A Synthesis of New Research on K–12 Online Learning

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Introduction

Online learning is an emerging but rapidly growing phenomenon in K–12 education. Although practitioners believe that online education is effective in reaching and serving a wide range of students, little empirical research has been performed to determine its effectiveness in elementary and secondary settings. Questions remain about the educational needs best addressed through online learning as well as its impact on school improvement and learner outcomes.

Programs of research informed by early lessons learned are needed to inform the future development of online learning. This synthesis summarizes the latest in a series of research efforts sponsored by North Central Regional Educational Laboratory (NCREL) to answer questions about online learning and promote the growth of effective programs and practices.[1]

In October 2004, NCREL developed and distributed a request for proposal (RFP) calling for new, quantitative online learning research. Rigorous research methodology was indicated as an important priority for all proposals. Required research methodology was defined as quantitative data collection supporting an understanding of the efficacy of online learning in the K–12 context.

Although methodology was not limited strictly to quantitative studies, the RFP defined the following methodological priorities:

- Priority 1. Fully randomized, experimental designs.
- Priority 2. Powerful (high validity and reliability) quasi-experimental designs (i.e., low on sources of invalidity).
- Priority 3. Correlational and survey research.
- Priority 4. Mixed-method case studies, "grounded" research, mathematical modeling, and/or other heuristic and exploratory research strategies with utility for disconfirming causal models that may or may not fit with existing or "extent" data. (Adapted from Whitehurst, 2003)

Randomized experimental designs were given a competitive priority. Proposals with research plans, including true experimental designs with random assignment of subjects to experimental and control groups, were ranked most highly during the proposal review. These priorities reflect the priorities of the Institute for Education Sciences, as explained in detail in the document titled *WWC Study Review Standards* (U.S. Department of Education, n.d.).

[1] The RFP development was based on four years of prior NCREL research documenting the lack of authoritative educational research examining K–12 online learning. This specific research initiative was commissioned as a response to specific recommendations from *The Effects of K–12 Distance Education on K–12 Student Outcomes*: *A Meta-Analysis* (Cavanaugh, Gillian, Kromrey, Hess, & Blomeyer, 2004; pp. 23–26.). Other NCREL works defining the effects and status of educational technologies and online learning in American schools include Waxman, Lin, and Michko (2003); Waxman, Connell, and Gray (2002); Watson (2005); Watson, Winograd, and Kalmon (2004); and Blomeyer (2002).

In the weeks following the distribution of the RFP, 33 proposals were received by the due date of November 8, 2004. The proposals were reviewed by both external and internal reviewers, and eight proposals were chosen for funding. Contracts for the eight successful proposals were executed, and their studies were completed in July 2005.

This synthesis is based on final research reports submitted to NCREL by the research teams. Copies of those reports are available on request from the research teams. (Contact information on the researchers appears in the Appendix.) Several of the studies already have been submitted or are being prepared for submission to peer-reviewed journals.

Section 1 of this document provides an overview of the field of online learning to establish the context within which the eight research studies were defined and conducted. Section 2 presents brief summaries of each of the eight studies, with an analysis of common themes, challenges, and issues in online learning. Section 3 presents specific implications for researchers, policymakers, and practitioners based on the eight studies.

Section 1
Overview of the Field

The emergence of online learning represents a convergence of several factors: the development of the Internet and the World Wide Web, the use of computers in instruction, the use of media to unite teacher and learner at a distance, and the integration of technology into all facets of education. Online learning is the latest form of distance education and also is a type of e-learning. K–12 online learning, which began as a way to expand the curriculum and educational access, is increasingly a tool of education reform. The theoretical and research basis of K–12 online learning is beginning to be established.

The Need for K–12 Online Learning

Many political and education leaders realize that global trends are changing the nature of education. When the National Governors Association (NGA) highlighted the Redesigning the American High School initiative at its 2005 annual conference, its invited speakers included education experts from China and India and a bestselling author whose latest book asserts that a third era of globalization is now under way—powered by individuals, not nations or corporations (Friedman, 2005). The rise of online technologies allows innovative entrepreneurs worldwide to participate effectively in the global marketplace. American K–12 students must be prepared to compete in this new environment.

The school reform models recommended by NGA and other organizations are based on characteristics such as personalization and individualization, which are strengths of online learning (Cavanaugh, Gillian, Kromrey, Hess, & Blomeyer, 2004) and central to success in the new global economy. Americans invented digital computers and the Internet and got a head start in getting connected in school and at home. Today's students, part of the Millenial generation, are digital natives, but the full potential of technology is not being realized in K–12 education—including the promise of online learning.

There are continuing concerns about the quality of K–12 education in the global context. National Assessment of Educational Progress (NAEP) reading and mathematics scores of U.S. 9-year-olds improved dramatically between 1999 and 2004, while achievement gaps between white and minority students shrank (Perie, Moran, & Lutkus, 2005). The No Child Left Behind Act helped spur these improvements. However, NAEP scores of 17-year-olds have not changed measurably in 30 years (Perie, Moran, & Lutkus, 2005). While U.S. Census Bureau statistics suggest an 85 percent graduation rate long-term, actual rates may be closer to 68 percent, with only half of minority students earning a diploma (Swanson, 2004). New strategies are needed if high school outcomes are to improve. Online learning is already used for Advanced Placement and early college credit, and its alternative and remedial uses are growing.

The No Child Left Behind Act calls for new forms of educational choice and supplemental educational services to serve students attending failing schools. Already a number of online learning options have emerged to provide alternatives for students and parents and to help teachers become highly qualified.

