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# Technology-enriched learning environments : creating a classroom environment for the 21st century

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## Abstract

The purpose of this literature review is to examine technology-enriched learning environments in order to implement proper and effective use – changing the classroom as we know it. The review provides a definition and descriptions of technology-enriched learning environments, research based evidence of how they affect-teachers and students, and three key barriers preventing institutionalization of technology-enriched learning environments. Key search terms include *technology-enriched learning environments, academic achievement, curriculum, teacher role, technology infusion,* and *professional development.*

This review concludes that with rapid developments and implementations of technology into the educational setting, educators, administrators and technology leaders need to be provided with a system of professional development and support. A constructivist pedagogy must also be present to effectively implement a technology-enriched learning environment that supports teacher and student achievement and development.

# Technology- Enriched Learning Environments:

# Creating a Classroom Environment for the 21st Century

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## ABSTRACT

The purpose of this literature review is to examine technology-enriched learning environments in order to implement proper and effective use - changing the classroom as we know it. The review provides a definition and descriptions of technology-enriched learning environments, research based evidence of how they affect teachers and students, and three key barriers preventing institutionalization of technology-enriched learning environments. Resources used to complete this review were research-based articles from peer-reviewed journals as well as books. Key search terms include *technology-enriched learning environments, academic achievement, curriculum, teacher role, technology infusion, and professional development.* This review concludes that with rapid developments and implementations of technology into the educational setting, educators, administrators and technology leaders need to be provided with a system of professional development and support. A constructivist pedagogy must also be present to effectively implement a technology-enriched learning environment that supports teacher and student achievement and development.

# INTRODUCTION

Students in schools across the world are connecting through virtual worlds, chat rooms, social networks, videoconferencing, cell phones, and the Internet. With rapid developments of these technologies this list continues to grow, as does the need for students to want to use them. Programs such as Global Schools Network (Global SchoolNet, 2007) and One Laptop Per Child (OLPC) (Negroponte, 2002) are enabling teachers and students to connect globally, enhancing the curriculum, expanding opportunities, and preparing students with 21st century skills. The task of connecting and communicating seems fairly easy for students as they have been born into a technology-enriched society. Farwick-Owens, Hester and Teale (2002) suggest that, "Access to technology makes school seem more 'real world' to the students and consequently, their learning pushes the boundaries of the traditional school curriculum" (page 620). Technology integration is more than just learning basic computer skills and software applications in a computer applications class. It's effectively integrating technology into an environment where it is used transparently in daily instruction and supports the curriculum (Edutopia Staff, 2008). Technology-enriched learning provides the likelihood that students will stay engaged and on task, reducing behavior problems. It can change the way teachers teach and offers other avenues to reach the multiple learning needs of students. Teachers, however, are still struggling to adopt and integrate these new technology tools and principles within the classroom causing researchers to question whether or not technology integration is the answer to student learning and success (Christensen & Knezek, 2001; Cuban 1986; Healy 1998; Keller & Bichelmeyer, 2004; Li, 2007; Prensky, 2006).

With technology as a driving force in education reform for 21st century learning, today's teachers are being challenged to integrate technologies into their daily instruction (NETS-S, 2007; NETS-T, 2007; Prensky, 2004). This trend towards enriching the learning environment has inspired the reviewer to define a technology-enriched learning environment, identify what major barriers exist in preventing institutionalization of technology-enriched learning environments, research how it is best used by the classroom teacher to foster student learning and implementation, and discover how students are benefiting from it. The analysis of this topic is important because if the reviewer examines what the research says about the effectiveness or ineffectiveness of technology-enriched environments for students and teachers then he/she can establish instructional design procedures (Reiser & Dempsey, 2002), and identify a model of professional development to help other educators make these environments more effective and efficient for future use by students, teachers, and school districts.

The purpose of this literature review is to examine technology-enriched learning environments and their impact on student learning and teacher use in support of changing the traditional classroom environment. This review will answer the following questions:

1. What is a technology-enriched learning environment?
2. What key barriers are affecting institutionalization of technology-enriched learning environments in an educational setting and implications for change?
3. How do technology-enriched learning environments impact teacher attitudes and beliefs about teaching with technology?
4. How do technology-enriched learning environments impact student achievement and development?

# METHODOLOGY

In locating valid resources for this review the reviewer accessed multiple online databases available through the University of Northern Iowa's Panther Prowler. The two main databases used were Wilson Web Education Full Text and EBSCO Full Text. The World Wide Web was used in addition to these databases. In conducting online searches Google and Google Scholar were used.

During the search process, the reviewer found a wide variety of resources available using technology-enriched learning environments as the primary descriptor. To narrow the searches, the reviewer used technology-enriched learning environments (with and without hyphen), academic achievement, curriculum, teacher role, technology infusion, 21st century learning, and professional development as key words and descriptors.

