# Understanding Technology Literacy:
# A framework for evaluating educational technology integration.

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## Abstract

Federal legislation currently mandates the integration of technology into the school curriculum because it is commonly believed that learning is enhanced through the use of technology. The challenge for educators is to understand how best to use technology while developing the technological expertise of their students. This paper outlines a framework of technological literacy designed to helps us understand, evaluate, and promote technology integration properly.

In general, this exploration found that technology literacy in educational situations follows a somewhat natural hierarchal progression. Technology literacy starts with a basic awareness of the technology and what it can do. Technology literacy then moves to a Praxis phase of training and practice. The ultimate goal for technology literacy is to gain a level of Phronesis, a level of practical competency and practical wisdom. Technology training often fixates on the lower levels of literacy, teaching what technology can do and providing guided practice. Gaining practical competency and practical wisdom is often left to the learner. In addition, standards for technology integration tend to focus predominately on quantity of use, rather than the quality of use and the decision making process that goes into whether to use technology. When evaluations of technology integration in schools are based on a use model they often do not consider technology literacy at it highest level.

## Introduction

The purpose of this paper was to outline a framework for understanding and assessing the technology literacy of teachers and students. Such a framework is required if we are to understand and properly evaluate technology integration efforts in the teaching and learning process. The proposed hierarchy was adapted from taxonomies of educational learning objectives and 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. This project was federally funded by a Transforming Education Through Technology Ed Tech

grant. This paper also draws on a recent study by the author which explored dispositional attitude differences in pre-service and in-service teachers towards the integration of technology in teaching situations.

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). Each of these levels form a continuum that involves a cyclical aspect of continual reeducation. Just as higher levels of cognitive development require some level of proficiency at lower levels, the highest levels of technological literacy requires students move through the lower levels. Learners must gain some degree of awareness with respect to the available technology and its basic purpose; reaching the higher levels of technology literacy also requires implementation practice in an authentic situation. This framework of technological literacy was designed to helps us understand, evaluate, and promote technology integration properly.

## Background

The current Elementary and Secondary Education Act, commonly referred to as No Child Left Behind (NCLB), mandates an emphasis on technology integration in all areas of K-12 education from reading and mathematics, to science and special education (U.S. Department of Education, 2002). As a result, education leaders at the state and local levels are expected to develop plans to effectively utilize educational technologies in the classroom. In addition, the educational 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. It is commonly believed that learning is enhanced through the use of technology. It is also believed that students need to develop technology skills in order to be productive members of society (U.S. Department of Education, 2002).

One concern for many researchers and school administrators is the fact that technology is not being integrated into instruction as much as theory suggests it should (Bauer & Kenton, 2005; Topper, 2004). By most measures, the quality and availability of educational technology in schools, and the technological literacy of teachers and students have increased significantly (McMillan-Culp, Honey, & Mandinach, 2005; Prensky, 2001; Russell, M., Bebell, D., ODwyer, L., & OConnor, K., 2003). In addition, there is a general commitment to technology in education; most educational practitioners value technology (Davies, & Linton, 2008); and yet, technology is not being integrated into instruction to the degree that most expect (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; Technology in Schools

Task Force, 2002; Rogers, 2000). In assessing technology literate teachers and students, 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. However, a basic premise of Bloom's taxonomy of cognitive learning outcomes suggests that the exercise of higher order skills involves the ability to evaluation 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 choose not to use a particular technology for equally informed rationale. Assessing the highest levels of technology literacy requires something more than evidence of technology knowledge and use. It requires us to answer the "why" question. Why do individual choose to utilize a specific technology or not?

The framework for assessing and understanding technology literacy developed from this evaluation is based on a continuum similar to other general frameworks and taxonomies of cognitive development and technology adoption (Hooper & Rieber, 1995; Miller, Linn, & Gronlund, 2009). However, the higher level of this framework is based in the Aristotelian notion of praxis and the goal of practical competence or 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. The uninformed or haphazard use of technology, regardless of quantity of use, may in fact be evidence of a lack of what Mishra & Koehler (2006) call Technological Pedagogical Content Knowledge or TPCK.

**Educational Technology**

The integration of technology into the school curriculum is mandated by NLCB legislation because it is commonly believed that learning is enhanced through the use of technology (U.S. Department of Education, 2002). However, not all share a common understanding of what technology is. For many, technology is synonymous with computer equipment, software, and other electronic devices. Technology integration means using this equipment in the classroom. However, this is a very narrow definition of technology. Educational technology includes any tool, piece of equipment or device, electronic or mechanical, which can be used to help students accomplish specified learning goals.