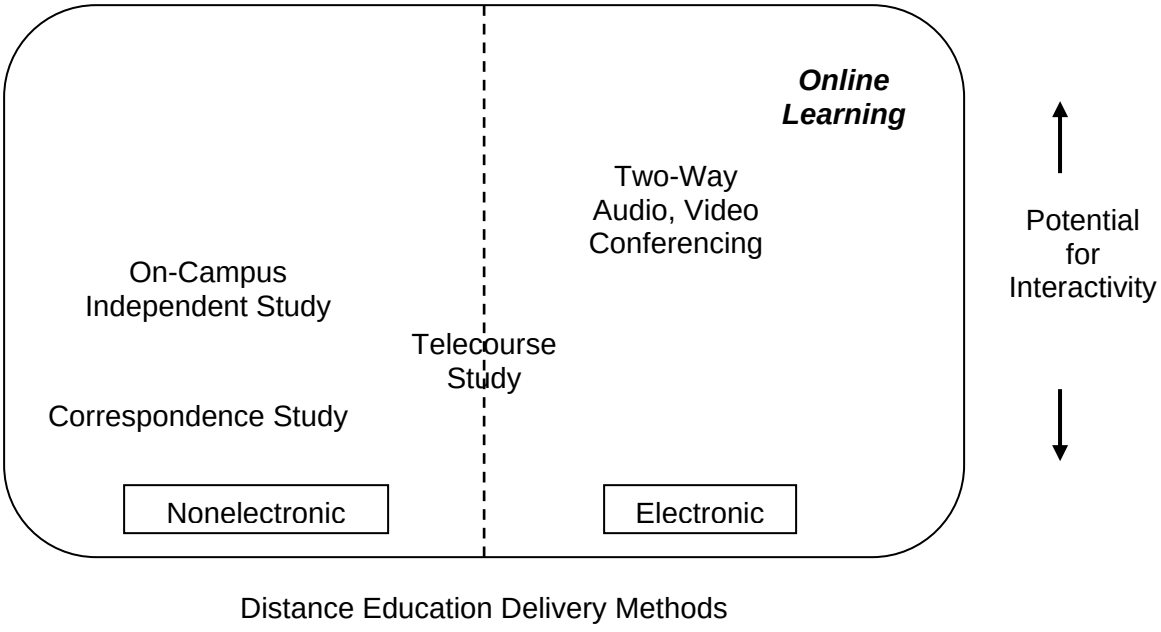
Online Learning: Virtual, Distance and E-Connections

Clark (2001) defines virtual schools as "educational organizations that offer K–12 courses through Internet- or Web-based methods" (p. 1). Watson, Winograd, and Kalmon (2004) see online learning as "education in which instruction and content are delivered primarily via the Internet" (p. 95). Virtual schooling or online learning occurs through a virtual school or online learning program that offers formal instruction, not merely instructional resources or content.

Online learning is a form of distance education—formal study in which teacher and learner are separate in time or space. Distance education can be delivered through nonelectronic methods (such as correspondence study) or through electronic methods. Electronic methods are primarily telecommunications-based (such as audio and video conferencing) and Internet-based (using information technologies such as computers). Mixed methods combine electronic and nonelectronic media. For example, telecourse study often combines videos with independent study by mail. Distance education is usually defined in U.S. Department of Education surveys as including only electronic or mixed methods. The supplemental use of electronic technologies to provide educational experiences at a distance is sometimes called distance learning. Students enrolled in distance education courses also may be said to be engaged in distance learning.

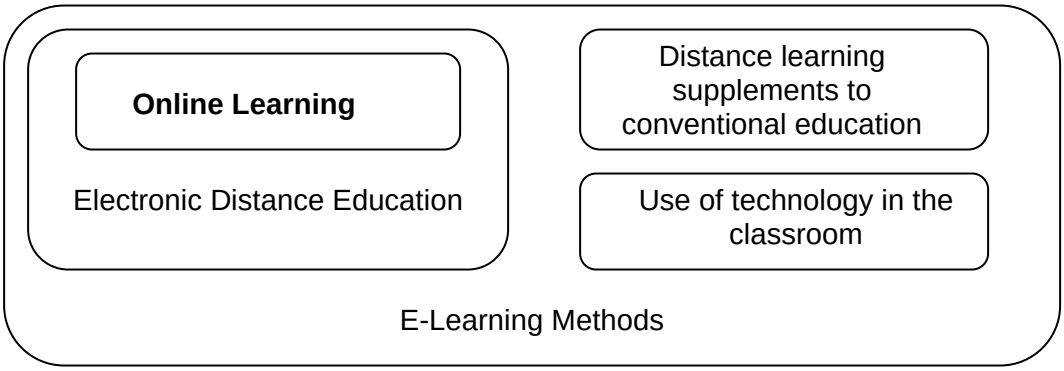
The potential for learner interaction with others is generally greater in electronic distance education but can vary widely based on the model used (Figure 1.1). A number of models have been proposed for interaction, a key feature of distance education theories. (See discussion under Theories of Distance, page 11.)

Figure 1.1. Online Learning as a Form of Distance Education



Online learning is also a type of e-learning. Some authors define e-learning as online distance education only, while others include all educational uses of online technologies. Internationally, the term *information and communication technologies* (ICTs) is commonly used to describe the use of electronic technology in education, business, government, or daily life. For the purposes of this chapter, e-learning is considered to be the use of electronic technologies or ICTs in education (Clark & Berge, 2005; Imel, 2002). E-learning may occur both in distance and conventional education and may involve electronic media that do not use online delivery. For example, electronic distance education through videoconferencing is seen as e-learning, as is the incorporation of supplemental online or video-based distance learning activities into conventional education, and classroom use of electronic technologies (Figure 1.2).

