2003

Evaluating the effectiveness of technology on learning in K-12 education

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Abstract

Demonstrating an impact on student learning due to technology innovations is extremely important in K-12 education. Billions of dollars have been spent on technology in education in the past several years. Stakeholders are demanding to know if this investment is impacting student learning and achievement. However, the assessment of technology in K-12 education is complicated due to the changing nature of technology and all of the variables involved in education. The purpose of this paper is to discuss the rationale for evaluating technology.in education, analyze the issues involved in evaluation, review current research on the impact of technology on student learning, and discuss guidelines for effective assessment of technology in K-12 education.

EVALUATING THE EFFECTIVENESS OF TECHNOLOGY ON LEARNING IN K-12 EDUCATION

A Graduate Review

Submitted to the

Division of Educational Technology

Department of Curriculum and Instruction

In Partial Fulfillment

Of the Requirements for the Degree

Masters of Arts

UNIVERSITY OF NORHTERN IOWA

by

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July 2003

This Review by: M. Ann Nicholson

Titled: Evaluating the Effectiveness of Technology on Learning in K-12 Education

has been approved as meeting the research requirement for the

Degree of Master of Arts

8/13/03
Date Approved

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Abstract

Demonstrating an impact on student learning due to technology innovations is extremely important in K-12 education. Billions of dollars have been spent on technology in education in the past several years. Stakeholders are demanding to know if this investment is impacting student learning and achievement. However, the assessment of technology in K-12 education is complicated due to the changing nature of technology and all of the variables involved in education. The purpose of this paper is to discuss the rationale for evaluating technology in education, analyze the issues involved in evaluation, review current research on the impact of technology on student learning, and discuss guidelines for effective assessment of technology in K-12 education.

Introduction

Several research studies have been conducted to determine what, if any, impact technology has had on instruction in K-12 education. According to Quinones & Kirshstein (1998):

> As more and more states, districts, and schools develop technology plans to ensure that technology will be used effectively to benefit student learning and achievement, the need to understand technology's impact on improving student achievement will become even greater. (p. ii)

This statement continues to be relevant today as schools evaluate their technology plans and examine the use of technology in education.

Billions of dollars have been spent in the last several years to infuse technology in education. According to Market Data Retrieval (2003), 5.6 billion dollars was spent on technology for K-12 schools in the 2002-2003 school year. Politicians, parents, administrators, and teachers are concerned with determining if this massive expenditure has created a significant impact of the educational process and student learning. Jones & Paolucci (2000) stressed the importance of demonstrating the value of technology in education.

> Given that educational technologies are currently receiving significant attention, questions are now being raised regarding the research and assessment results that support the adoption and inclusion of technology in all levels of the education system, particularly because the investments have been and remain so high. (p. 17)

Districts are being pressured to provide data to investors in the technology infrastructure that clearly demonstrates a positive impact on learning and student achievement.

The task of evaluating the effectiveness of technology has been somewhat daunting due to the constantly changing nature of technology and the fact that technology is difficult to define and isolate from other important variables in the educational process. However, several studies exist which document the positive effect of technology on learning and provide some potential guidelines for evaluating technology in K-12 education.

Methodology

The reviewer conducted a search of the ProQuest, EBSCO, and Infotrac academic databases; reviewing articles related to assessing or evaluating technology in K-12 education. Keyword searches were done on "educational technology" as well as variations and combinations of "assessment," "evaluation," "technology," and "K-12 education". Most of the articles selected were written between 1990 and 2003. A search was also conducted for research available by professional or governmental organizations such as the International Society for Technology in Education (ISTE), North Central Regional Educational Laboratory (NCREL), The Milken Family Foundation, The Center for Applied Research in Educational Technology (CARET), Apple Classrooms of Tomorrow (ACOT) the Association for Educational Communications and Technology (AECT), and the U.S. Department of Education Office of Educational Research and Improvement. Other resources used included *The Journal of Educational Multimedia and Hypermedia;* the *Journal of Research on Technology in Education;* the *Journal of Research on Computing in Education;* and the *Journal of Technology, Learning, and*

Assessment. Many of the articles selected were referenced in more than one database or organizational website.

Analysis and Discussion

"In today's social and political climate, an undertaking as conspicuous and expensive as technology must produce results obvious to everyone with a stake in education" (Milone, 1996, p. 103). However, demonstrating the impact of technology on learning is an extremely difficult endeavor. Cuban (1986) stated that "the merits of computers as classroom tools and the qualitative issues embedded in the act of teaching need to be considered seriously, especially because teaching is less susceptible to measurement" (p. 91). One factor that impacts the evaluation of technology is the type of data required by different stakeholders (McNabb, Hawkes, & Rouk, 1999). Politicians and policyholders may want standardized assessment information that shows the effect of technology while teachers may need information and data that pertains to teaching practices.

The assessment of technology in education has been fraught with controversy and conflict. McKenzie (as cited in Jones & Paolucci, 2000) speculated that some of the difficulty with assessing technology's impact is a result of an "inability of program participants to conduct appropriate studies, vested interests in protecting new programs, little respect for educational research by the educational community, and unwillingness to set program goals" (p. 18). These obstacles would need to be accounted for and surmounted before effective and reliable evaluations could be conducted.