The purpose for using educational technology is to enhance learning, however, learning does not take place simply because technology is used (Kleiman, 2000). Learning also happens without technology. In a technology enhanced learning environment, technology may get in the way if it fails to function correctly or could be accomplish well enough or even better without the use of certain technology. Selecting which technologies to use and when to use them is important. For example, a pen and paper or a word processor are both technologies that can and are used in classrooms. Integrating these technologies properly into the instructional process is a matter of both practical competence and practical wisdom. In order for a learning activity to be improved, the technology selected must be effectively and purposefully utilized in a way that

enables the intended learning objectives to be accomplished (Fisher, Dwyet, & Yocam, 1996; Kozma & Croninger, 1992; Lemke, 2005). One must understand the instructional purpose and how the technology might be utilized best to accomplish that purpose. Knowing how to use the technology is important but knowing when to use technology is more important.

Reasons for using educational technologies might be to save time or improve the effectiveness of a student's learning efforts. For example, a digital thermometer that tracks changes in temperature over time can be used along with a spreadsheet to produce charts and graphs quickly and correctly. Rather than spending time recording data then creating charts and graphs by hand, students could focus on other possibly more important aspects of the learning like interpreting the information. Sometimes the technology enables learning activities to take place. Some laboratory investigations are simply too dangerous to be carried out in the classroom. These experiments can however be simulated with technology. Without educational technologies these learning activities would be relegated to a traditional lecture based classroom situation where students are either told the information or asked to read about the concepts in textbooks. In both these situations the technology used would be less effective if teacher and students were not skilled in the use of the technology. In both these situations the decision to use technology should be based on an understanding of how the technology will facilitate the intended learning.

**Technology Literacy in Education**

Students and teachers are expected to gain skill or expertise with the educational technologies they will employ. However, educator at times struggle trying to define and measure technology literacy. Technology literacy has been defined in different ways using a variety of labels. Computer literacy is sometimes used synonymously for the term technology literacy. Computer literacy refers to the knowledge and ability a person has to use computers (McMillan, 1996; National Research Council Committee, 1999). It can also refer to the comfort level someone has with using computer programs and other applications that are associated with computers. Likewise, the definition of information and communication technology literacy focus on the ability to gather, organized, 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 paper focuses on a broader perspective of educational technology literacy.

Hansen (2003) defines 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) suggest that a technologically literacy person can 'use technology as a tool for organization, communication, research, and problem solving' (p. 1). For the purposes of this paper, 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 a 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.

**Understanding Technology Literacy in Education**

While interesting, the description of digital natives and digital immigrants (Prensky, 2001) does not fully explain the phenomenon of literacy in a technology age. The assumption that students are more technologically literate simply because they are exposed to technology is incorrect, or rather, incomplete. Certainly people become skilled with technology only when they are made aware of its function, have access to it, and practice using the technology. Still, 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 that they are somehow instinctively more able to use 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). Students enjoy using technology, and many of them have good information-gathering skills, but often they lack sophistication in understanding and evaluating the information they retrieve (Stucker, 2005). Technology proficiency in some areas (e.g., Internet, email/texting, facebook, computer games, or iTunes) often results in a deceptive sense of self-sufficiency. Educators sometimes mistake this confidence, or lack of inhibition, for skillfulness in using instructional technology for academic purposes. Too often many of these students have little or no working knowledge of the educational technologies being provided to them to facilitate their academic learning. They must be taught.

Constructing knowledge is a human activity that can be facilitated by technology; yet, 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 interest in the technology for technology literacy, and activity involving technology for learning. 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 technology, as a tool, will facilitate their learning. When this happens 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 simply becomes a way to accomplish the expected learning (Davies, Sprague, & New, 2008).

## A Framework for Understanding and Assessing Technology Literacy

The framework presented in Tables 1 and 2 are a representation of the way technology skill and expertise is developed. This framework for understanding technological literacy 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. Each of these levels form a continuum and involve a cyclical aspect of continual reeducation. Just as higher levels of cognitive development require lower level skills, the highest levels of technological literacy requires the learner to be awareness of the available technology and their basic purpose; it also requires implementation practice. In addition, practical wisdom, the highest level of technology literacy, cannot be attained without an authentic context.