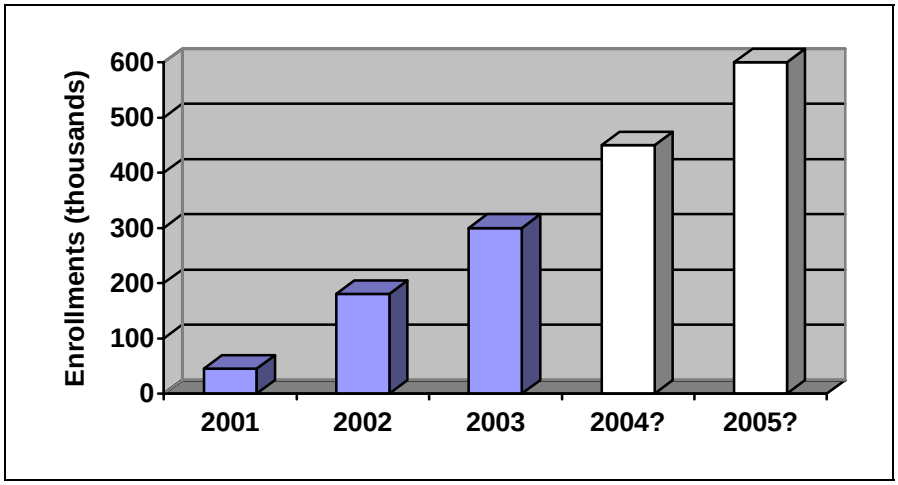
Figure 1.2. Online Learning as a Form of E-Learning



Growth in Online Learning

Recent surveys show that K–12 online learning is a rapidly growing phenomenon. Eduventures estimated 300,000 K–12 enrollments in online courses in 2002–03, based on a survey of 88 online course providers (Newman, Stein, & Trask, 2003), up from estimates of 40,000 to 50,000 enrollments in 2000–01 (Clark, 2001) and 180,000 in 2001–02 (Peak Group, 2002). Based on a national survey of school districts, the U.S. Department of Education (Setzer & Lewis, 2005) estimated 328,000 public school enrollments in online or video-based distance education courses in 2002–03. Breakouts were not available for online-only enrollments. These estimates may include students enrolled in one or more courses. Accurate estimates of current enrollments are not available but may be extrapolated based on prior trends (see Figure 1.3).

Figure 1.3. Estimated Growth in K–12 Online Learning, 2001–Date



To keep things in perspective, more than 53 million students attend U.S. public or private schools (Livingston & Wirt, 2005), so perhaps 1 percent of K–12 students have taken an online course. Online learning is more widespread in postsecondary education, where an estimated 1.9 million students enrolled in at least one online course in 2003 (Allen & Seaman, 2004). This number represents almost 12 percent of the 16.4 million students enrolled in postsecondary education that year (Snyder, Tan, & Hoffman, 2004). Videoconferencing is still an important distance education method. Although 59 percent of public school districts enrolled a student in an online course, 55 percent had at least one videoconferencing enrollment (Setzer & Lewis, 2005). Nonelectronic distance education has not disappeared either. Independent-study high schools still enrolled 164,000 students in 1997–98 (Pittman, 2000), although many are now transitioning to online learning (Smalley, 2005).

Educational Level

The emergence of programs designed to serve elementary and middle school students has led to more frequent use of the term *virtual school* rather than *virtual high school* to denote a K–12 online learning program (Clark, 2001). Only 3 percent of public school enrollments in online or video-based distance education in 2002–03 were in elementary or middle schools. About 68 percent were in high schools, and the rest were in K–12 unit schools combining elementary and secondary grades (Setzer & Lewis, 2005). Most online learning still occurs at the high school level, where lackluster academic outcomes suggest a need for new education reform strategies.

Course Offerings

A U.S. Department of Education survey of public school districts (Setzer & Lewis, 2005) provided a breakdown of 2002–03 distance education enrollments by content area. Core content areas such as social sciences (23 percent), English/language arts (19 percent), and mathematics (15 percent) constituted slightly more than half of the offerings. Enrollments in foreign languages were 22 percent in rural schools, compared with only 5 percent in large city schools. Taking courses that offer both high school and college credit or an early start on college is a growing source of online enrollments in public schools. About 45,300 distance education

enrollments (14 percent) were in Advanced Placement or other college-level courses. A survey of public secondary schools (Waits, Setzer, & Lewis, 2005) arrived at an estimate of 44,900 distance education enrollments in 2002–03 in dual credit courses, excluding enrollments in Advanced Placement (AP) courses.

Types of Virtual Schools

State-level virtual schools are developed, administered, or funded in part by state government, and intended to provide online learning statewide (Watson, Winograd, & Kalmon, 2004). Twenty or more states currently operate their own virtual school.[2] The largest virtual schools include the Utah Electronic High School, with around 35,000 enrollments in 2004–05, and the Florida Virtual School, which reported 33,000 enrollments that year. According to the latest information available, 26 states have state-level policies governing online learning programs, but only 8 of those have state-level virtual schools (Watson, 2005)[3]. About 22 percent of U.S. public school districts report enrollments in state virtual schools by their students (Setzer & Lewis, 2005). State virtual schools usually are intended to provide supplemental courses to students attending regular schools, although they may also serve homeschoolers. Some state virtual schools offer both online and video-based courses, leveraging state investments in telecommunications and computer networking.