Many researchers have been dubious or cautious of the benefits of technology in education. Cuban (1986) predicted "that most teachers will use computers as an aid, not unlike film and television" (p. 99). Casey (2000) warned:

> Educators must ensure that every inclusion of technology is purposeful and designed to meet the needs of the learners and the integrity of the curriculum. Only when used as tools to write with, think with, communicate with, and problem solve with, will the technology find a positive role in every classroom in our country. (p. 141)

These cautionary statements and predictions make the task of assessing technology seem almost insurmountable.

Another difficulty with evaluating technology in education is the problem with isolating technology from other variables. Many elements such as curriculum, teaching strategies, social factors, and administrative policies combine in the educational process (McNabb, Hawkes, & Rouk, 1999). Isolating the effects of technology from all the other elements in the school environment can be exceedingly difficult.

Technology covers a wide range of activities and resources, which further complicates the process of evaluation. Different districts may view technology in extremely diverse ways. Some districts may view technology as something for basic skills practice, while other districts may view technology as a resource for learning critical thinking skills (Heinecke & Blasi, 1999). Milone (1996) stressed that "the process for evaluating the effectiveness of technology in improving student learning is highly context dependent" (p. 104). The process of evaluating the impact of word processing on learning would differ significantly from evaluating the impact of Internet research on learning. Schacter (1999) stated that "learning technology is less effective or ineffective when the learning objectives are unclear and the focus of the technology use is diffuse" (p. 10). According to Johnson (1998) "one reason educators find it difficult to describe and measure technology's impact is that schools do not use it in a single way for a single purpose" (p. 12). Johnson further suggested that there are four major ways in which technology is used in schools: (1) for administrative purposes, (2) for information retrieval, (3) for teacher tools and resources, and (4) for student learning. One could argue that all of these uses can have a positive impact on student learning, but conducting the research and finding the data to support this argument could be extremely challenging.

The constantly changing nature of technology further acerbates the difficulties with evaluation. Charp (1998) stated that "another problem with evaluating technology is that it's forever changing. You're constantly chasing a moving target" (p. 6). Milone (1996) also addressed the issue of rapid changes in technology and the difficulties in keeping abreast of the changes. This results in an added challenge to the evaluation of technology because a program or type of technology evaluated one year might not be available in the future. The *Writing to Read* program by IBM that was used for early literacy instruction and researched by Casey (2000) is an example of just such a situation. *Writing to Read* combined word processing with text-to-voice capabilities and word prediction. This program, along with intensive teacher training, showed promise for developing reading and writing skills in young learners. The Riordan Foundation financially supported the *Writing to Read* programs in 36 states. However, IBM dropped support of the software in 2000. A new version of the program is expected to be available in the fall of 2003. In the meantime, districts that wanted to replicate the success of schools involved in the *Writing to Read* program were unable to do so.

Several studies on the impact of technology on education have focused on specific applications or initiatives. West Virginia implemented a statewide technology initiative in 1989, and collaborated with the Milken Family Foundation in documenting and evaluating the initiative (Mann, Shakeshaft, Becker, & Kotthamp, 1999). West Virginia's program was called Basic Skills/Computer Education (BS/CE) and focused on the basic goals of reading, language arts, and mathematics. The components of the initiative were: (a) software that focused on the basic skills, (b) sufficient student access to computers, and (c) professional development. Schools were provided with three to four computers per classroom, a printer, and a file server. Each school could decide whether to place the computers in labs or divide them among the classrooms. The software selected was IBM and Jostens Learning, and schools could select the one that best met their needs. The IBM software utilized whole and small group instruction with an emphasis on problem solving and higher order thinking skills. The skill areas addressed were in reading, mathematics, and writing. The Jostens Learning program provided individualized instruction based on the students' needs. This software also focused on reading, mathematics, and writing and provided a management and assessment system.

Research for BS/CE was based on quantitative measures such as the Stanford Achievement Test (9th Edition) as well as surveys of time spent on computers and qualitative measures such as interviews, observations, and case analysis (Mann, Shakeshaft, Becker, & Kotthamp, 1999). A representative sample of 950 fifth graders from 18 schools was selected for the research. Data was analyzed based on a model composed of technology professional development, attitudes toward technology, and access to the computers and software. "The more of each model components that the students experienced, the higher the gain score on the Stanford-9" (p.27). Results of the study indicated that BS/CE helped all students, but students without access to computers at home demonstrated the biggest gains.

Many studies have been performed that examined the use of Computer Assisted Instruction (CAI) on reading achievement. Soe, Koki, & Chang (2000) conducted a met-analysis of seventeen of these studies. For the purposes of the meta-analysis, the researchers identified three levels of CAI based on the amount of interaction between the student and the computer: These levels were (1) drill and practice, which consisted of reinforcement of specific skills and immediate feedback; (2) tutorial, which provided information or clarified concepts in addition to providing practice; and (3) dialogue, which allowed the student to interact with and give instructions to the computer. The researchers attempted to answer the following questions:

- How effective is computer-assisted instruction in teaching students to read?
- Is it especially effective for certain types of outcomes or certain types of students?
- Under what conditions is computer-assisted instruction most effective for the teaching of reading? (p. 5).

