

Technology's Impact on Teaching and Learning

If you are hoping to purchase electronic resources with No Child Left Behind funds, you'll need to understand whether the available resources meet the requirements of the NCLB legislation—that is—whether they are backed by research and aligned to content standards.

By John Cradler

Subject: Standards- and technology-based research

Audience: Tech coordinators, administrators, teachers, library media specialists

Grade Level: K–16 (Ages 5 & up)

Technology: Technology-based learning resources

Standards: NETS•T II; NETS•A I (www.iste.org/standards)

This is the seventh in a series of articles addressing critical questions about educational uses of technology from the Center for Applied Research in Educational Technology (CARET). For additional research findings, visit CARET at <http://caret.iste.org/>.

The recently enacted No Child Left Behind (NCLB) legislation has brought much attention to the scientific validation of learning resources and interventions. Specifically, NCLB requires that learning resources—including those that are technology based—be closely aligned to state academic standards and that research document the extent to which such resources result in student academic achievement gains as measured by standards-based assessments. (*Editor's note:* See Resources on p. 57 for the NCLB and other Web addresses.) Given this requirement, a process is necessary to first document the extent to which resources are aligned to the standards and then to conduct research to determine the extent to which programs and strategies can result in student acquisition of skills and knowledge based on those standards. However, a major barrier to conducting adequate educational research is a lack of federal, state, or private funding and resources to conduct the type of research called for by NCLB. It is critical that members of the U.S. Congress as well as state legislators seriously consider finding ways to subsidize research needed to determine what works in education and in educational technology.

In this article, I report on the preliminary findings from efforts to:

1. align technology-based learning resources with standards
2. conduct research that would document the extent to which use of such resources results in improved student achievement in core content areas

The discussion about standards alignment of electronic learning resources is based on data collected by the California Learning Resource Network (CLRN). The research on the effects of technology in relation to standards is based on information collected by the Center for Applied Research in Technology (CARET).

Standards and Technology-Based Learning Resources

It is widely assumed that the greater the alignment of a learning resource to curriculum standards, the greater would be the probability that such resources would improve learning as measured by standards-based assessments. Based on this assumption, California established the CLRN—an easy-to-access, one-stop resource that provides information on how to develop and/or find lesson plans that effectively integrate instructional technology into curriculum and helps educators identify and select electronic learning resources that target specific state-adopted content standards. CLRN has attracted the attention of the U.S. Department of Education (ED) as a possible resource to help educators find standards-aligned resources to comply with the Enhancing Education Through Technology component of NCLB. In a related development, the California Department of Education requires that any electronic learning resources purchased with NCLB funds be reviewed and listed on the CLRN Web site in an effort to ensure that teachers are using content-aligned resources in classrooms. Several other states are known to be considering establishing their own versions of CLRN or using CLRN if the state standards are similar to the California standards.

Current Findings. After reviewing more than 1,200 supplemental electronic learning resources in the CLRN online database in detail, I conducted an analysis of the extent of alignment of these resources to the California Content Standards (Cradler, 2003). It is important to note that most electronic learning resources are intended to be supplemental rather than to cover the whole range of standards in a particular strand or grade level. The exceptions are programs commonly known as skill building, integrated learning systems, or tutorials, which generally cover more skills in a given standards con-

tinuum. The major findings resulting from the analysis follow:

1. On average, the supplemental electronic learning resources reviewed aligned to less than 40% of the standards in most of the strands or topics, including English/language arts, mathematics, science, and history/social studies.
2. Less than 10% of curriculum standards tend to be assessed or tested as a feature or component of most electronic learning resources.
3. Math and reading tend to use interactive multimedia, whereas science and social studies tend to rely more on video and Web-based resources.

In addition, reviewers and publishers sometimes report that electronic learning resources address cognitive or process skills and knowledge not explicitly addressed or described in the current content standards.