In selecting the sources to analyze, the reviewer used credible databases that provided full text articles found in peer reviewed journals with a date range of 1996 - 2008. The quality of the content presented in the article abstract as well as the relevance of the information in relation to the topic was also leading criteria in the analysis process. After conducting Internet searches, using Google Scholar, the reviewer selected articles that were cited in many articles (50 or more) and provided background information about the author(s). Sites with a domain of .edu and .org were also used as leading criteria. If a valid article was not available online then the reviewer used the above mentioned databases to locate a copy.

# ANALYSIS AND DISCUSSION

## The Technology-Enriched Learning Environment Defined

Walking into a classroom labeled *technology-enriched,* one would find an environment of "tools" that are not dependent upon the subject matter being taught, but rather integrated across the curriculum at any grade level and subject area. Hopson, Knezek, and Simms (2002) describe a technology-enriched learning environment as an environment that provides "active learning, authentic tasks, challenging work, complex problem solving, and higher-order thinking skills" (p. 110). Page (2002) defines a technology-enriched learning environment as an environment that promotes lifelong technology-enriched learning environment is an environment of many technology tools therefore not every classroom will have similar tools. However, it is for certain that a learning habits with a commitment for further learning or learning to learn. A technology-enriched environment will contain constant activity and collaboration among students and teachers.

Findings from several research studies (Staples, Pugach, & Himes, 2005; Sugar 2005; Dove & Zitkovich, 2003) suggest that a true technology-enriched environment provides students and teachers with an abundance of tools (hardware and software). Hardware may consist of several computers in a classroom, handheld personal data assistants (PDAs), digital cameras, audio/video recording devices, smart boards, and more recently a laptop for every student. Hardware and software are accessible at all times with the ability to be portable for travel outside of the school walls. Technology-enriched environments enable students to improve higher-order thinking skills, work in peer collaborative groups, maintain control of their own learning, and feel successful in

accomplishing tasks (Dove & Zitkovich, 2003; Hopson et al. 2002; Mayer-Smith et al. 2000; Page 2002;).

Recent research efforts from Lowther, Ross, and Morrison (2003), Staples et al. (2005), Dove and Zitkovich (2003), and Garthwait and Weller (2005) provide evidence that students and teachers are benefiting from technology-enriched learning environments in terms of comfort levels of implementation and use in a daily school routine, but this has not always been the case. In order for the reader to better understand how a technology-enriched environment can fully impact the daily activities of student and teachers, it is necessary to review a brief history of technology-enriched learning environments and how they have evolved the classroom.

## Evolution of Technology in Education

The technology-enriched classroom began in the early 1900s with the introduction of silent film for use as an instructional aid in the classroom. By the 1920s, the excitement of silent film began to slowly diminish and the introduction of the radio set began. This new form of technology was used to enrich the learning environment and lasted well into the mid 1940s. Cuban (1986) states that, "radio sets had failed to become as common in the classroom as the blackboard. Nor had they achieved this by the 1950s when the enthusiasm for television kindled the dreams of another generation of school reformers" (p. 26). By 1982, the computer became the new promise of technology in education, and "in 1984 it was reported that there was one computer for every 125 students and in 2000 one computer for every 5 students in public schools" (Mouza, 2002, p. 272). Once these wonder machines were in place, the introduction of the Internet in the mid-1990s and more advanced computer-based technologies gave teachers new insight to

more technology use and allowed teachers to enhance their curricula in a variety of ways. Thus the use of technology in the education system began to flourish (Bebell, Russel, & O'Dwyer, 2004) and the traditional look of the classroom started to transform from one full of simple tools (blackboard, television set, film projector) to one full of advanced technology tools, earning the label "Technology-Enriched Learning Environment." While a new label was established for implementation and dissemination purposes, this type of the environment has yet to become fully institutionalized in the education arena. Developers of technology, business and community advocates, and many forward thinkers in education reform envisioned an environment that would flourish and prepare students for a technology-filled future. A cycle of implementation failures surfaced, however, and many factors that caused teachers to be afraid and unsure of what technology had to offer and how to implement it effectively in their daily instruction still exist today.

## Barriers to Successful Implementation

During the early 1980s-1990s advocates for technology use in education poured funding into hardware acquisition and training, in support of creating technology-enriched learning environments in the educational setting. The education world however, was not as successful in implementing these tools as other industries have been (Page, 2002). Cuban (1986), Becker (2000), Healy (2002), and Page (2002) cite lack of equipment, funding, training, and proper use as causes for the unsuccessful implementation of technology tools in an educational setting.