The researchers found computer-assisted instruction did have a positive effect on reading achievement, but there was a wide range of variation in the effect across the seventeen studies. They concluded that "computer applications can play a significant role in teaching and learning. However, the precise nature of that role still needs to be researched with greater depth and precision" (p.15). In other words, they were able to quantify a positive effect on reading achievement but were unable to determine precisely why or how that effect occurred. Soe, Koki, & Chang (2000) proposed questions to be researched by future studies including the role of the teacher, the most effective strategies for using CAI in reading, and the components of a reading curriculum that are positively impacted by curriculum-assisted instruction.

Several studies have dealt with the effect of technology on the writing process. Barrera, Role, & Diemart (2001) compared the effects of writing with computers versus handwriting with a group of first graders. They were influenced by studies conducted by Moxley, Warash, Coffman, Brintono, & Concannon (as cited in Barrera et al., 2001) that indicated writing achievement was improved through the use of computers for the following reasons: (a) students with fine motor difficulties were able to type legible letters, (b) the text produced by typing was more legible and easier to proofread than handwritten text, (c) revision was easier with computers, and (d) inserting self selected graphics aids the writing process. Barrera et al. used three different software programs in their study: *Writing and Publishing Center*, *Wiggle Works*, and *Stories and More*. Writing instruction and prewriting preparation were the same for all students, but the actual writing was done sometimes with computers and sometimes by hand. Observations of the students at work and an analysis of 383 handwritten and 374 computer written assignments led the researchers to conclude that "when students use computers to generate written compositions, they consistently wrote more words and sentences" (p. 221). Observations indicated that students who composed with computers were better able to read their compositions to their peers because they had repeatedly read them on the computer's screen while writing. This seemed to increase collaboration among students. The researchers also stressed that "teaching computer usage skills to ensure facility with keyboarding and the editing features of word processing is recommended" (p. 216). This instruction can be critical to the success of using word processors with young students.

Owston & Wideman (1997) conducted a three-year study of student writing processes, beginning in third grade. The study was conducted with a group of students who had access to word processors on a daily basis and were compared with a group of students from another school where computer use was infrequent. Classroom settings, student characteristics, and the approach to writing instruction were similar in both buildings. Owston & Wideman evaluated students' writing for quantity and quality. Writings were analyzed and scored based on development features and mechanics. At the end of the study, the researchers concluded "the quality of the writing students produced at the high access site was superior in both its deeper structure and surface features" (p.217).

Another study focused on the effects of word processing on sixth graders' writing (Grejda & Hannafin, 1992). The authors assigned students to three groups based on how revisions were made. One group used only word processing, a second group used only paper and pencil, and a third group used a combination of both methods. Instruction in editing and revising was provided to all students and the students who used the word processor were given training in the application, *Bank Street Writer*. The researchers concluded, " word processing students performed more consistently than other students did. Those students were more successful in revising existing as well as original writing, and they made more revisions to their work" (p. 148). This conclusion provides additional support for the impact and effectiveness of technology on student writing.

Studies and discussions have also been conducted on the effects of using technology in writing instruction for students with Learning Disabilities (LD) (MacArthur, Ferretti, Okolo, & Cavalier, 2001). With the advent of the Individuals with Disabilities Education Act (IDEA), No Child Left Behind (NCLB) legislation, and the push for inclusion of special needs students in the regular education classrooms, any discussion of the effects of technology on instruction should reflect a consideration of special needs students. MacArthur et al. reviewed fifteen years of research on the use of technology with mildly disabled students. Based on the research, MacArthur et al. stated that the revision and editing capabilities of word processing combined "with instruction in revising can increase the amount and quality of revising and improve the overall quality of writing by students with LD" (p.289).

A meta-analysis of research on the impact of technology on student writing was conducted by Golberg, Russell, & Cook (2003). The researchers selected twenty-six studies conducted between 1992-2002. The studies were analyzed to determine outcome measures based on quality, quantity, and revision. The quality of writing was measured in most of the studies by using rubrics, which resulted in an overall holistic rating. The quantity of writing was based on the number of words. The definition of revision varied across the studies. Some studies based the definition on the number of words inserted or deleted while others focused on format revisions such as spelling, grammar, and punctuation.

Golberg, Russell, & Cook (2003) reported that there was a significant positive effect on the quantity of student writing when word processing was used. They noted that this positive effect was larger for middle and high school students. Their results also indicated a positive effect on the quality of student writing. Once again, this effect was determined to be larger for middle and high school students. The researchers' analysis of revision was limited to six out of the thirty studies, and therefore an average effect size was not calculated. However, the researchers stated that "these six studies all report that students made more changes to their writing between drafts when word processors were used as compared to paper-and-pencil" (p. 16).