Current Implications. Implications from these findings are that it is important to study the extent to which the standards are addressed by these supplemental electronic learning resources and whether the ways they are addressed make optimal use of the technology as a resource to enhance existing curriculum and pedagogy. A few of the questions resulting from the CLRN analysis follow:

- Are the 20%–50% of the standards addressed by electronic learning resources the most promising standards for supplemental applications of technology to address?
- Does the alignment of programs to standards really mean student learning will be increased in contrast to programs that have not been aligned to standards purported to improve learning?
- Are there motivational and cognitive factors that indirectly improve learning according to standards that are uniquely provided by the use of some technology applications?

These are only a few of the questions that need to be answered, which suggests the need for both a comprehensive review and analysis of existing research as well as new research.

Research and Technology-Based Learning Resources

Tied to the assumption that aligning learning resources with content standards can result in greater achievement is the need for research that actually tests and attempts to validate learning resources in terms of their effects on learning based on standards-based assessment tools. CARET was established to review current research and evaluation studies to identify, summarize, and disseminate practical implications of studies that clearly document the effects of technology on standards-based instruction. Of the more than 650 studies CARET has screened for review so far, approximately 150 have been referenced in answering critical questions in the areas of student learning, professional development, online learning, assessment, and curriculum and instruction. Approximately 60 of those 650 have undergone intensive review, and 45 of those 60 were found to be both relevant to the critical questions asked by educators and to have sufficient credibility to be posted on the CARET Web site. These include 9 summary papers or reports, 23 survey studies and meta-analyses, 5 program evaluations, and 8 formal experimental or quasi-experimental research studies. In other words, less than 20% of the 650 reviewed studies offered practical and applied findings and conclusions that would help educators make informed planning decisions about how to use and integrate technology-based learning resources into curriculum and instruction. There is obviously a shortage of formal controlled research—a fact that figures in federal mandates coming out of NCLB—but what CARET found was that even in the case of experimental work, most studies report findings

with respect to statistical significance and research implications and yet report very little information on the educational significance or on the implications for teaching and learning.

Most researchers identify limitations of their research in terms of the difficulty in controlling the many changing variables found in school environments. Many studies tend to investigate the use of technology as a tool to facilitate the completion of work (e.g., word processing to support writing, statistical programs and spreadsheets to aid in conducting mathematical and statistical analysis, graphics tools to aid in drawing, and the Internet as a resource for students to conduct research and to collaborate globally with other students). Studies of organizational and technical resources available to support teachers' integration of technology often do not link their analyses of context and teachers' technology use to measures of student learning. Technology-based learning resources that show the greatest gains in academic achievement are those that:

- are sequential
- include student-performance guide branching to optimal difficulty levels
- include embedded assessments
- can be operated more or less independent of a classroom environment

The following is a list of the major weaknesses found in studies CARET reviewed:

- Several studies that provide appropriate statistical design fail to adequately describe the intervention and the conditions under which the intervention or resources are implemented.
- When academic measures, such as standardized tests, are used, they often do not directly relate to the content and/or the intended objectives of the learning resources studied.
- Studies of student learning often use only one measure of student learning,

such as a curriculum-specific assessment, rather than multiple forms of assessment that might also include assessment of process skills.

- Often, it is not clear what specific research or evaluation questions the study is attempting to answer.
- Small sample sizes that reduce statistical significance are often used.
- Large samples are used that often are not disaggregated by important variables that need to be addressed for the study to be replicated.
- Measures that are not objective and/or validated are sometimes used to assess student learning.
- Context or conditions under which technology is used are not adequately described or related back to the findings and conclusions.
- Applications of the technology are not clearly specified.
- Academic standards the intervention is intended to address are not clearly specified.
- Technology-based learning resources are studied alone and not compared with similar resources.
- Results are based more on contextual variables than on the intervention studied.
- Conclusions provided are sometimes not adequately supported by the data collected.
- Studies are often descriptive with no quantitative measures and do not use control or comparison groups.
- Staff development studies on technology use often do not relate changes in teachers' instructional use of technology to changes in students' academic achievement or use of technology for learning.
- Surveys often do not combine analysis of self-reports with observations and/or measures of teacher proficiency or student learning.