Virtual school consortia pool the costs of content and instruction across multiple schools, facilitating development of a shared curriculum that follows common design standards (Cavalluzzo, 2004). It is probably simplest to consider the overall consortium as the online learning program in this case. About 34 percent of school districts reported distance education enrollments through other districts in their state in 2002–03, and many of these are probably due to consortia. The largest consortium, operated by Virtual High School (VHS Inc.), had 6,100 enrollments in 2004–05 and served about 268 participating schools in 29 states and 24 countries. VHS cooperative schools get 25 student seats in online courses when one of their trained teachers instructs a course section (Pape, 2005).

Postsecondary institutions are major providers of K–12 online learning, and they build on a long history of distance education. At least seven independent-study programs at universities have developed an online high school curriculum, making them virtual schools as well, while other postsecondary online learning programs serving K–12 students originated in gifted education, dual enrollment, or early college credit. About 48 percent of public school districts reported an online or video-based distance education enrollment through a postsecondary institution in 2002–03 (Setzer & Lewis, 2005).

In 2004–05, there were about 86 cyber charter schools in 16 states, serving around 31,000 students (Center for Education Reform, 2005). These tuition-free public schools are operated

[2] Clark (in press) estimates 20 state virtual schools in 2005, while Watson (2005) estimates 21.

[3] Watson (2005) reports that eight states have both statewide online learning programs and state-level policies: Alabama, Arkansas, California, Colorado, Florida, Louisiana, Maryland, and Nevada. Watson also reports the following 13 states as having statewide online learning programs but without specific state-level policy: Georgia, Hawaii, Idaho, Illinois, Iowa, Kentucky, Michigan, Mississippi, North Dakota, Utah, Virginia, West Virginia, and Wisconsin. See the Summary Tables on pages 120–121 in Watson, 2005.)

independently by an eligible entity under a charter that makes them accountable to their sponsoring agency. Most enrollees are former homeschoolers. While funding methods vary, the costs of charter schools are generally paid by the district in which a student resides, directly or through reduced state aid. The interest in and controversy over cyber charter schools belies their student numbers, which are equivalent to about 3.1 percent of all charter school students (Center for Education Reform, 2005) and 2.8 percent of all homeschoolers (Princiotta, Bielick, & Chapman, 2004).

It appears that most K–12 online learning participants take an online course or two while attending a regular public school full-time. In 2002–03, about 6,000 U.S. public high schools (38 percent) had at least one student enrolled in a distance education course delivered by online or video-based methods. About 1 in 4 school districts reported enrolling students in distance education courses provided by the district itself (Setzer & Lewis, 2005). Even if only a small percentage operate a freestanding program with their own online instructors and content (purchased or developed), this would mean that hundreds of districts operate their own online learning programs or "virtual schools."

Private schools and for-profit e-learning providers also offer online learning programs, although the scope of their programs is more difficult to estimate. About 18 percent of public school districts reported distance education enrollments through independent vendors in 2002–03 (Setzer & Lewis, 2005).

Expanding Access and Improving Education

Concerns about equity and access to education spurred initial growth in online learning, which is now viewed as a strategy for achieving education reform. The first impetus to the growth of K–12 distance education was an interest in expanding educational options and providing equal opportunities for all learners. There is a long history of using distance education for these purposes, especially in small and rural schools. A Michigan superintendent created the first independent-study high school in 1923 for students at risk of dropping out (Michell, 1923). Among K–12 unit school districts with 300 students or less responding to a 1992 national survey, half reported offering a distance education program, usually satellite-based (Barker & Hall, 1994). A decade later, rural high schools were twice as likely as urban high schools (47 percent to 25 percent respectively) to report a distance education enrollment via online or video-based methods (Setzer & Lewis, 2005).

Historical inequities in educational access helped spur development of virtual schools. High school students completing AP courses and passing AP exams can boost their grade point averages and receive early college credit. A lawsuit filed against the state of California in 1999 documented inequitable access to AP courses in rich and poor public schools. Around the same time, race-based university admissions policies began to be eliminated in California and other states. The University of California responded with an online college preparatory program that offered AP courses and AP exam review for poor and minority high school students (Hernandez, 2005). Other states followed suit, using funding sources such as the federal AP Incentive Program to create online AP programs serving low-income students.

The No Child Left Behind Act is probably the most far-reaching piece of education reform legislation ever enacted at the federal level. To receive federal education funding under No Child Left Behind, state and local agencies must meet timelines for improving schools and teacher qualifications. Public schools are required to show adequate yearly progress (AYP) each year, including for minority, disabled, economically disadvantaged, limited-English-proficient, and migrant students. Those who cannot show AYP must fund alternative school-choice options after two years and provide supplemental educational services after three years.

Prior to passage of the No Child Left Behind Act by Congress in 2002, the primary focus of technology use in schools was on installing hardware, software, and connectivity infrastructure and using e-learning to expand educational opportunities. Today, according to *Education Week*, one major use of technology is to document student achievement under No Child Left Behind (Editorial Projects in Education, 2005).