Table 1

*Levels of Technology Literacy*

| Literacy Level | | Type of User | Usage Level |
|---|---|---|---|
| Awareness | Functionally Illiterate<br>Limited literacy | Non user<br>Potential user | None/Resistant<br>Limited |
| Praxis | Developing<br>Experienced | Tentative user<br>Capable user | Guided/Directed<br>Bring it on |
| Phronesis | Practical Competence<br>Practical Wisdom | Expert user<br>Discerning user | Power<br>Selective |

Table 2

*Characteristics of users at various levels of technology literacy*

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

### Awareness Level

For someone to become technologically literate they need to be exposed to the technology. As people move through this level they become aware of the educational technologies available to them and the basic purpose and function of that technology. They are

able to answer the question, what can this technology do? This is literacy at its most basic level. When a specific technology is mentioned, someone at this level might recall what people say about it and remember the technology's function. They know about the technology but as yet are not able to use the technology proficiently, if at all. This is a type of declarative knowledge.

Learners are more likely to successfully negotiate this level if they are actively seeking out opportunities to learn about new technologies. Resistant learners (i.e., both students and teachers) would be much less likely to take the time and effort to develop an awareness of what technologies exist 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 the futility of that effort given their individual circumstances. Funding for technologies may not be available. One computer in a classroom is unlikely to allow a teacher to fully and properly implement that technology as an instructional resource in their classroom. This however 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 task with the technology. Someone at this level is able to answer the question, how do you use this technology? This is a form of procedural knowledge. As a learner's technology literacy improves, they would be 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?

Learner are most likely to succeed at this level when they are provided with expert guidance coupled with practice involving simulated problem solving activities. Students at this stage often move from a novice user to an enthusiastic user. Often the quantity of use at this stage and the enthusiasm for the technology increases dramatically. Unbridled enthusiasm can however lead to misuse of technology. Consider, for example, the person who learns to use a spreadsheet and is so enthralled with the application that they use it in place of a word processor. While this can and has been done, this is an example of how overly enthusiastic users may lack technology literacy at its highest level. To the man with a hammer, every problem is a nail. The uninformed or haphazard use of technology, regardless of the quantity of use, may in fact be evidence of a lack of what (Mishra & Koehler, 2006) call Technological Pedagogical Content Knowledge or TPCK. This is sometimes seen with teachers at the praxis level. Using technology because you can or in a way that does not accomplish the 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 with the development of wise technology use and informed technology integration. This is a type of conceptual or conditional knowledge. It is a reflective practice.

In order to attain a level of practical competence and practical wisdom, the learner must have an authentic situation in which to use technology. Wise use of a technology is context dependent and is not based on mandates for technology use. Wise and competent use of educational technology is dependent on the appropriate and effective use of technology given a specific learning situation. In order to work at this level of competency the user must understand the learning task and how the technology will facilitate the 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 would be important; but knowing why the technology is being use or not being used is essential in determining technology literacy at this level.

## The Cyclical Nature of Developing Educational Technology Literacy

The more you look at the issue of literacy the more you find how difficult it is to truly be technologically literate. The environment in which we exist and strive for literacy is subject to an ever changing context, rapidly changing technology, the reality of educational policies, the pragmatic realities of funding, and the multiplicity of instructional objectives, values and goals. In many ways technology literacy constitutes a moving target. This is why developing literacy involves a cyclical maintenance aspect of continual reeducation.

Certainly it may be possible for individuals to achieve a general degree of technological literate, however, few people could claim to be competent with technology in every educational situation or to be technologically literate with all educational technologies. In fact, once practical competency with a specific technology in a specific situation is obtained 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 is specific situations; that same person might fail to use the technology appropriately in other educational situations. The concept of being literate with educational technologies is not a one time achievement; being literate is a lifelong endeavor. It involves reflective practice. It is also subject to an individual's ability to effectively use the technology and the continual refinement of one's skills and abilities.

## Implications for Evaluating Technology Integration in Learning Situations

In order for technology to be used effectively as a learning tool, both teachers and students must first become familiar with its purpose and operation. Being able to use the technology is an essential prerequisite to the effective utilization of technology as a learning tool. In terms of instructional effectiveness and efficiency, a guided practice approach seemed to be much better than a self-discovery approach. Engaging in guided practice exercises with the equipment tends to reduce the amount of time required to help students become familiar with equipment and allows students as a group to get started on their primary learning activities more quickly (Davies, Sprague, & New, 2008). For both teachers and students there will be a learning curve associated with using technology that is new to them; practice using the equipment reduces frustration and problems when students are expected to complete a learning activity enabled by the technology. However, providing training and practice with specific technology does not necessarily develop technology literacy that can be transferred to other situations. If individuals, teachers and students, are to become truly literate with the technology they must be provided with an authentic situation where they are allowed to select the learning technologies they will use. It is the ability to transfer their knowledge of the technology to unique situations that makes an individual competent. It is knowing when and how to utilize specific technology that makes them wise users of technology.