Several studies have addressed increased motivation as an indicator that technology is positively affecting student learning. Golberg, Russell, & Cook (2003) stated that "a few of the excluded studies noted that computers tended to motivate students, especially reluctant writers" (p. 18). Bangert-Drowns & Pyke (2002) noted that "students are often enthusiastic and persistent in their interactions with educational software" (p. 23). However, they claimed that the traditional methods of quantifying student engagement by "time-on-task" does not adequately describe the type of engagement and the impact on learning. Therefore, the researchers developed a rating scale for teachers to use in order to measure and describe student engagement with educational software. The rating scale measured seven different types of engagement: (1) literate thinking, (2) critical engagement, (3) self-regulated interest, (4) structure-dependent engagement, (5) frustrated engagement, (6) unsystematic engagement, and (7) disengagement. In addition to the rating scales, the students' scores from the fourth grade standardized reading test, Degrees of Reading Power, were used for comparison. The correlation between reading and software engagement was given as the rationale for using the standardized reading scores. Two fifth grade teachers and a computer teacher from an elementary school were chosen to participate in the study and were trained in the use of the rating scale by the researchers. The frequency of the seven forms of engagement was documented for each student.

In their discussion of the study, Bangert-Drowns & Pyke (2002) stressed that "students enthusiastically engage in computer interactions, but such enthusiasm does not always translate into meaningful learning" (p. 34). The researchers indicated that there may be a correlation between literate engagement with educational software and standardized reading scores. However, the researchers also pointed out some weaknesses of the study: a small sample size, potential rater unreliability, and potential bias. While the engagement rating scale shows possibilities for meaningful data collections, the researchers suggested that "replications with different degrees and kinds of control of extraneous variables are warranted to lend greater confidence to this study's findings" (p. 35).

Liao (1998) performed a meta-analysis comparing the effects of multimedia and traditional instruction on student achievement. Hypermedia instruction was defined as instruction utilizing interactive media, computer simulators, or interactive videodiscs. Traditional instruction was defined as classes using lecture/demonstration for instruction. Thirty-six studies were chosen for the analysis. All of the studies occurred in educational settings, provided quantitative results for both types of instruction, and were published between 1986 and 1997. Liao concluded "that the effects of using hypermedia in instruction are positive when compared to the effects of traditional instruction" (p. 351).

However, the study does not indicate what factors or components of hypermedia instruction contributed to the positive effects.

Some of the research on the effects of technology on student learning examines how the technology is used. Mills & Tincher (2003) go beyond indicating how the technology is used and have developed a model for evaluating technology integration. They developed a "set of technology standards and indicators to describe best practices for expert teaching and student learning using technology" (p. 382). The eighteen standards were divided into three phases based on using the technology for professional productivity, delivering instruction, or integrating into student learning. The authors created a matrix with one dimension based on the technology standards and the other dimension consisted of variations for each standard based on specific categories of technology integration that represented specific teaching practices. Each variation included a level of use in order to determine a range "of technology integration from 'unacceptable' to 'ideal'"(p. 387). The matrix was used to create the Technology Integrations Standards Configuration Matrix (TISCM) checklist, which was then used to collect baseline data regarding technology integration for a small, midwestern school district (see Appendix A). The assessment was re-administered at the end of the school year, after teachers had participated in district-wide technology staff development.

The results of the TISCM assessment indicated that technology integration is a developmental process, which starts with teachers using technology for productivity. "The TISCM also suggests that when educational best practices for teaching and learning with technology are clearly defined and established, the professional skills of teachers will begin to exemplify the stated expectations" (p. 394). Clearly, this suggestion calls for a good understanding of what uses teachers are making of technology, why they are using technology, and how they are using technology. The TISCM, therefore, is more than a static measurement. It is a tool that can be used in the planning process of technology innovations as well as a tool for measuring the success of technology integration (Mills, 2001).

Apple has conducted research on the impact of technology in the classroom through the Apple Classrooms of Tomorrow (ACOT) project (Ringstaff, Yocam, & Marsh, 1996). The ACOT project focused on creating Teacher Development Centers to prepare teachers to create inquiry-based tasks, use a wide range of technology, and develop a portfolio assessment strategy that involved students reflecting on their learning. Research involved tracking teacher participation, documenting the growth of the Teacher Development Centers, and gauging the impact of the program on the participating teachers. Information was collected through questionnaires, observations of workshops and classrooms, journals, and interviews. Analyses indicated that "instructional changes in classrooms occurred in three major areas: classroom organization, level of use of technology by both students and participants, and participant's philosophical beliefs and attitudes toward teaching" (p. 3). While this study focused more on changes in instructional practices and beliefs, there are some anecdotal references to changes in student learning. One teacher reported that her special education students were more willing to read. Another teacher stated that technology was a motivator for her special needs students and their oral language skills were increasing.

The importance of evaluating the use of technology in education seems obvious and crucial. Much of the current research demonstrates the positive impact of technology on student achievement, but often falls short of identifying exactly why and how the technology produces improvement in student learning. There are implications for following definite guidelines in future studies. Charp (1998) suggested three factors that need to be addressed before measuring the effectiveness of educational technology: (1) availability of the technology, (2) necessary changes in teaching styles, and (3) the importance of having tools and applications that work. Milone (1996) maintained that "the single most important factor determining how technology influences student learning is the degree to which the technology is integrated into the curriculum" (p. 10). All of these factors need to be considered before conducting an assessment of the technology.