Progress in Implementing E-Learning and Online Learning

In the National Education Technology Plan (NEPT), the U.S. Department of Education (2005b) presents a national vision for technology in which virtual schools and e-learning are seen as a strategy for attaining key educational goals. One of seven NETP action goals for improving the use of educational technology is "support e-learning and virtual schools" (p. 41). Five recommendations support this strategy:

- Provide every student access to e-learning
- Enable every teacher to participate in e-learning training.
- Encourage the use of e-learning options to meet No Child Left Behind requirements for highly qualified teachers, supplemental services, and parental choice.
- Explore creative ways to fund e-learning opportunities.
- Develop quality measures and accreditation standards for e-learning that mirror those required for course credit. (U.S. Department of Education, 2005b, p. 42)

Progress is being made on these goals, based upon information currently available. There is presently no national effort to collect regular, systematic information about virtual schools and e-learning (with the exception of Watson, 2005). A variety of entities have gathered evidence on an episodic basis using different measures. A recent effort to gauge the extent of digital learning opportunities for children (Children's Partnership, 2005) is laudable but illustrates the patchwork nature of current information.

Provide every student access to e-learning. By 2003, nearly 100 percent of U.S. public schools had access to the Internet and 95 percent used broadband. About 93 percent of classrooms were online. The average ratio of students to computers with Internet access was 4.4 to 1 (Parsad & Jones, 2005). A majority of K–12 students already have access to e-learning—if it is defined as the use of technology or ICTs in education. In 1999, about 52 percent of K–12 teachers said they used technology in instruction (Lanahan, 2002). About 90 percent of children ages 7 to 17 reported using computers in school, as did 97 percent of high school students (U.S. Bureau of the Census, 2004). Some studies (e.g., Levin & Arafah, 2002) provide limited evidence on the

frequency and types of student use. Significant differences remained in home access by family income, education, and minority status.

Enable every teacher to participate in e-learning training. Evidence on current participation in e-learning training is limited. Based on a series of U.S. Department of Education surveys, Parsad and Jones (2005) found that public school teachers with classroom technology access, training, and support were much more likely to report instructional use of technology. About 82 percent of schools reported making professional development in the instructional use of technology available to teachers in 2003. School estimates suggest that less than half of all teachers participated that year, although the percentage who received technology training over time was not studied. The Enhancing Education Through Technology program requires that 25 percent of funding to schools be spent on staff development. Evidence on the extent of training for online teachers is anecdotal. It is likely that less than 1 percent of all teachers nationwide are trained as online teachers. The intensity, duration, and quality of staff development for online teachers appear to vary significantly.

Encourage the use of e-learning options to meet No Child Left Behind requirements for highly qualified teachers, supplemental services and parental choice. As noted previously, failing schools must provide school-choice options and then supplemental educational services (SES). The No Child Left Behind Act also requires that all teachers be certified in their content area by the end of the 2005–06 school year. Kleiman (2004) provides guidelines and examples of the use of e-learning to meet No Child Left Behind "highly qualified" teacher standards. Some SES providers provide online tutoring services. Cyber charters are one approach to providing for school choice. Florida Virtual School, as a freestanding public school district, also is a school-choice option in its home state. Blomeyer and Dawson (2005) discuss components of e-learning-friendly state and federal policies for accountability, equity, funding, and quality in support of No Child Left Behind. Some states and districts have developed strategies for using e-learning to meet No Child Left Behind requirements.

Explore creative ways to fund e-learning opportunities. Funding online learning programs and e-learning is a great challenge. A number of federal programs that fund e-learning activities have been eliminated (such as the Technology Incentive Challenge Fund), while others are now proposed for elimination (such as Enhancing Education Through Technology). Federal programs such as the E-Rate ($2.2 billion a year since 1998) and Enhancing Education Through Technology (about $400 million a year) may have helped narrow the technology gap between rich and poor schools. The National Education Technology Plan (U.S. Department of Education, 2005b) suggests consideration of budget restructuring, leasing, and multiyear technology innovation funds by states and districts. State-supported virtual schools vary greatly in their costs and funding methods (Watson, 2005). Who funds participation in virtual schools is a key issue, especially with the potential diversion of funding from traditional public schools to cyber charters (Cavalluzzo, 2004).

Develop quality measures and accreditation standards for e-learning that mirror those required for course credit. Quality measures have developed for online K–12 courses by a number of organizations, including the Southern Regional Education Board (2000) and the National Education Association/Virtual High School Inc. (2002). The regional accrediting

associations have developed a Commission on International and Trans-Regional Accreditation (CITA) for schools that cross regional boundaries, including distance learning providers (Evans & Griffin, 2004). However, like state school laws (Watson, 2005), these general distance education criteria do not always fit online learning. Less traditional accreditation sources may not be as acceptable to colleges or employers. Virtual schools that provide supplemental courses may decide not to seek regional/CITA accreditation to avoid the appearance of competition with the local schools of record that they serve.

Frameworks for Online Learning Research: Objectivist and Constructivist Viewpoints

Different theoretical perspectives can add value to the design and delivery of online learning. Ally (2004) summarizes key positions of the behaviorist, cognitivist, and constructivist schools of thought, noting the overlap between their concepts and how all three are commonly incorporated into the design of online learning. For example, testing and feedback mechanisms align well with teaching facts, or "what," in support of the behaviorist view of learning as a change in observable behavior due to external stimuli. A cognitivist focus on how the mind learns may be best for structuring complex learning of processes and principles that explain "how," using techniques that support and motivate different kinds of learners as they make the connections.

Learning the "why" about online learning may be stimulated by constructivist approaches that use interaction within a situational context to encourage learners to think and reflect while constructing their own personal meaning. Behaviorists and cognitivists, sometimes referred to as *objectivists*, typically see reality as existing objectively, independent of the human mind. Constructivists see knowledge as constructed by the learner or the social group based upon experiences, resulting in multiple realities. The objectivist and constructivist views may best be seen as the opposite ends of a continuum. Instructional designers often follow objectivist or constructivist paradigms in their development of distance education courses; they should consider using the one that best fits a given educational context (Vrasidas, 2000).