### Evaluating 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. Certainly teaching can be enhanced with the use of technology, but an understanding of the learning goals as well as the utility and function of the technology in accomplishing these goals is needed if the technology is to be used effectively. Mishra & Koehler, (2006) use the term Technological Pedagogical Content Knowledge, or TPCK, when describing classroom teachers who demonstrate technology literacy at the phronesis level. For teachers, the authentic situation is their classroom. In order to demonstrate technology literacy, teachers must have content knowledge (CK) and pedagogy knowledge (PK). In other words, they must understand the content they are to teach; they must also know the best way to teach the content they are expected to teach. TPCK is acquired when teachers gain technology knowledge (TK), in other words, when they effectively and appropriately integrate technology into the learning process. Teachers who have TPCK choose to use specific technology because they understand the pedagogy for teaching specific content and how the technology will facilitate the accomplishment of the intended learning goal. They may choose not to use technology when the learning might be accomplished effectively in another way or with other technologies.

When evaluating technology literacy of teachers and how well they integrate technology into their classroom, the first question an evaluator must ask is why a specific technology is being used. The alignment of technology use with intended learning objectives is required. The reasons for using specific educational technologies might vary but the decision to implement a specific technology, or not, 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.

### Evaluating Students' Technology Literacy

For students in school, developing the highest level of technology literacy also involves using technology to accomplish specific learning objectives. The learning process becomes an authentic situation for them. Providing an authentic situation for students to develop a degree of competency might involve inquiry based or problem based learning situations. A key element in this would include allowing students to choose the technology they will use to accomplish the required learning. A prerequisite for the development of a phronesis level of technological literacy would be to train students in the use of a variety of technologies so they might gain expertise in the wise and competent use of technology to accomplish their learning goals. Obviously having access to the technology they choose to use is a prerequisite as well.

When evaluating technology literacy of students, again the first question to ask is why a specific technology is being used. A related issue would be to determine whether the student understands how specific technologies might best be used but understanding why they select specific tools for accomplishing a learning task is fundamental in any evaluation of a student's technology literacy. Once you have answered the why question you should then evaluate how well the technology was used to accomplish the learning task.

## Conclusions

Teachers, students and administrators are expected to integration technology into their school activities because it is commonly believed that learning is enhanced through the use of technology (Technology in Schools Task Force, 2002; U.S. Department of Education, 2002). As a result of this expectation, technology integration has increased over the last few years (McMillan-Culp, Honey, & Mandinach, 2005; Russell, M., Bebell, D., ODwyer, L., & OConnor, K., 2003). However, measuring the extent to which technology is implemented and used effectively can be a challenging task. 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), the focus of these assessment strategies tends 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 paper involves three levels: (1) Awareness, (2) Praxis (i.e., training), and (3) Phronesis (i.e., practical competence and practical wisdom). Just as higher levels of cognitive development require some level of proficiency at lower levels, the highest levels of technological literacy requires students move through the lower levels. Assessing technology literacy at the highest level requires an evaluation of the quantity and quality of use; but more important, assessing the practical wisdom level of technology literacy must include an evaluation of the decision making process that goes into whether to use technology. Assessing technology literacy at the highest level requires a performance assessment involving an authentic situation in which the user must make decisions about which technology will, or will not but used; then an assessment of how well they accomplish the integration task considering the intended learning objectives.

This framework of technological literacy was designed to helps us understand, evaluate, and promote effective technology integration. Each of these levels forms a continuum that involves a cyclical aspect of continual reeducation. Due to rate of technology innovations and an ever changing context of practice, technology literacy is not something one attains, rather something we maintain. 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 typically functions at the lower levels of literacy. Gaining practical competency and practical wisdom requires an authentic problem based learning situation. This cannot always be done in formal technology training situations, but there are plenty of opportunities for assessing technology literacy in a typical school setting. When evaluating technology integration a proper understanding of technology is essential. The evaluation should look beyond technology use and consider the reason for using the technology.

## References


Bauer, J., & Kenton, J. (2005). Toward Technology Integration in the Schools: Why It Isn't Happening. *Journal of Technology and Teacher Education, 13*(4), 519-546.

