1) that learning is enhanced through the use of technology and (2) that students need to develop technology skills in order to be productive members of society (U.S. Department of Education, 2001).

By most measures, the quality and availability of educational technology in schools along with the technological literacy of teachers and students have increased significantly (McMillan-Culp, Honey, & Mandinach, 2005; Prensky, 2001; Russell, Bebell, O'Dwyer, & O'Connor, 2003). And, while most education practitioners value technology (Davies & Linton , 2008a); many researchers and school administrators are concerned that technology is not being integrated into classroom instruction as much as theory suggests it should (Bauer & Kenton, 2005; Topper, 2004).

One problem with the expectation that technology be used in schools may involve a fundamental misconception regarding educational technology literacy. The typical method for understanding technological literacy is based on a premise of technology adoption (Hall & Khan, 2003; International Society for Technology in Education, 2007 & 2008; Moersch, 1995; Technology in Schools Task Force, 2002; Rogers, 2000). A common, but likely misguided, assumption of technology adoption suggests that technology use is the best empirical evidence that someone is in fact technologically literate. Moersch (1995), for example, provides an extremely useful framework describing levels of technology implementation (LoTi). Like other indicators, the LoTi Framework tends to rely on pervasive use of and access to advanced digital tools as an indicator of the highest level of technology integration and literacy. However, a basic premise of Bloom's taxonomy of cognitive learning outcomes suggests that the exercise of higher order skills involves the ability to evaluate proper implementation and usage beyond simply procedural knowledge (Miller, Linn, & Gronlund, 2009). This implies that an intelligent, technologically literate teacher may choose not to use certain technologies for sound, pedagogically informed reasons. A student may decide not to use a particular technology with an equally informed rationale. Assessing the highest levels of technology literacy requires something more than evidence of knowledge and use. It requires an answer for the *why* question: Why do individuals choose to utilize a specific technology or not?

Educational Technology and Technology Literacy

Although it is commonly believed that learning is enhanced through the use of technology (U.S. Department of Education, 2001), not all share a common understanding of what technology is. For many, *technology* is synonymous with computer equipment, software, and other electronic devices, and *technology integration* means using this equipment in the classroom. However, this definition is rather narrow. *Educational technology* includes any tool, piece of equipment or device--electronic or mechanical--that can be used to help students accomplish specified learning goals (Davies, Sprague, & New, 2008b). Reasons for using educational technologies may include saving time or improving the effectiveness of a student's learning efforts. Still, the uninformed or haphazard use of technology, regardless of quantity, may in fact be evidence of a lack of what Mishra & Koehler (2006) call *technological pedagogical content knowledge* or TPACK.

Technology literacy has been defined in different ways using a variety of labels. *Computer literacy*, sometimes used synonymously with the term technology literacy, refers to the knowledge and ability a person has to use computers (McMillan, 1996; National Research Council Committee, 1999) or to the comfort level someone has with using computer programs and other applications associated with computers. Similarly, the definition of *information and communication technology literacy* focuses on the ability to gather, organize, analyze, and report information using technology (Leu & Kinzer, 2000). These terms focus on specific aspects of technology literacy and have an educational context; however, the definition used for this article focuses on a

broader perspective of educational technology literacy.

Hansen (2003) has defined *technology literacy* as "an individual's abilities to adopt, adapt, invent, and evaluate technology to positively affect his or her life, community, and environment" (p. 117). Eisenberg & Johnson (2002) suggested that a technologically literate person can "use technology as a tool for organization, communication, research, and problem solving" (p. 1). Undoubtedly, developing technology literacy and implementing it well in a classroom situation likely involves a complex interaction of epistemic and pedagogical beliefs, intrapersonal factors, social factors, and affordances of the environment (Ertmer, 2005; Leu, 2006; Richardson, 1996). For the purposes of this article, technology literacy in educational situations is defined as the ability to effectively use technology (i.e., any tool, piece of equipment or device, electronic or mechanical) to accomplish required learning tasks. Technology literate people know what the technology is capable of, they are able to use the technology proficiently, and they make intelligent decisions about which technology to use and when to use it.

Technology Literacy and Today's Student Population

While interesting, the description of "digital natives" and "digital immigrants" (Prensky, 2001) does not fully explain the phenomenon of literacy in an age of technology. The assumption that students are more technologically literate than their parents simply because they are exposed to technology at an earlier age is incorrect--or rather, incomplete. Certainly people become skilled with technology only when they are aware of its function, have access to it, and practice using it. Yet exposure to technology does not make someone a technology expert any more that living in a library makes a person a literary expert. It is a common fallacy to suppose that because students are growing up in a technological age they are somehow instinctively capable of using technology to learn what is expected of them in school. Students today are no more or less capable of learning to use available technologies than students have been in the past. In fact, today's students typically use technology primarily for social pursuits (i.e., communication and entertainment) but not necessarily for academic learning (Peck, Cuban, & Kirkpatrick, 2003).