The No Child Left Behind Act is clearly written from an objectivist viewpoint, as it requires use of standardized testing to study changes in learner knowledge and skills and hold schools accountable for academic improvement across student subgroups. The guidelines for research and evaluation issued by the U.S. Department of Education to support No Child Left Behind also fall clearly into the objectivist camp. Many educators take a more constructivist view. If students do not remain constructively engaged in learning, they may drop out or fall behind, ultimately leading to flat test scores and lower graduation rates. Good teachers are lifelong learners who are willing to learn new techniques, but they often seek to customize and apply those techniques selectively based on their perceptions of the needs of particular learners or groups.

Experienced teachers at all levels often see teaching as an art, not a science, and prefer craft knowledge or best practices to science-based, nonmalleable scaleable interventions. However, a focus on academic outcomes can allow considerable leeway in the processes actually used to improve learning. Even if an instructional method is based on constructivist principles, it may be found to be effective in improving academic outcomes through experimental research.

Theories of Distance Education

Researchers studying the effectiveness of distance education usually do not address theory in their studies (Saba, 2004). However, theories and models are essential to the field's credibility over the long term (Garrison, 2000). Peters (1967) was among the first to use the term *distance education* in describing an "industrialized" theory for distance-teaching organizations, and this usage is still relevant to large-scale online learning programs today. Many other theoretical perspectives followed.

Dialogue and Structure

Wedemeyer (1971) defined the characteristics of independent learning and the structure of independent study. In his theory of transactional distance, Moore (1973) added the concept of dialogue or interaction. Distance education programs with low dialogue and structure would seem most distant to the learner and would require the most learner autonomy for successful participation, while those with high dialogue and structure would seem the least distant and would require less personal responsibility and self-directedness from learners. Moore's theory had a major influence on the emerging field. Saba (2004) and others have sought to validate it through research. Anderson, Rourke, Garrison, and Archer (2001) posit three ways in which online teachers create a teaching presence: design and administration, discourse facilitation, and direct instruction. Constructivists may prefer to see increased critical dialogue and reduced structure, using new technologies that facilitate communication (Lauzon, 1992).

Types of Interaction

Interaction is a key component of distance education theory. Interaction in distance education can be learner-teacher, learner-content, or learner-learner (Moore, 1989). Clearly, online distance education offers opportunities for all three kinds of interaction, through features commonly built into course management systems such as automated instruction, communication tools, and discussion tools. Holmberg (1989) focused on the provision of learner-content interaction through well-designed instructional materials, which he characterized as a "guided didactic conversation" (p. 43). Hillman, Willis, and Gunawardena (1994) suggest a fourth type of interaction, learner-interface interaction, noting that learner skills in using the technology interface influence learning and that interfaces must be designed for usability.

Independence and Collaboration

Theorists have sought to reconcile distance education theories based on independent study with new forms of distance education, such as videoconferencing and online learning (Garrison, 2000). Henri (1992) developed a collaborative model of the nature of computer-mediated communication that has proven useful in discourse analysis. Anderson (2004) proposes a model for e-learning that encompasses both collaborative and independent study modes.

Synchronous and Asynchronous Methods

Garrison (2000) notes the need for theory to explain both distance education methods that rely primarily upon asynchronous written communication (such as independent study or online learning) and synchronous audiovisual communication (such as videoconferencing). Simonson, Schlosser, and Hanson (1999) take a different path, proposing an equivalency theory for synchronous distance education methods such as videoconferencing, for which they believe the underlying premise is to provide experiences for the learner as equivalent to conventional instruction as possible. They see primarily asynchronous methods such as online learning as best fitting under the theories of independent study proposed by Moore (1989) and others.

Differences Between K–12 and Adult Learners

Distance education theorists usually focus on postsecondary education, and they often draw upon adult education theories that share learner-centered concepts with the cognitive and constructivist schools. But a range of educational theorists have noted differences between child and adult learners that should be taken into account. Younger online learners may have a lower degree of the autonomy needed to learn independently and less internal locus of control and intrinsic motivation to persist in their studies. They may need age-appropriate developmental activities as they move through cognitive stages. Online collaboration tools can help learners perform learning tasks that are within their means if they have the help of others. Constructivist theories suggest children may lack the rich experiences needed to construct knowledge of the world around them and would benefit from the scaffolding that online learning environments can be tailored to provide (Cavanaugh et al., 2004; Slavin, 2003).

Science-Based, Design-Based, and Mixed-Methods Research

Scientifically based research is clearly best for seeking to determine whether a particular intervention causes meaningful changes in student achievement. However, design-based and mixed-methods research hold promise for making formative improvements to the effectiveness of online learning. They also can improve understanding of online learning and link theory to practice and outcomes. Online learning researchers must address not only the effectiveness of an intervention but why it is effective (Cavanaugh et al., 2004).

Design-Based Research

The Design-Based Research Collective (2003) argues for a blending of empirical educational research with theory-driven design of learning environments. Designed-based researchers see this methodology as key to understanding how and why educational innovations work in practice. These researchers ground their work in specific theoretical concepts and seek to "understand the relationships among educational theory, designed artifact, and practice" (p. 1).