Davies, R., & Linton , J. (2008, Mar) *Understanding Dispositional Dissonance*. Paper presented at the Michigan Academy of Science, Arts & Letters Annual Meeting at Western Michigan University, Kalamazoo, MI.

Davies, R., Sprague, C., & New, C. (2008) Integrating Technology into a Science Classroom: An evaluation of inquiry-based technology integration. In D.W. Sunal, E. L. Wright, & C. Sundberg (Eds.), *The Impact of Technology and the Laboratory on K-16 Science Learning series: Research in Science Education* (pp. 207-237). Charlotte, NC: Information Age Publishing, Inc.

Eisenberg, M.B. & Johnson, D. (2002) *Learning and Teaching Information Technology: computer skills in context, ERIC Digest*. ERIC Document Reproduction No. ED 465 377.

Fisher, C., Dwyet, D., & Yocam, K. (1996). *Education and technology: Reflections on computing in classrooms*. San Francisco, CA: Jossey-Bass.

Hall, B., & Khan, B. (2003). *Adoption of New Technology*. NBER Working Paper. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=410656.

Hansen, J. W. (2003) To Change Perceptions of Technology Programs, *Journal of Technology Studies, 29,* 16-19.

Hooper, S., & Rieber, L. (1995). Teaching with Technology. In A. C. Ornstein (Ed.), *Teaching: Theory into practice*, (pp. 154-170). Needham Heights, MA: Allyn and Bacon.

International Society for Technology in Education (2007). *National Educational Technology Standards for Students*. Retrieved from http://www.iste.org/AM/Template.cfm?Section=NETS

International Society for Technology in Education (2008). *National Educational Technology Standards for Teachers*. Retrieved from http://www.iste.org/AM/Template.cfm?Section=NETS

Kleiman, G. M. (2000). Myths and realities about technology in K-12 schools. In the Harvard Education Letter Report [online]. *The digital classroom: How technology is changing the way we teach and learn.* Retrieved from http://www.edletter.org/dc/kleiman.htm

Kozma, R. B., & Croninger, R. G. (1992). Technology and the fate of at-risk students. *Education and Urban Society, 24*(4), 440-453.

Lemke, C. (2005). Measuring progress with technology in schools. *THE Journal, 32*(9), 16-20.

Leu, D. J., & Kinzer, C. K. (2000). The Convergence of Literacy Instruction With Networked Technologies for Information and Communication. *Reading Research Quarterly, 35*(1), 108-127.

McMillan, S. (1996). Literacy and computer literacy: Definitions and comparisons. *Computer & Education, 27*(3-4), 161-170.

McMillan-Culp, K., Honey, M., & Mandinach, E. (2005). A Retrospective on Twenty Years of Educationa Technology Policy. *Journal of Educational Computing Research, 32*(3), 279-307.

Miller, M. D., Linn, R. L. & Gronlund N. E. (2009). *Measurement and Assessment in Teaching* (10th ed.).

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A new framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054.

National Research Council Committee on Information Technology Literacy. (1999). *Being fluent with information technology.* Washington, D.C.: National Academy Press.

Peck, C., Cuban, L., & Kirkpatrick, H. (2003). High-tech's high hopes meet student realities. *Education Digest, 67*(8), 47-54.

Plouffe, C., Hulland, F., & Vandenbosch, M. (2001). Research Report: Richness Versus Parsimony in Modeling Technology Adoption Decisions. *Information Systems Research, 12(*2), 208-222.

Prensky, M. (2001). Digital Natives, Digital Immigrants . *On the Horizon, 9*(5).

Rogers, P. (2000). Barriers to Adopting Emerging Technologies in Education. *Journal of Educational Computing Research , 22*(4), 455-472.

Russell, M., Bebell, D., ODwyer, L., & OConnor, K. (2003). Examining Teacher Technology Use: Implications for Preservice and Inservice Teacher Preparation . *Journal of Teacher Education, 54*(4), 297-310.

Stucker, H. (2005). Digital "natives" are growing restless. *School Library Journal, 51*(6), 9-10.

Technology in Schools Task Force (2002). *Technology in Schools: Suggestions, Tools, and Guidelines for Assessing Technology in Elementary and Secondary Education*. Retrieved from http://nces.ed.gov/pubs2003/tech_schools/chapter7.asp

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 and Teacher Education, 12*(3), 303-317.

U.S. Department of Education, Office of Elementary and Secondary Education (2002). *No child left behind: A desktop reference.* Retrieved from https://www.ed.gov/admins/lead/account/nclbreference/page.html