Cuban (1986) suggests that time constraints, lack of funding, and lack of teacher training are all contributing factors to the failure of technology-enriched learning

environments. He also predicted that "most teachers will use computers as an aid, not unlike radio, film, and television" (p. 99). To further investigate Cuban's argument, Becker (2000) began conducting the *Teaching, Learning, and Computing* (TLC) survey in 1998. The TLC website contains nine full reports that represent best practices of technology use in education. Findings from these surveys agreed with Cuban's argument that there are many factors limiting computer use in the classroom. Based upon these findings Becker (2000) suggests that technology-enriched learning environments can work in education under certain conditions. Those conditions being (a) teachers are comfortable and possess moderate skills in computer use, (b) the daily school schedule allots ample time for computer use on assigned tasks, (c) an abundance of equipment is available and accessible, and (d) the teacher's philosophy supports that of constructivist pedagogy. Two similar findings in both Cuban's (1986) and Becker's (2000) research were limited time and access to equipment as well as the teacher's role in the learning environment. Together these researchers report weaknesses in the usefulness and effectiveness of investing in technology in education, and with this long list of weaknesses one wonders where to begin. For the purpose of this review the reviewer has chosen to focus on three main barriers affecting the cycle of technology integration necessary to implement technology-enriched learning.

## Main Barriers

Three main factors affecting full implementation of technology-enriched learning environments are an absence of constructivist based pedagogy, an absence of on-going professional support for teacher's technology use, and lack of support at the

administrative level (Healy, 1998; Marra, 2004; Savery & Duffy, 1995; Sugar, 2005; Staples et al., 2005).

### *Teacher Pedagogy*

*Constructivism* is a learning theory that describes how learners construct new knowledge from prior experiences. Many associate constructivist theories to teacher *pedagogy* but it is important to remember that pedagogy is the way in which a teacher teaches and constructivism is a learning theory. However, when following the theories of constructivism one begins to change their teaching practices to promote an active learning environment which students learn by doing and build upon prior experiences creating an environment with a constructivist approach to learning. Healy (1998) describes Papert's idea of constructivism as "all learners absorb and remember best when they themselves 'construct 'or figure out the underlying principles of the lesson rather than having the teacher 'spoon-feed' it to them" (p. 25). When using a constructivist or project-based approach to learning with technology, students become reflective thinkers and problem solvers. Judson (2006) suggests that using technology is not a goal of constructivism but rather constructivism allows for the use of technology. Technology allows students to access resources outside of the classroom, connect with each other, and work together to collaborate and solve real world problems (Marra 2004; Mayer-Smith et al., 2000; Savery & Duffy, 1995). Students are enabled to construct new knowledge from prior knowledge and begin to use a form of reflective reasoning described by Palloff and Pratt (1999) as *triple loop learning*. Marra (2004) suggests that in order for the teacher to promote an active learning environment, where the teacher is the facilitator and the students are in charge of the work, the teacher must possess constructivist qualities and a

project-based approach to learning. In their quest to provide a clear framework of constructivism Savery and Duffy (1995) outline eight principles to implementing constructivist based approach to learning within the learning environment. To create a constructivist learning environment the teacher must:

1. Anchor the learning to a larger problem.
2. Support the learner to develop ownership of the problem.
3. Design an authentic task.
4. Design a complex learning environment.
5. Step aside and allow the learners to have ownership of how they complete the task.
6. Design a learning environment that supports and challenges the learner.
7. Use alternate assessment procedures.
8. Allow for reflection of the problem and process. (p. 3)

Researchers such as Becker (2000), Cuban (1986), Mayer-Smith et al. (2000), Mara (2004), Mouza (2003), Lowther, Ross, and Morrison (2003) provide a common ground of research that suggests teachers who use constructivist pedagogy within a complex learning environment to achieve higher-order thinking skills will be more successful in implementing a technology-enriched learning environment. It is not only the teacher's use of the tools, but rather how she is using these tools to improve engagement and higher-order thinking skills of the students. In support of creating technology-enriched learning environments, with students in mind, the International Society of Technology in Education (ISTE) created the National Educational Technology Standards for students (NETS-S). NETS-S identifies six standards that include (a) creativity and

innovation; (b) communication and collaboration; (c) research and information fluency; (d) critical thinking/problem solving and decision-making; (e) digital citizenship; and (f) technology operations and concepts (ISTE, 2007). These standards aid teachers in incorporating computer skills in daily instruction without specifically teaching the skills. ISTE also created the National Educational Technology standards for teachers (NETS-T) that identifies five standards teachers should meet when designing, implementing, and assessing learning for students with technology (ISTE, 2007).