In general, CARET reviews are showing that if educational technology studies addressing student achievement are to produce information that helps edu-

cators to plan and use technology effectively, such studies must accomplish several things. They must:

1. Ensure that technology-based learning resources align with and are designed to enable students to develop the skills and knowledge based on the standards for which the resource is intended.
2. Ensure that the assessments are direct and valid measures of the skills and knowledge implied by the curriculum standards addressed by the electronic learning resource being studied.
3. The state curriculum standards and related assessments should directly or indirectly relate to the instructional uses and purposes of the learning resource or technology application being studied.
4. Carefully document the manner in which the technology-based intervention is implemented to the extent that someone could replicate the intervention.
5. Carefully document the conditions or context for the intervention and then relate any of these factors to the outcomes.
6. Use large enough samples so that the resulting data can be disaggregated according to unanticipated (or anticipated) implementation and contextual variables.
7. Use control groups when possible and, if similar resources or strategies using technology are known, then use comparison groups to provide a comparative analysis of the interventions with the control group.
8. Consider that the overall goal of the study is to determine which elements of the technology-based intervention can be replicated in other settings and still produce the same or similar results.
9. Incorporate valid measures of problem solving or cognitive skills and/or measures of motivation to supplement academic measures, as technol-

ogy is often found to enable development of motivation and cognitive skills often not included in state academic standards.

Recommendations

In general, a study should provide sufficient information about the effective implementation and use of the technology-related intervention. It should also suggest the professional development, technical support, administrative support, time, prerequisite teacher skills, standards to address, types of assessments, and any other factors determined by the research to be necessary to replicate the summative findings of the original study.

Even though many studies are weak in the application of research methodology, it is possible to review large numbers of small or weak studies and look for trends. Taking studies together and then drawing somewhat non-empirical conclusions based on this “best evidence” approach must suffice until more reliable empirical studies are supported and completed with results reported in ways that can be easily applied by the education community. In spite of the absence of a large quantity of research, an ongoing survey of users indicates that with CARET’s in-depth review of a relatively small number of studies and a best-evidence review of a large number of limited studies and evaluations, it is possible to provide an important source of more or less objective information to inform technology planning from the state to the classroom levels. The demands of NCLB for accountability combined with the strong interest shown by the education community, strongly suggest that efforts like that initiated by groups such as CARET and CLRN should be expanded as there exists a great deal of information about electronic learning resources yet to be reviewed, analyzed, and communicated to educators.

Funding is another important issue to consider when designing studies to

fulfill the requirements of NCLB. Most projects do not set aside funding for evaluation and research unless it is a requirement. And, when evaluation is required, it is usually less than 10% of the total project budget. In almost every case, educators need to ask when reviewing studies, were there sufficient resources available to conduct a credible evaluation of the implementation of the electronic learning resources in question? Another issue is that most education agencies and producers of electronic learning resources do not have the expertise to conduct the rigorous scientific research of the level now required under NCLB. The U.S. Congress and state legislatures should consider ways to subsidize such educational research.

These are the major considerations that should be addressed in both reviewing and designing studies on the implementation and effects of technology in teaching and learning.

Resources

CARET: <http://caret.iste.org>
 CLRN: www.clrn.org
 Enhancing Education Through Technology
 fact sheet: www.nclb.gov/start/facts/21centtech.html
 NCLB: www.nclb.gov

Reference

Cradler, J. (2003). *Supplemental electronic learning resources aligned with California content standards for Grades K–12 as currently identified by California Learning Resources Network*. Sacramento: California Department of Education.



John Cradler is the co-director of the CARET project and president of Educational Support Systems (ESS). He first became involved with technology when working with the South San Francisco Unified School District. In 1974, while looking for a more efficient way to provide reading tutoring for special education students, he discovered a Stanford University project on computer-assisted instruction, which was adapted to support a phonics tutoring project called Success Controlled Optimal Reading Experience (SCORE).