The U.S. Department of Education published *An Educator's Guide to Evaluating the Use of Technology in Schools and Classrooms* (Quinones & Kirshstein, 1998). This guide provides a framework for organizing and conducting an evaluation of technology use in education. The authors stressed that the first and perhaps the most important question to ask is why the evaluation is being conducted. While there may be several reasons for doing the evaluation, "one important purpose of any evaluation should be continual program improvement" (p. 3). Other reasons for evaluation may include determining the effect of technology on students, catching and correcting potential problems, and providing information on possible technical assistance needs. The authors pointed out that the answers to this question might vary depending on the evaluators' or stakeholders' roles.

Quinones & Kirshstein's (1998) recommended other important questions to ask at the beginning of the evaluation process:

- What is an evaluation anyway?

- Where do I start?
- What questions should I ask?
- What information do I need to collect?
- What's the best way to collect my information?
- What are my conclusions?
- How do I communicate my results?
- Where do I go from here? (p. 1)

The authors have developed worksheets to go along with each of the previous questions. These worksheets provide a foundation for planning, organizing, and conducting an evaluation of technology initiatives in education. The authors' also created an evaluation overview diagram that can be helpful as districts consider the steps involved in the evaluation process (see Appendix B). This diagram provides an overview for the evaluation process, stresses the importance of disseminating the evaluation information, and suggests using the data and information to modify technology programs. In fact, the authors encourage districts to plan their evaluation of technology at the same time they plan their technology programs. Parallel planning and evaluation allows for the collection of baseline data and the structuring of staff development and technology innovations to fit the evaluation model.

Quinones & Kirshstein (1998) pointed out that both qualitative and quantitative data might be collected, depending on what type of information is needed. Quantitative data may include the number of computers per students, the number of minutes per week that students use computers, and the number of hours teachers spend in technology staff development training. Qualitative data could include narrative observations of students using computers. "Knowing what students do when using the computers...and how much time students spend using computers...provides a more complete understanding of student computer usage than either type of data individually" (p. 16). The authors also recommended going from the questions developed at the beginning of the evaluation process to goals and benchmarks, then down to specific measures, which will help determine the types of data needed.

Heinecke & Blasi (1999) addressed The Secretary's Conference on Educational Technology with some suggestions and concerns pertaining to the evaluation of technology in education. In regards to the question of whether or not technology impacts student learning, the authors stated that the response "depends on how you define student learning and how you define technology" (p.1). Instead, evaluation questions should focus on when does educational technology work and under what circumstances. The authors point out that one essential circumstance for ensuring the effective use of technology is providing training for teachers on integrating technology into the curriculum.

Heinecke & Blasi (1999) made several recommendations for evaluating the use of technology in education. They stressed the importance of using multiple measurements and including performance indicators such as attendance, dropout rates, and discipline referrals. Assessment of higher order thinking skills may be demonstrated through portfolios and projects. The authors recommended that evaluation should include all of the variables and contexts in which the technology occurs. "This includes looking at technological factors, individual factors, organizational factors and teaching and learning issues" (p. 1).

Baker (1999) provided several ideas and guidelines for determining the effectiveness of technology in education and stressed that "evaluation should be planned at the beginning of an innovation rather than tacked on at its end. Evaluation is a planning tool as well as a way to systematically collect and interpret findings and document impact" (p. 1). Baker emphasized the importance of clearly identifying the goals for using the technology, which could be used (a) to meet goals or needs that cannot be met in other ways, (b) to provide instructional opportunities and resources that meet the needs and pace of the learners, or (c) to manage classrooms.

Baker (1999) suggested measuring outcomes through a variety of evaluation methods, both quantitative and qualitative. Possible measures could include standardized or commercial test scores, questionnaires, projects, performance-based assessment, surveys, and essays. The author cautioned, "that if you use open-ended tasks, such as performance or essay examinations, you need to use clear criteria to judge performance, and performance should be validly and consistently measured among raters" (p. 1). Along with carefully clarifying criteria for open-ended assessment tasks, the author advocated the elimination of bias that might occur when teachers evaluate their own students. Baker also supported the use of computer-based assessments such as those designed by the Center for Research on Evaluation, Standards, and Student Testing (CRESST) to measure "problem solving, content understanding, knowledge representation, search strategies, collaboration, and Internet learning" (p. 1).

Jones and Paolucci (2000) advocated using an Instructional System Design approach to educational technology evaluation. They suggested creating a matrix of instructional objectives, delivery systems, and outcomes to provide "a foundation for controlled studies that contribute meaningful inputs to the open question on the effectiveness of technology on learner outcomes" (p. 24). Their matrix listed learning domains, learner profile information, and task descriptions under instructional objectives. The delivery systems included locus of control, presence, media, and connectivity. Learning outcomes included lower order and higher order cognitive skills. This matrix provides a framework for organizing and evaluating the multiple dimensions involved in the integration of technology in learning.

McNabb, Hawkes, and Rouk (1999) have identified seven critical issues in the evaluation of the effectiveness of technology in education. The first critical issue points out that the effectiveness of technology is linked to the other school improvement initiatives. Based on this observation, evaluators need to be cognizant of all of the elements involved in the learning process in an attempt to isolate the effects of technology.