Constructivist-based pedagogy allows the teacher to create learning situations that are real world by helping the students understand meaning and make connections (Keller & Bichelmeyer, 2004). In order to implement constructivist pedagogy in technology-enriched learning environment, however, teachers must be properly trained in using technology, and feel comfortable using it. Studies show that those who learn how to use technology while learning to teach content are more likely to use technology effectively in the classroom (Adcock, 2008).

### *Professional Training*

Teachers need to feel comfortable and ready to use technology before integrating it into a classroom environment for their students. In recent years technology has been used by teachers to complete daily administrative tasks such as record keeping, e-mails, creating documents, etc. Many school districts provide in-service training that focuses on completing daily administrative tasks as software changes. However, funding to support in-service programs that allow teachers to collaborate and share ideas for integrative technology use in the classroom is lacking. In a nationwide survey conducted by Rother (2003), over 600 public and private school teachers identified a need for more technology

integration training. A larger majority (76%) of the respondents identified a need for more training to "make best use of the technology in the classroom" (p. 37). Many teachers that participated in the survey had less than five hours of integrated technology training while 33% reported no training within one year. Teachers with little to no computer training (45%) believed computers to be very useful, as did those (60%) with more than five hours of training. Many teachers reported learning computer skills through daily use and trial and error. They also believe that computers are very useful for student activities however; this is not a strong indicator that they are comfortable creating daily lessons that include the use of multiple technology tools. According to Keller and Bichelmeyer (2004) "professional development is the necessary nexus between accessible technology and technology integration" (p. 19), and the teacher must learn how to use the technology and then "be helped" to learn how to use it effectively with their students.

Through the *Eiffel Project,* Mouza (2003) developed a twelve-week research study in the spring of 2000 which was divided into two separate sessions. The workshops allowed teachers to participate in hands-on technology training to support technology integration in the classroom. They also helped teachers gain technical skills needed to operate the hardware and software they would be using in their classroom. Fifteen teachers from six different schools, with one to thirty-four years of teaching experience participated in these workshops. Of the fifteen participants three teachers were selected, using special criteria, to be part of an in-depth case study analysis. During the first session, eight weeks of two hour workshops, the teachers learned technical skills as well as how and when to use technology in their daily instruction. The second session, or final

four weeks of the study, participants were required to develop and implement their own lessons that integrated technology. During the last four weeks of the study research staff conducted weekly on-site visits and helped teachers adapt and implement technology projects, as outlined in their newly created lessons, to enrich the curriculum (Mouza, 2003). Findings from this study report that to effectively implement a technology-enriched environment teachers must:

1.) Be provided with a sound "ongoing professional development program".

2.) Align professional development training with the teachers' needs.

3.) Provide a peer support program.

4.) Provide strong and ongoing administrative support. (p. 287)

Mouza (2003) also suggests that the teachers must have proper training to develop a facilitator role and be forward thinkers not complainers. The participants who improved their technical skills and practiced implementing technology-enriched projects felt more prepared to work in the technology-enriched environment. They also had more confidence in presenting these lessons to their students.

Similar to Mouza's research, Sugar (2005) conducted a study in which he tested the usefulness of a "technology coach program" using a "bottoms-up" approach. For this study Sugar began a six-week pilot study during the 2000-2001 school year with five high school teachers from the same school district. At the culmination of the six-week pilot study he expanded his research efforts to further investigate this approach. For his expanded research the original five high school teachers were used in addition to four other schools. All teachers in the additional schools (two elementary and two middle) taught in the same school district as the high school teachers. Nine teachers, six female

and three male, participated in the study for a period of four months. The main goal of the program was for teachers to receive professional development in integrating technology tools available in the classroom. The program also focused on building technology skills and ability levels by providing participants with several projects tied to the curriculum. Through the *Technology Coach Program* one coach with an instructional technology degree and teaching experience met with teachers on a weekly basis. During the meetings the topic of discussion was up to the teacher and the coach was "instructed to be empathetic to the teachers' needs" (p. 553). Results of this research indicated that of the 50 projects the teachers participated in, 94% of them were rated effective or very effective. The teachers also reported that this type of program was the most effective training they had received for the first time in many years. They wished to continue this program as it provided them with learning that they needed, and gave them confidence to use technology within the curriculum. Because this program built upon teachers' individual technology skills and abilities, the teachers felt more comfortable using the technology and some began to try new technology projects on their own. Many of the teachers who participated in this program commented that they received the technology training and collaboration they needed through several training sessions, unlike a day of in-service where one set of skills is addressed. Lastly, another crucial aspect of this research project was that the administration was included throughout the implementation of the project. While the effect of administrative support on the success of the teachers was not documented, administrators were asked to complete surveys about their teachers' experiences with the technology coach project. This information was used to document the effectiveness of the program as well as the teacher experiences. The administrators

surveyed reported that "the technology coach project should continue during the next school year" (Sugar, 2005, p. 555).