Design-based research can be used in complex educational settings where intervention components cannot easily be disentangled for study in isolation. It can be used to identify contextual factors and build understanding of how the intervention works, making it possible to take these factors into account when planning experimental research. For example, alternating

cycles of design-based implementation studies and experimental research may help refine understanding of why learning does or does not take place. Such approaches may be used to demonstrate the most effective combinations of instructional methods and media (Smith & Dillon, 1999), making it possible to attain education reform goals more quickly. For example, students from a population of interest may be randomly assigned to sections of an online course segment, with different instructional design or other features, to identify effective treatments prior to comparisons with students in conventional study.

Mixed-Methods Research

While random assignment studies are clearly the best approach to studying causal changes in educational outcomes, attempts to use these studies to improve education may be unsuccessful in the absence of a "well-integrated, methodologically diverse research effort" (Raudenbush, 2005, p. 1). A variety of nonexperimental quantitative and qualitative research methods may help identify the most promising interventions that in particular contexts can change the most important outcomes for target groups of learners. Standardized academic content area tests do not measure all significant learning impacts (Smith & Dillon, 1999). Mixed methods are necessary to identify outcomes of interest and develop defensible outcome measures. Promising interventions may emerge from many methods, such as small-scale implementation studies, case studies, or secondary analyses of existing data. These methods may help identify children who have the most potential benefit from interventions. Mixed methods also may help researchers determine whether context issues or resource constraints may impact the effectiveness of an intervention.

Effectiveness of K–12 Online Learning

In higher education, the Sloan Consortium has served as a focal point for experimental and applied research and the development of a community of researchers devoted to improving online learning effectiveness, affordability and satisfaction. Research on K–12 online learning rarely has been conducted in a sustained, systematic manner. There is a pressing need for efforts to organize and systematize research on the effectiveness of K–12 online learning, such as the NCREL K–12 Online Learning Research Initiative (of which this synthesis is a part).

Emerging Evidence of Effectiveness

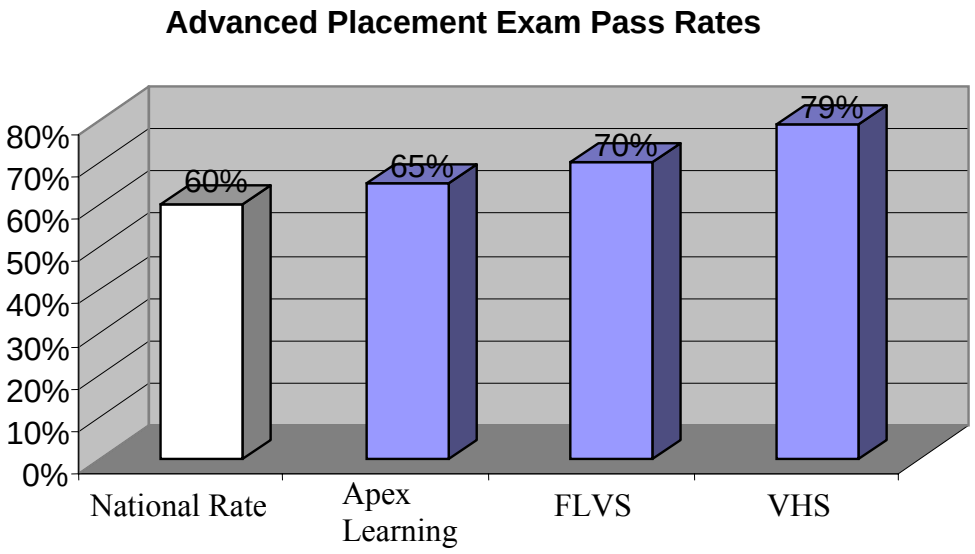
Online learning programs often use performance data to help demonstrate effectiveness. For example, the Virtual High School, Florida Virtual School, and Apex Learning all have released results demonstrating that their students receive a passing score of 3 or higher on AP exams at a higher rate than the national average (Figure 1.4), giving these students a head start in college.

While evaluation studies are useful for demonstrating K–12 online learning's benefits to stakeholders, few provide evidence of effectiveness meeting the standards of scientifically based research recently established by U.S. Department of Education.

The effectiveness of online learning, distance education, and e-learning has been the subject of hundreds of studies, but few provide the best kinds of evidence on academic, satisfaction, or

other student outcomes. Compilations of studies have given way to more systematic meta-analytic methods that allow the magnitude of the effect of an intervention to be quantified across multiple related studies.

Figure 1.4. Mean Percentage of Students in Three Online Learning Programs Who Sat for Advanced Placement Examinations and Achieved a Passing Score



Science-Based Research Standards

The randomized field trial or random assignment study is seen as the "gold standard" for studies of educational effectiveness by the Education Department. Evaluations of funded projects are expected to feature random assignment of students to treatment and control groups whenever feasible to determine if there is a causal relationship between project participation and meaningful changes in student achievement or teacher performance. A few rigorous quasi-experimental designs are acceptable when an experimental study is not feasible, such as those using score cutoffs (regression discontinuity) or matched comparison methods to assign students (U.S. Department of Education, 2005a). Less rigorous quasi-experimental methods may compare student groups with differing characteristics. Studies selected for inclusion in the What Works Clearinghouse (www.whatworks.ed.gov) must meet similar criteria.

Some rigorous studies are under way or are too recent to have been incorporated into meta-analyses. For example, as mandated by the No Child Left Behind Act, the U.S. Department of Education currently is conducting a national study of the conditions and practices under which educational technology is effective in improving academic achievement. This study focuses on the effectiveness of selected interventions at different grade levels for students in low-income schools, using experimental designs with random assignment of participants (Agodini, Dynarski, Honey & Levin, 2003). The interest of Congress in conducting this study indicates a continuing interest in the effectiveness issue.