Another critical issue concerns the need for expanding current methods for evaluating technology's impact on education. According to McNabb, Hawkes, & Rouk (1999) "The issue that confronts schools is broader than technology. It is about learning and the need to find new ways to identify and measure the skills and knowledge that students gain from using technology" (p. 5). The difficulty of this task is in part due to the constantly changing nature of technology and technology tools. The authors stressed the importance of schools, educators, and administrators working together to improve and expand the evaluation of educational technology. This issue is connected in part to the next critical issue, which calls for multiple sources of data that go beyond the collection of standardized test scores. Instead of merely determining at the end of a specified period of time if student achievement has improved due to the infusion of technology, districts need to also collect quantitative and qualitative data that "tells what technology applications work, under what conditions, and with which students" (McNabb et al., 1999, p. 6). Just knowing that students scored higher on one or more areas of a standardized test does not provide specific information about how or why the increased scores were improved.

Another critical issue related to the evaluation of technology is the need for schools to report evaluation findings to a diverse group of stakeholders. Those involved in making policy may want summative data related to student achievement. Those stakeholders involved in teaching and programming may need formative data in order to evaluate and revise technology plans. This is related to the next critical issue, which stresses the importance of using "a common language and standards of practice" (McNabb et al., 1999, p.7) in evaluation of technology. Deciding on common goals, terminology, and methods early in the evaluation process can facilitate the communication of information and keep all stakeholder groups focused on a common vision.

The next critical issue emphasized the importance of involving educators in the evaluation process. Teachers should function as partners with other researchers in the process and should not bear the burden for the success or failure of technology in education by themselves. Teachers need to be provided with quality staff development on how to use technology effectively as well as how to improve student learning with technology. Indeed, the need for effective technology staff development was echoed in several of the research studies and articles cited previously (Heinecke & Blasi, 1999; Mills & Tincher, 2003; Ringstaff, Yocam, & Marsh, 1996).

The final critical issue stresses the need for thorough planning before adopting technology innovations. “Some existing policies need to be ‘transformed’ to match the new needs of schools using technology” (McNabb, Hawkes, & Rouk, 2000,p. 3). Evaluation information can and should be used to determine policies and best practices related to the use of technology. For example, the number of computers per building, the location of the computers, and after school computer access are some of the issues that may need to be addressed by policy or guidelines in order to maximize the potential effects of technology on student learning.

These critical issues suggest a holistic approach to evaluating the effectiveness of technology in education. Both qualitative and quantitative data are needed as well as clear, common language and procedures.

Conclusion and Recommendations

Evaluating the impact of technology on learning in K-12 education is a difficult process. The definition of technology can vary dramatically from district to district, depending on how the technology is used. The constantly changing nature of technology further complicates the evaluation process. However, many reliable studies have been conducted that document the positive impact of technology on student learning and achievement.

There should be little doubt that evaluating the impact of technology on K-12 education is a worthwhile endeavor. Politicians, parents, teachers, and other stakeholders need to know if the investment in technology is making a worthwhile difference in education. Evaluating technology in education is also necessary in order to modify and improve existing programs and innovations. Relying on previous research can provide a foundation for district technology planning and evaluation, but should not be a substitute for each district's careful examination and assessment of its technology programs and innovations.

The evaluation process should ideally be determined and organized at the same time as technology innovations are being planned. In order to adequately assess technology's impact, the assessment process should be guided by a structured approach with clear definitions and objectives. Evaluation of technology is directly related to how the technology is used, which in turn is related to teacher training and student outcomes. All of the contributing variables involved in using technology should also be considered in the assessment: access to technology; quality of the technology and types of technologies used; teaching strategies; teacher preparation; and learner goals and outcomes. Gathering baseline data through a variety of qualitative and quantitative measures is also extremely important. Data collection procedures must be clearly defined to yield information that is meaningful to all stakeholders.

Assessment of technology in education should serve a two-fold purpose. Besides indicating the success or failure of a program or initiative, assessment should also serve to inform decisions and change practices and procedures to facilitate the appropriate and intelligent integration of technology into education. Therefore, both formative and summative evaluations are critical and valuable for gauging and improving the impact of technology in education. Districts that plan for evaluating technology use in conjunction with technology planning, involve all the stakeholders, examine all of the factors involved in technology and learning, and develop clear guidelines and multiple measurements will be able to collect valuable and meaningful data that can be used to monitor and improve the impact of technology on learning.