Staples et al. (2005) provided findings similar to that of Mouza and Sugar. In their research study three schools with very different and unique urban school demographics worked with a local university to receive PT3 grant funding to create a technology-enriched learning environment and provide teacher training for implementing the technology. One school was a year-round neighborhood school consisting of about 700 students. Eighty-five percent of the student population was African-American and students with disabilities were integrated into general education classes. The second school had a student population of 650 and 72% of the students were African-American with two-thirds qualifying for free and reduced lunch. The third school had a student population of 350 students with multi-aged classrooms and project-based learning foundations. Eighty percent of the student population was African-American and qualified for free and reduced lunch. The study took place over a three year period of time, from 1999-2002. At the beginning of the study all three of the participating schools were in desperate need of updated technology as well as technology support personnel. Technology integration was also reported to be very low. Teachers however, reported having "a high belief in the value of technology integration, they acknowledged that their belief of technology integration was inconsistent with their practice and that they were not using technology often or well" (p. 289). Each school was staffed with a half-time technology support specialist as well as support from the participating university. All three schools received the same technology resources but tended to utilize these resources in different ways. Results of this study support the need for strong professional

development when creating technology-enriched environments as well as the need to effectively plan for technology integration. Therefore, it is purposeful for a school to purchase and maintain technology only if professional development support and training about the technology is provided. Lastly, similar to reports from Sugar (2005), administrative support is equally important to professional training in creating a technology-enriched environment.

### *Administrative Support*

Administrators must take a more active role in supporting teachers' technology use. They must move from their managerial roles of overseeing daily activities of the school to a more active role of advocating and supporting the needs of teachers and students. According to Whitehead, Jensen, and Boschee (2003) "teachers need help to overcome obstacles and integrate technology into their instructional practices" (p. 18), and administrators must ask themselves what they need to do to help. When administrators display leadership in support of technology-enriched learning, teachers will feel more secure to jump on board to integrate technology in the curriculum (Windschitl & Sahl, 2002). This does not mean that administrators are solely in charge of technology implementation but rather providing funding for materials and professional development needed to support teacher implementation. Administrators must advocate for proper funding of technology monies for professional development, one-third or 33% (Whitehead et al., 2003), and include in their budget a technology specialist. If funding for a technology specialist is not available several other alternative options would be to: (a) seek out technology savvy teachers who volunteer their time to help fix hardware and software problems or assist others with implementation efforts; (b) reach out to other

schools within the same district to share a technology support person; or (c) enlist the help of students by creating volunteer or credit programs as incentives for helping (Moses, 2008).

Creating alternative programs that allow students, with the aid of a teacher(s), to handle hardware and software issues provides more free time for technology specialists to collaborate with teachers in creating lessons and projects for technology-enriched learning environments. With programs that support the inclusion of students as technology support specialists one begins to wonder how students are affected by technology-enriched learning environments. If a student is able to perform tasks mostly completed by trained professionals, what capabilities do they have, in terms of knowledge creation and skills, when working in a technology enriched learning environment? How do students function in terms of academic achievement and development in a technology-enriched learning environment?

## Impact of Technology-Enriched Learning Environments

A teacher can learn a lot from her students. In a world of data-based decision making and No Child Left Behind, teachers must design instruction to meet students' learning needs while providing complex learning environments that evoke higher order thinking skills. In the technology age, teachers must also design instruction to expand opportunities and provide students with 21st century skills. While a student's environment affects his learning and behavior, a teacher does as well. In constructing technology-enriched learning environments, teacher's attitudes and beliefs about teaching with technology can equally, if not more, impact a student's academic performance and

development (Christensen & Knezek, 2001; Garthwait & Weller, 2005; Judson, 2006; Prensky, 2003) .

*Teacher Attitudes and Beliefs*

Marc Prensky (2006) describes most teachers as "digital immigrants", people who have learned about technology later in life. Most digital immigrants resist change in the age of technology and have a negative view of its intended uses. Prensky (2003) also notes that by resisting change in the age of digital technology we are creating a lethal effect in students' education. Many teachers often are afraid of what their students can do with new technologies. They are uncomfortable in allowing students to use it in the classroom before they have sufficient training. Teachers have to be aware of the environment they are creating and, as mentioned earlier, they must change their pedagogy to incorporate technology tools. In shifting their teaching from giving students information to coaching them to find the information and construct meaning, teachers begin to develop positive and negative views as to how technology can enhance their teaching. Several research studies suggest that teachers will use technology when they feel it is necessary to the lesson and they will only use it if they feel comfortable with it (Christensen & Knezek, 2001; Garthwait & Weller, 2005; Li, 2007; Zhao, Pugh, Sheldon, & Byers, 2002).