Constructing knowledge is a human activity that can be facilitated by technology, but students must go beyond seeing technology as a motivational or entertaining item and begin seeing the technology as a tool to accomplish specific learning objectives. Students are generally enthusiastic about using educational technology, but teachers sometimes mistake technology interest for technology literacy, and activity involving technology for learning through technology. Motivation to use technology is not enough; students must get past the novelty of the technology and begin to use it because they see how the tools of technology will facilitate their learning. When they gain this perspective, the technology becomes transparent, almost invisible to the learning process. Equipment with which students are familiar is more likely to be used as a learning tool. Once students start focusing on the goal of completing a learning task, using technology becomes merely a way to accomplish the expected learning (Davies, Sprague, & New, 2008b).

Technology literate people know what the technology is capable of, they are able to use the technology proficiently, and they make intelligent decisions about which technology to use and when to use it.

Research Methods

The framework presented in this study is based on the results of two studies conducted by the author. The first was an observational study that surveyed pre-service (student teachers) and in-service (practicing teachers) regarding their attitudes towards technology and technology integration. In this study an interesting trend was noted in which pre-service teachers tended to value technology much more than in-service teachers (Davies & Linton , 2008a). This first study was limited however in its ability to explain why this phenomenon occurred. The second study, which was predominately used in the development of the technology literacy framework presented in this article, was a five-year evaluation of a National Science Foundation (NSF) project which integrated learning technologies into sixth grade science classrooms utilizing a problem-based learning approach. One aspect of the evaluation was conducted using a grounded theory approach. Participating teachers, and their students, were observed regularly over a five year period as they learned to use new technology and integrate that technology into their classrooms (Davies, Sprague, & New, 2008b). A constant comparative method of data analysis was utilized in the development of the framework presented below.

Levels of Technology Literacy

Literacy Level		Type of User	Usage Level
Awareness	Functionally illiterate Limited literacy	Non user Potential user	None/resistant Limited
Praxis	Developing Experienced	Tentative user Capable user	Guided/directed Bring it on
Phronesis	Practical competence Practical wisdom	Expert user Discerning user	Power Selective

Table 1.

Characteristics of Users at Various Levels of Technology Literacy

	Typical Activity	Literacy Question
Awareness	Hear about new technologies Learn of capabilities of new technologies	What can it do?
Praxis	Practice customary implementation Explore/attempt variety of applications	How do you __? Do you? Are you?
Phronesis	Effective use of technologies capabilities Discerning/appropriate use of technologies	Why are you?

Table 2.

A Framework for Understanding and Assessing Technology Literacy

The framework presented in Tables 1 and 2 represents the way technology skills and expertise are developed. This framework involves three levels: awareness, praxis, and phronesis. The higher levels of this framework are based in the Aristotelian notion of praxis and the goal of practical competence and practical wisdom, phronesis. In this sense the highest level of technological literacy has as its objective the development of wise technology use and informed technology integration. These levels are represented as a continuum that requires a cyclical process of continual reeducation. Just as higher levels of cognitive development require lower level skills, the highest levels of technological literacy require the learner to be aware of the nature and purpose of the available technology and to practice implementation. In addition, practical wisdom, the highest level of technology literacy, cannot be attained without an authentic context.

Awareness Level

To become technologically literate, learners need to be exposed to the technology. Moving through this level they become aware of the educational technologies available to them and the basic purposes and functions involved. This is literacy at its most basic level. They are able to answer the question, *What can this technology do?* When a specific technology is mentioned, someone at this level might recall what people say about it and what can be done with it. They know about the technology but as yet are not able to use it proficiently, if at all. This is a type of declarative knowledge (Woolfolk, 2008).

Learners are more likely to successfully negotiate this level if they are actively seeking out opportunities to learn about new technologies. Resistant learners (both students and teachers) are much less likely to take the time and effort to become aware of what technologies are available and how these technologies might benefit their learning.

At this level a learner may demonstrate a rudimentary level of practical wisdom, but only in a limited sense. Teachers, for example, may choose not to learn about or become familiar with a particular technology because they recognize that their individual circumstances limit its availability or usefulness. In some schools funding for technologies may not be available. In others the limited number of computers in each classroom prevent teachers from fully and properly implementing that technology as an instructional resource. Such avoidance does not constitute the kind of practical wisdom portrayed at the phronesis level.