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Appendix A

Technology Implementation Standards Configuration Matrix

TECHNOLOGY IMPLEMENTATION COMPONENT	4 IDEAL USE	3 MODERATE USE	2 MINIMAL USE	1 UNACCEPTABLE USE	0 NO USE
1. Operate common technology devices including computer keyboard, mouse, monitor, printer, video camera, digital camera, VCR, scanner, or projection device.	Create a picture with a digital or video camera OR scan an image with a scanner and transfer to a computer file.	Connect a projection device to computer and project monitor image to a screen.	Connect keyboard, mouse, monitor, and printer to computer.	Use mouse and/or keyboard function keys to select a screen icon.	None of these
2. Perform basic file management tasks on a computer and local area network.	Locate, copy, or move files from a local computer drive to a network drive or folder.	Create a folder on a local drive and copy/save files in the folder.	Search for a file by name, type, or date.	Save an application file (word processing, spreadsheet, database) to a location on a local drive.	None of these
3. Apply trouble-shooting strategies for solving routine hardware and software problems that occur in the classroom.	Download and install software updates or install software updates from a local or network drive.	Remove a paper jam from a printer; install paper and ink cartridge in a printer.	Determine if a computer is logged-on to a computer network.	Properly shut down and restart computer when computer hangs or locks up.	None of these
4. Use software productivity tools to prepare publications, analyze and interpret data, perform classroom management tasks, report results to students, parents, or other audiences, and produce other creative works.	Prepare a report in a word processing document that includes a table that is imported or pasted from a spreadsheet or database file.	Create a spreadsheet using calculations and computation functions and format for printing.	Create a word processing document and format for printing.	Load application software (word processing, spreadsheet, database) and enter information.	None of these
5. Use technology to communicate and collaborate with peers, parents, and the larger community to nurture student learning.	Prepare an email distribution list and send an email message to every contact on the list.	Add and retrieve an attachment to/from and email message.	Add a name and address to an email address book OR set email program to apply a signature to all email messages.	Send an email message to an existing name on the school network address book.	None of these

Source: Mills, S. (2001). The technology implementation standards configuration matrix: A tool for analyzing technology integrations. *National Forum of Applied Educational Research Journal.*

Technology Implementation Standards Configuration Matrix (cont.)

6. Use technology to locate, evaluate, and collect educational research/best practices information from a variety of sources.	Subscribe to and participate in discussion groups or chat rooms of practitioners or subject-matter experts.	Subscribe to and read electronic newsletters or journals related to an area of education.	Perform a search using an Internet search engine OR perform a search of CD-ROM reference materials or on-line library catalog.	Browse the Internet to locate useful information using specific URLs.	None of these
7. Practice and model responsible use of technology systems, information, and software.	Develop classroom guidelines and procedures for students for computer and network use based on school district acceptable use policy and provide orientation on proper use of equipment and software.	Develop classroom guidelines and procedures for students for computer and network use based on school district acceptable use.	Read and discuss school district acceptable use policy with students at least once each semester.	Be familiar with school district acceptable use policy (have read it).	None of these
8. Facilitate equitable access to technology resources for all students.	All students regularly use classroom computer or go to computer lab to perform learning activities related to specific learning objectives.	All students use one or more educational software packages to reinforce or supplement learning objectives.	Some students use classroom computer or go to computer lab to reinforce or supplement learning objectives.	Some students use classroom computer or go to computer lab after completion of classroom learning activities.	None of these
9. Manage student learning activities in a technology-enhanced learning environment.	Conduct and facilitate student learning activities using educational software on a classroom computer or in the computer lab or on a regular basis.	Conduct and facilitate student learning activities using educational software on a classroom computer or in the computer lab occasionally.	Students use a classroom computer or computer lab on their own as an instructional supplement.	Students use a classroom computer or computer lab on their own for activities unrelated to classroom learning objectives.	None of these

Technology Implementation Standards Configuration Matrix (cont.)

10. Evaluate and select informational and educational resources based on the appropriateness to learning objectives, hardware requirements, and software features.	Develop a plan with a budget to purchase technology for classroom or lab including hardware requirements, software features, and relation to learning objectives.	Develop a technology plan for classroom or lab including hardware requirements and software features.	Describe two or more technology resources that teacher would like to use for instruction or classroom learning activities.	Describe one technology resource that teacher would like to use for instruction or classroom learning activities.	None of these
11. Demonstrate strategies to assess the validity and reliability of data gathered with technology.	Communicate criteria and strategies to students for determining the quality of web page content; develop an electronic list or database (text or HTML document) of appropriate web sites and search engines for use with classroom learning activities.	Communicate criteria and strategies to students for determining the quality of web page content. Develop a list of appropriate web sites and search engines for use with classroom learning activities.	Establish and communicate criteria and strategies to students for determining the quality, reliability, and validity of web page content.	Describe two or more criteria or strategies students should use for critically evaluating the quality, reliability, and validity of web page content.	None of these
12. Use multiple technology contexts and a variety of productivity tools to provide classroom instruction.	Use a multimedia presentation application or web pages to create and present instruction on multiple topics.	Use a multimedia presentation application or web pages to create and present instruction on a single topic.	Use word processing to create worksheets, handouts, and tests OR use videotapes and CD-ROMs to reinforce/supplement classroom instruction.	Use supplemental materials in teacher's manual to reinforce or supplement classroom instruction.	None of these
13. Employ technology in classroom learning activities in which students use technology resources to solve authentic problems in various content areas.	Integrate two or more technology-based learning experiences per semester into classroom instruction that are established for targeted curriculum themes or learning objectives.	Integrate one technology-based learning experiences per semester into classroom instruction that is established for targeted curriculum themes or learning objectives.	Students use a classroom computer or go to computer lab to reinforce or supplement learning objectives.	Students use a classroom computer or go to computer lab after completion of classroom learning activities.	None of these

Technology Implementation Standards Configuration Matrix (cont.)