Judson (2006) created a study to determine if the beliefs teachers held about student learning affected the way in which they integrate technology. For this study 32 classroom teachers from primary to secondary grades volunteered to participate. At the beginning of the study they took a survey that measured their beliefs about instruction and attitudes toward technology use, and they were also observed working in the

classroom for the duration of a lesson (p. 586). The survey was divided into four categories (a) Teaching Philosophy, (b) Computer Use Attitudes, (c) Computer Use Objectives, and (d) Computer Knowledge and Skills. The results of the survey indicated that teachers believed they were constructivist in their pedagogy and considered technology to be useful to teaching and learning in the classroom. However, when the researcher stepped into the classroom the reported beliefs about instruction and technology use did not correlate with what the researcher observed (p. 590). Judson (2006) suggests that while teachers hold certain beliefs about instruction and integrating technology, they may not always follow through with these beliefs in the classroom. Findings from this study also indicated the need for professional development that links teacher beliefs about technology and how they can use it to create technology-enriched environments.

As teachers begin to understand that technology integration efforts take time to enact they will then begin to understand how this type of environment affects students, and this will lead to sharing and learning from each other to enhance student learning (Duhaney, 2000; Palak, Walls & Wells, 2006; Prensky 2003; Windschtil & Sahl, 2002).

### *Student Achievement and Development*

According to Farwick-Owens, Hester, Teale (2002), "Computers and internet technologies are by no means a magical solution to raising educational achievement in our schools, but they do provide an array of new opportunities for accessing information and promoting significant learning among students" (p. 616). By providing their students with technology enhanced inquiry based learning, the researchers discovered that technology played a key role in helping the students make inquiries and affected their

learning outcomes. Students used the Internet and computers as a means of accessing information to answer questions they created. Knowledge gained in the search process led students to ask more questions and produce in-depth answers, leading to what Palloff and Pratt (1999) describe as a system of *triple loop learning.* While the use of technology was not the main focus of this study, students positively used technology to produce real life projects that were of interest to the students. The students also learned how to use the technology on two different levels: a simple level to organize information and edit their work and a complex level to communicate telecollaboaratively, access information, and produce high quality presentations (Farwick-Owens et al., 2002).

In a study to improve higher-order thinking skills, Hopson, Knezek, and Simms (2002) conducted research among fifth and sixth grade students over the course of two school years. The treatment group of students was enrolled in the district's technology-enriched magnet program and was selected randomly from their applications. Students in this program attended the six schools in the district. The comparison group was composed of students who were not enrolled in the technology-enriched magnet program as well as students from comparable schools without a technology-enriched curriculum (p. 111). The treatment group in this study used the district's fifth-grade technology curriculum in a technology enriched-environment. The treatment group was provided with a 1:2 ratio of computers to students as well as other digital technologies. The teachers were trained to use the technological tools provided and an abundance of software and hardware was available at all times (e.g. scanners, computers, cameras). The comparison group was instructed in a traditional classroom setting; teachers were not trained to use technology; technology-based projects were not provided; and computers

were not present in the classrooms (Hopson et al., 2002). Treatment students conducted their own research and constructed meaningful high-quality presentations using several forms of technology tools. Control students used technology in computer labs to improve computer literacy and remediation. Findings from this study concluded that "the creation of a technology-enriched classroom environment appears to have had a minimal but positive effect on student acquisition of higher-order thinking skills" (p. 114). While this study does not fully support the need for technology-enriched learning environments to promote higher-order thinking skills it does "add to the limited amount of research on the use of computers to enhance the student development of higher-order thinking skills" (p. 114).

Mayer-Smith, Pedretti, and Woodrow (2000) conducted a study in which science classrooms were converted into technology-enriched learning environments to determine whether this type of setting is gender dependent in terms of effective learning. In transforming these science classrooms into technology-enriched learning environments, networked student stations, laserdisc players, printers, data gathering equipment, computer simulators, digitizing and video capabilities, Internet access, and interactive features were provided to the treatment group. Students used computers to study software generated simulations, take tests, process and analyze data in their science labs, and create presentations. While students were using these technology tools to complete various activities they were also working at their desks; writing in study guides or collaborating with other students about data they gathered. When researchers entered the classroom they noticed that there was a constant flow of activity from the students, but not every student was working on the same task nor were they working at the same pace.

The results from this study provided evidence that gender should not be an issue when promoting technology-enriched learning environments. More importantly technology-enriched learning environments "promote student engagement and success" for all students (Mayer-Smith et al., p. 61).