Praxis Level

At this level learners engage in activities that help them become familiar with the customary uses and functionality of the technology. They gain experience using the technology and are

able to accomplish simple tasks. Someone at this level is able to answer the question, *How do you use this technology?* This is a form of procedural knowledge (Woolfolk, 2008). As their technology literacy improves, learners are able to explain how a specific technology might be used to accomplish specific tasks. They would also likely answer "yes" to the question, *Are you using technology?*

Learners are most likely to succeed at this level when they are provided with expert guidance accompanied by practice involving simulated problem solving activities. Students at this stage often move from novice use to enthusiastic use. Often at this stage the quantity of use and the enthusiasm for the technology increase dramatically. Unbridled enthusiasm can, however, lead to misuse of technology. For example, a person who learns to use a spreadsheet may become enthralled with the application and use it in place of a word processor. While this can and has been done, the situation does show how overly enthusiastic users may lack technology literacy at its highest level. To the man with a hammer, every problem is a nail. Teachers at the praxis level sometime misuse technology in this way. Using technology only because one can use it or using it in a way that fails to accomplish learning goals may imply some level of competence, but may also signify a lack of practical wisdom.

Phronesis Level

At the highest level of technology literacy, learners have become adept at using technology. They are skilled at learning new technology and are not afraid to use technology to accomplish their learning goals. Still they may choose not to use technology. Someone at this level is able to answer the *why* question, *Why do I use or not use technology in this specific situation?* The highest level of technology literacy is attained when the learner develops wise technology use and informed technology integration. This level constitutes conceptual or conditional knowledge (Woolfolk, 2008). It includes reflective practice.

In order to attain a level of practical competence and practical wisdom, the learner must be able to apply technology to authentic situations. Wise and competent use of educational technology depends on context, not mandate. Appropriate and effective use of technology is context dependent and contingent on the specific learning situation. In order to work at this level of competency, the user must understand the learning task and recognize ways the technology will facilitate attainment of the learning goal.

Measuring technology literacy at this level requires a performance assessment involving an authentic situation. Observing *how* the technology is being used is important; but knowing *why* the technology is being used or not being used is essential for those who attain the phronesis level.

The Cyclical Nature of Educational Technology Literacy Development

The more one examines the issue of technology literacy, the more one becomes aware of how difficult it is to be truly technologically literate. The environment in which we live and strive for literacy is continually changing: with new and more complex technology, frequently shifting educational policies, pragmatic funding realities, and a multiplicity of instructional objectives, values and goals. In many ways technology literacy is a moving target (Leu, 2006). Thus developing this capacity involves a cycle of continual reeducation.

Certainly individuals can achieve a general degree of technological literacy; however, few people could claim to be competent with technology in every educational situation or to be literate with all educational technologies. Additionally, once an individual attains practical competency with a specific technology in a specific situation, the pragmatic or wise application of that technology may change. In addition, someone might be extremely competent with the use of some technologies and integrate them well in specific situations but fail to use the technology appropriately in other educational contexts. Being literate with educational technologies is not a one-time achievement; it is a lifelong endeavor. It involves reflective practice, and one's skills and abilities must be continually refined.

Implications for Evaluating Technology Integration in Learning Situations

For technology to be used effectively as a learning tool, both teachers and students must first become familiar with its purpose and operation. One must be able to use the technology before developing the capacity to use it as a learning tool. To gain instructional effectiveness and efficiency, guided practice seems to be much better than self-discovery. The guided practice exercises tend to reduce the amount of time required to become familiar with equipment and allow groups to get started on their primary learning activities more quickly (Da-

vies, Sprague, & New, 2008b). Both teachers and students need to expect a learning curve associated with using new technology, and practice using the equipment reduces frustration and problems at meeting expectations. However, training and practice with specific technology does not necessarily develop technology literacy that can be transferred to other situations. If teachers and students are to become truly literate with the technology, they must be provided with an authentic situation for which they are allowed to select the learning technologies. It is the ability to transfer knowledge of the technology to unique situations that makes an individual competent. It is knowing when and how to utilize specific technology that makes a person a wise user of technology.

Teachers' Technology Literacy and Technology Integration

All teachers are expected to be highly qualified. Being highly qualified, however, is not the same as being highly effective. The goal of technology integration in education is the wise and competent use of technology to facilitate learning. As teachers gain experience in the classroom their view of technology importance and potential use tends to change (Davies & Linton , 2008a). Certainly teaching can be enhanced with the use of technology, but effective use of technology requires understanding of the learning goals as well as the utility and function of the technology in accomplishing these goals. Mishra & Koehler's (2006) term *technological pedagogical content knowledge* (TPACK) accurately describes classroom teachers who demonstrate technology literacy at the phronesis level. For teachers, the authentic situation is their classroom. To teach effectively, teachers must have content knowledge (CK) and pedagogy knowledge (PK). They must understand the content they are to teach and must also know the best way to teach it. TPACK is acquired when teachers additionally gain technology knowledge (TK): when they effectively and appropriately integrate technology into the learning process. Teachers who have TPACK choose to use specific technology because they understand the pedagogy for teaching specific content and know how the technology can facilitate accomplishment of the intended learning goal. They may choose not to use advanced levels of technology when the learning might be accomplished effectively in another way or with more traditional technologies.