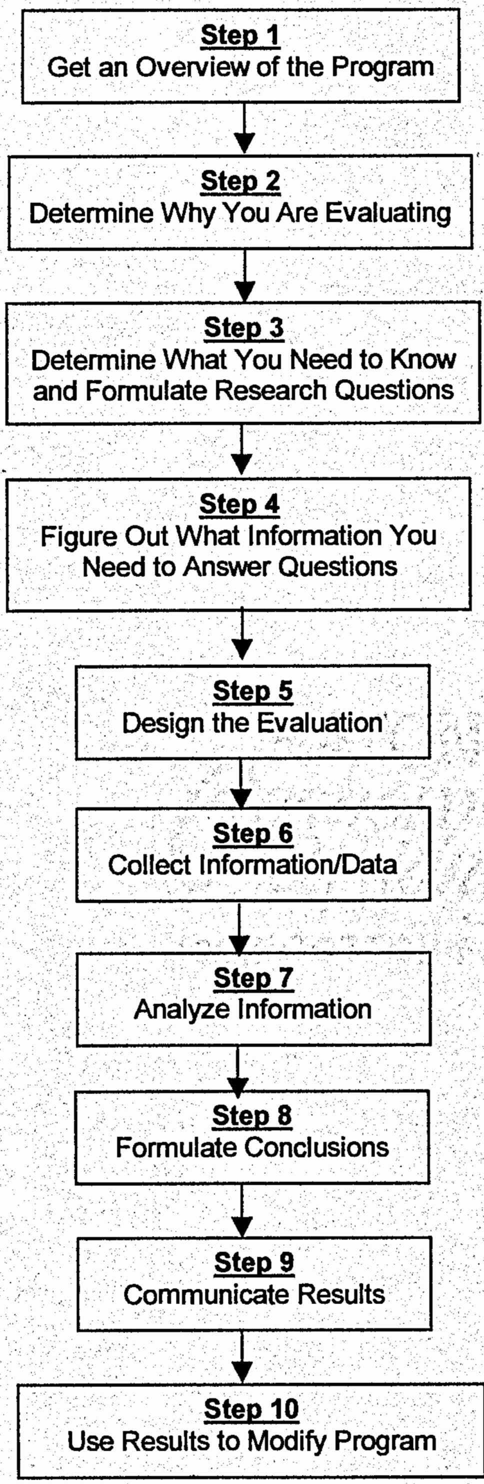
14. Use technology resources to provide learning contexts requiring the use of problem solving, critical thinking, informed decision-making, knowledge construction, and creativity by learners.	Integrate two or more technology-based projects per semester into classroom instruction. Requiring students to solve problems or formulate decisions.	Integrate one technology-based project per semester into classroom instruction requiring students to solve problems or formulate decisions.	Students use a classroom computer or go to computer lab to reinforce or supplement learning objectives.	Students use a classroom computer or go to computer lab after completion of classroom learning activities.	None of these
15. Implement technology-based learning experiences that utilize a variety of grouping strategies to address the diverse learning needs of students (e.g. cooperative, project-based, collaborative, individualized, teams).	Create an individualized learning plan for each student and track accomplishment of learning goals in the plan using a computerized productivity tool.	Routinely use individual and cooperative learning strategies that result in the completion of technology-based products of learning.	Occasionally use a team-learning (small group) strategy to complete a technology-based learning activity.	Allow students to work in pairs or small groups on the computer to learn or use educational software.	None of these
16. Apply multiple methods of evaluation and assessment to determine learners' use of technology for learning, communication, and productivity.	Use action research methods to determine whether technology and classroom teaching methods are impacting student learning.	Evaluate demonstrations of student technology skills using checklists, rubrics, and benchmarks to assist students in assessing their performance.	Evaluate student technology skills using objective tests and subjective evaluation of student-produced materials.	Evaluate student technology skills using objective tests only.	None of these
17. Engage learners in the development of electronic portfolios that document their technology-based educational experiences.	Students are required to maintain an electronic portfolio of technology-based products of learning using web pages or a multimedia presentation application and demonstrate technology skills and experiences.	Students are required to maintain an electronic portfolio of technology-based products of learning using a word processing document.	Maintain an electronic file of various student technology-based products of learning.	Maintain a cumulative folder of various student technology-based products of learning.	None of these

Technology Implementation Standards Configuration Matrix (cont.)

18. Use technology resources and productivity tools to collect, analyze, interpret, and communicate learner performance data and other information to improve instructional planning, management, and implementation of instructional/learning strategies.	Maintain and aggregate performance data for students in electronic files. Modify classroom and individual instruction based on analyses of student performance data.	Use an electronic gradebook (or spreadsheet or database) to keep track of student grades and track student mastery of learning objectives.	Use an electronic gradebook (or spreadsheet or database) to keep track of student grades.	Write evaluations of student work or progress and notes to parents using word processing and/or email.	None of these

Appendix B

Evaluation Overview



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