Page (2002) conducted a study in five Louisiana schools to determine the effects of technology-enriched learning environments and students of low socioeconomic status (SES). Students and teachers of the five experimental groups were equipped with a multitude of hardware (one teacher computer, four or more student computers , Internet access, multiple printers, digital camera, scanner, etc.) whereas the five control groups were a traditional classroom with little or no access to technology. The results of this study provide several pieces of evidence "regarding the measures of self-esteem and their results, it can be concluded that technology-enhanced classrooms aid in raising the self-esteem levels of low SES elementary students" (p. 402). This study also concludes that:

> Children in technology-enriched classrooms appear to score higher on standardized tests in mathematics, to take control of their own learning environment, to work well in cooperative groups to accomplish a common task and to place worth in their ability to be productive students and citizens. (p. 403).

Dove and Zitkovich (2003) conducted "empowering research" in a science program for gifted elementary students, grades four, five, and six. Their research, "*Our Lake Online Project",* provides evidence that by equipping students with computers, internet access, hand held devices (PDAs), digital cameras, digital micro projectors, and other technology tools to conduct research, students are able to conduct independent research based on their own inquiries. This project enabled the students to create and plan

science experiments using specialized software for the science curriculum. The technology tools provided were very portable, allowing the students to conduct the majority of their research outdoors and on-site. The students became experts of their experiments, and the technology provided them access to experts in the field as well as an unlimited amount of documented research. Students were able to communicate telecollaboaratively with experts to improve their projects and create high quality presentations. Through this project students encountered technology difficulties with glitches in software functions and connection issues when working on-site, and while these issues frustrated students they also enabled them to take control of the situation and troubleshoot the problem(s). Overall this project "empowered" students to engage in on-site expeditionary learning with the use of integrated technologies.

Similar to the research conducted by Dove and Zitkovich (2003), Bodzin (2008) created a study in which an after-school program was created for fourth grade students in an urban area of Allentown, PA. The study was designed to use integrated technologies to improve students' knowledge and awareness of the "pond ecosystem" located near the school they attended. Technology use was not a major goal in this study but rather an addition to improve the investigations made by students. The three main goals of this project:

> Consistent with goals for 21st century learning (Partnership for 21st Century Skills) were to (a) engage students in long-term investigations, (b) promote student learning about local environment, and (c) foster environmental stewardship and promote civic responsibility (p. 49).

Students in this study were not part of a talented and gifted (TAG) program like the students of Dove's and Zitkovich's (2003) study, however, findings report that the students developed questioning and investigating skills that led them to become stewards of the environment around them. It also helped motivate students to participate and engage in an after-school program, as well as create a need within the students to learn more about these activities. Finally, this project helped the students become involved in the community by reaching out to others and teaching them about the environment around their community.

While research is limited in the area of student achievement and development in technology-enriched learning environments research presented in this section provides evidence that students are benefiting and growing academically and socially in technology-enriched learning environments. For this to happen however professional development that included training and support for constructivist pedagogy, on-going professional training for teachers, and administrative support was present allowing the teachers to create an environment that fostered student learning with technology.

A Model for Implementing Technology-Enriched Learning Environments

In the search for the perfect model to support implementation of a technology-enriched learning environment the reviewer sought to find one that employs a "cycle" of continued growth including constant thought, reflection, and revision on behalf of the implementing teacher, as well as a cycle of on-going professional support for the teacher. The reviewer chose the Iowa Professional Development Model (Iowa Department of Education, 2005) as it is a model of continued professional growth with a revolving pattern. Within this model framework there are two separate cycles of implementation.

The larger cycle is what happens in the classroom. In this cycle the teacher implements; reflects on how the implementation is working; gathers data from students, colleagues, anecdotal evidence; and reflects on gathered data. This cycle repeats this pattern throughout the year enabling the teacher to constantly reflect and improve upon her teaching.

The smaller cycle within the larger one is that of professional development. It too is a circular pattern of on-going support throughout the school year. Within this cycle the teacher meets with colleagues and attends professional support training to improve her teaching in the classroom. The teacher also reflects on the data gathered on a daily basis within this professional development cycle. While the smaller cycle is intended to be a separate area of development from the larger cycle both cycles ultimately work together to provide educators, and administrators with ongoing professional support. Therefore, when implementing a model of continued professional support and development, such as the Iowa Professional Development Model (Iowa Department of Education, 2005), the teacher, administrator, and professional support personnel must remember that technology should not be the driving force to implement constructivist pedagogy, but rather a transparent tool that allows the students to (a) communicate and collaborate, (b) research and access information, (c) apply critical thinking and problem solving skills, (d) understand technology operations and concepts, (e) enhance digital citizenship skills, and (f) think creatively and develop innovative products (NETS-S 2007).