"It is a common fallacy to suppose that because students are growing up in a technological age they are somehow instinctively capable of using technology to learn what is expected of them in school."

When evaluating technology literacy of teachers and their effectiveness in integrating technology into their classrooms, an evaluator must first ask why a specific technology is being used. Technology use must be aligned with intended learning objectives. The reasons for using specific educational technologies might vary, but the decision of whether to implement a specific technology must ultimately lead to facilitating or accomplishing the desired learning objectives. Once the evaluation establishes why the technology is being used, the question of how well the technology is being used should be addressed. Even when appropriate tools are selected, not every teacher implements the educational technology well.

Students' Technology Literacy and Use

For students as well, developing the highest level of technology literacy involves using technology to accomplish specific learning objectives. The learning process is their authentic situation. A teacher might provide an authentic situation for students to develop a degree of competency by giving an inquiry-based or problem-based learning assignment. Students must be allowed to choose the technology they will use to accomplish the required learning. A prerequisite for developing a phronesis level of technological literacy is to train students in the use of a variety of technologies so they might gain expertise in selecting and using technology to accomplish their learning goals. Obviously having access to the technology they choose to use is a prerequisite as well.

As with teachers, observers who are evaluating technology literacy of students must first understand why a specific technology is being used. The evaluator must determine whether the students know how specific technologies might best be used, but understanding why they select specific tools for accomplishing a learning task is fundamental. After answering the *why* question, assessors should evaluate *how well* the technology was used to accomplish the learning task.

Conclusions

With the popular belief that technology enhances learning and the resulting expectation that teachers and administrators should integrate technology into their school activities (Technology in Schools Task Force, 2002; U.S.

Department of Education, 2001), technology integration has increased over the last few years (McMillan-Culp, Honey, & Mandinach, 2005; Russell, Bebell, O'Dwyer, & O'Connor, 2003). However, measuring the extent to which technology is implemented and used effectively can be challenging. While there have been several attempts to explain what technology integration might look like and how to assess technology literacy (International Society for Technology in Education, 2007, 2008; Technology in Schools Task Force, 2002), in practice these assessment strategies tend to rely on technology adoption as a key indicator when evaluating technology literacy. A use model for determining technology literacy is easy to implement but insufficient if technology literacy is to be measured at its highest level.

The conceptual framework for understanding technology literacy presented in this article involves three levels: (1) Awareness, (2) Praxis (i.e., training), and (3) Phronesis (i.e., practical competence and practical wisdom). To attain the level of phronesis, students must progress though the lower levels, as is true with other, higher level learning/thinking skills. Assessing technology literacy at the highest level requires evaluation of the quantity and quality of use; but more important, assessing technology literacy and integration at the practical wisdom level must include evaluation of the decision making process for whether to use technology. A performance assessment is necessary, involving an authentic situation in which the user must make decisions about which technology will or will not be used; assessment should focus on how well the individual accomplishes the integration task considering the intended learning objectives.

This framework of technological literacy was designed to help educators understand, evaluate, and promote effective technology integration. The progression through these levels can be visualized on a continuum that includes a cycle of continual reeducation. Due to change rate of technology innovations and the continually evolving context of practice, technology literacy is not something one attains, rather something one maintains. In order to properly integrate technology into a school setting, teacher and students must gain proficiency with specific technologies and have opportunities to select technology tools to help them accomplish their learning goals. Technology training is essential for this to occur, but this typically involves only the lower levels of literacy. Gaining practical competency and practical wisdom requires an authentic problem-based learning situation, which is not always possible in formal technology training situations, but can be feasible in a school setting. When evaluating technology integration, a proper understanding of technology is essential, but assessors should look beyond technology use and consider the reasoning behind it.

An important part of the instructional technology discipline will always include pushing the envelope to develop new ways to use technology in educational situations. Training technology users will always include becoming aware of and providing practice with new technology. However, reflective practice demands that we critically analyze our methods; in this case, why we use technology in specific situations. At times we must temper our enthusiasm for technology use and evaluate appropriate technology integration first in terms of *why* we are using the technology, then *how well* the technology was used to accomplish the learning task.

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