# CONCLUSIONS AND RECOMMENDATIONS

Based upon the evidence reviewed, the reviewer concludes that technology has rapidly evolved since the early 1900s (Bebell et al., 2004; Cuban, 1986; Mouza, 2003; Page, 2002) and with this evolution a push for technology reforms within the curriculum have surfaced. Technology alone should not be the focus of reform. Creating an enriched learning environment for all students that uses technology to foster creative thinking and collaborative learning should be the focus.

In the era of No Child Left Behind (NCLB) another top priority in education reform presently is the need for schools to produce high achieving students who possess skills to work with 21st century tools. The Partnership for 21st Century Skills (2004) identifies six key areas as a collective vision for 21st century learning to strengthen American education. These six areas include: (a) Core subjects, (b) 21st Century content, (c) Learning and thinking skills, (d) Information and communications technology (ICT) literacy, (e) Life skills, and (f) 21st century assessment (Partnership for 21st Century Skills, 2004). These six components must work together to prepare students for 21st century learning, and teachers need to create a classroom environment that allows for the inclusion of these skills in the daily routines of the classroom. Students need the skills and tools that allow them to access and analyze information, process it, and apply it to daily tasks.

As future technology leaders and advocates for technology in education, educators, administrators, community members, and technology developers need to provide on-going support and funding to create complex technology-enriched learning environments that promote the effective uses of various technologies (hardware and

software), foster student achievement and development, and provide expanded opportunities for communication and collaboration outside the classroom walls. The hardware and software should not be the driving forces of the curriculum but rather transparent tools to support the curriculum and complete daily tasks. Simply supplying classrooms with these technology tools, however, does not ensure they will be properly used. Teachers and administrators must be provided training opportunities to support teacher pedagogy and to use technology tools within the learning environment.

In providing educators with the proper training and support, the focus must be on creating a constructivist pedagogy that leads to the use of technology tools. A model of professional development, similar to the Iowa Professional Development Model (Iowa Department of Education, 2005), that provides a continuous process of support in and out of the classroom over an extended length of time, will help to establish best practices of implementing technology in the daily routine of the classroom. Such a model will also provide a support system among teachers to provide collaboration and comfort in utilizing the available technology. For this environment to be fully successful as well as effective and efficient, the proper tools need to be available in terms of hardware and software, and teachers must be trained on how to effectively integrate these tools.

Support for implementing technology-enriched learning environments must also come from the administrative level. Administrators must be forward thinkers and visionaries of technology integration to provide all students with complex learning environments. Administrators must be leaders in their buildings as well as districts, seeking funding for professional development as well as technology tools needed to create a technology-enriched environment (Whitehead et al., 2003; Windschitl & Sahl,

2002). Finally, administrators must support the needs of teachers in terms of time provided to collaborate with other colleagues, equipment available to carry out daily tasks, and sharing of new innovative ideas that teachers have to enrich the learning needs of all students.

There are several aspects to consider in terms of the teacher's role in a technology-enriched learning environment such as (a) comfort level when using technology tools (Christensen & Knezek, 2001; Garthwait & Weller, 2005; Li, 2007; Zhao, Pugh, Sheldon, Byers, 2002), (b) relationship between teachers' beliefs about student learning and beliefs about using technology to support learning (Judson, 2006), and (c) resistance to change (Prensky, 2003) that impedes the movement toward this type of environment. In the end, the successfulness of the teacher and student relies on teacher pedagogy, training, and the use of technology as a tool to expand opportunities and enhance the curriculum.

In the area of student achievement and development it is critical to constantly review how technology-enriched environments are affecting students. As the needs of students change, their environment must change to meet these needs. Research from Farwick- Owens et al. (2002), Hopson et al. (2002), and Mayer-Smith et al. (2000), provides evidence that while the technology-enriched learning environment does not directly affect student achievement, it does engage the students in the learning process and allows students to take control of their learning. This type of environment also encourages students to apply critical thinking skills while seeking out new information to create innovative projects.

Recommendations for future research to expand and enrich this area would be to conduct longitudinal research applying the Iowa Professional Development Model (Iowa Department of Education, 2005) along with a "Peer Coaching" program (Sugar, 2005) to determine the effects of continued professional support in creating technology-enriched learning environments.

Student achievement research is limited to the effects of technology-enriched environments directly related to student achievement, therefore, more results in this area would also help to enrich this review as well as provide evidence to policy makers and funding departments for more funding for the creation of technology-enriched environments.

Further research is also needed in the area of how postsecondary institutions are preparing pre-service teachers to teach in a technology-enriched learning environment. Technology is here to stay and educators must work together to develop common practices of implementation and integration of technology within the curriculum to improve the education of our students to prepare them for a 21st century society.

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