A common theme voiced by researchers seeking to identify comparison studies for inclusion in meta-analyses is that although hundreds of studies or reports purport to address the effectiveness of distance education, only a small percentage meet established standards as experimental or quasi-experimental research and also adequately report methods and results. To date, meta-analyses have primarily included quasi-experimental studies. However, when many quasi-experimental studies meeting minimum standards of rigor are synthesized, it is reasonable to expect that the results can be aggregated to draw conclusions about the general impact of online learning. The distribution of effect sizes across multiple meta-analyses has been used to set thresholds of effectiveness in random assignment evaluations of education programs (Schochet, 2005). Meta-analyses limited to studies meeting What Works Clearinghouse standards may be feasible in the future.

Research on Academic Achievement

Meta-Analyses of Computer-Aided Instruction

During the past three decades, a number of meta-analyses have systematically examined the effects of technology use on K–12 student achievement outcomes. Between 1982 and 1991, at least 23 meta-analyses were conducted on the effects of computer and technology assisted education (Lipsey & Wilson, 1993). Kulik (1994) reviewed 12 of these meta-analyses, finding that they showed positive but small effects, with treatment students scoring at the 64th percentile on achievement tests compared to the 50th percentile for comparison students. More recent meta-analyses have examined the effectiveness of computer-assisted instruction on the academic achievement of elementary students (Ouyang, 1993) and secondary students (Christmann, Lucking, & Badgett, 1997).

NCREL has organized and funded a series of meta-analyses to determine the effects of technology on academic performance in Grades K–12. The first, conducted by Waxman, Connell, and Gray (2002), was based on 20 studies of the use of computer-assisted instruction and online activities in conventional education settings. These researchers found a mean study-weighted effect size across all outcomes of .30 with a 95 percent confidence interval (CI) of .004 to .598, indicating a small, positive effect for computer-assisted instruction (CAI). This study was extended in an effort to increase the body of acceptable studies considered and to increase confidence in mean effect size. Waxman, Lin, & Michko's (2003) expanded work was based on 42 studies conducted between 1997 and 2003. They reported a weighted mean effect size of .410 with a 95 percent confidence interval of .175 to .644. They found positive effect sizes for cognitive outcomes (.448) and affective outcomes (.464) such as satisfaction or motivation, but a negative effect size in 3 studies for behavioral outcomes (-.091), such as persistence in learning tasks.

Meta-Analyses of Educational Uses of Distance Learning Technologies

Five meta-analyses related to online learning or distance education in K–12 have been completed in the last few years (Table 1.1). Cavanaugh (2001) performed a meta-analysis of 19 studies in which technologies such as videoconferencing and online telecommunications (e-mail and Web) were used in K–12 education settings, either as a supplemental distance learning application in regular classes or as a primary distance education method. Measures of student achievement were the dependent variable. Results indicated a very small, positive effect for distance technologies. Based on the confidence interval, no claim was made of a significant difference in achievement. The six studies using online technologies showed a small to moderate positive effect size, while the 13 studies using videoconferencing had an effect size near zero.

Table 1.1. Meta-Analyses of Distance Education and Online Learning, 2001–04

Authors, Date	Outcomes	Technology	Educational Level	Study *N*	Weighted Mean Effect Size	95% CI (upper/ lower)
Cavanaugh (2001)	Achievement	Distance technologies	K–12	19	+0.015	-1.113 to 1.407
Bernard et al. (2004)	Achievement (also attitude, retention)	Online learning	Higher ed and K–12	232	+0.0128	-0.0068 to 0.0325
Ungerleider and Burns (2003)	Achievement, satisfaction (combined)	Online learning	Higher ed and K–12	16	Near zero	N/A
Shacher and Newman, (2003)	Achievement	Online learning	Higher ed and K–12	86	+0.37	0.33 to 0.40
Cavanaugh et al. (2004)	Achievement	Online learning	K–12	14	-0.028	0.060 to -0.116

Distance Education and Online Learning Meta-Analyses

Bernard, Brauer, Abrami, and Surkes (2004) conducted a meta-analysis of 232 studies of distance versus conventional education that used online or video-based methods in K–12 or higher education settings. Effectiveness was studied through achievement, attitude, and retention outcomes. These researchers found a mean average effect size across all outcomes that indicated no significant difference across all effects. Online learners slightly outperformed their face-to-face counterparts on achievement measures, while holding similar attitudes about their courses, but also were likely to have lower course retention rates. On the other hand, videoconferencing students were outperformed by conventional students and had less positive attitudes than conventional students. Their retention rate was similar to conventional students and higher than that of online students.

Ungerleider and Burns (2003) conducted a meta-analysis of 12 online learning studies, 10 at the postsecondary level and 2 at the secondary level. Achievement and satisfaction were used as outcome variables. An effect size of zero was found for achievement in online learning

compared with conventional study, indicating no significant difference. Effect sizes calculated for satisfaction on four studies showed a small to moderate effect in favor of conventional study.

A Meta-Analysis of K–12 Online Learning

Cavanaugh et al. (2004), the most recent meta-analytic study funded by NCREL, examined the effects of Web-based distance education on the academic outcomes of students across a range of K–12 grade levels. It is the only meta-analysis to date specifically designed to answer the question "Is K–12 online learning effective in terms of academic achievement?" In this study, Cavanaugh et al. identified 14 studies completed between 1999 and 2004 that met inclusion criteria. Student achievement measures served as the outcome variable. The weighted mean effect size was negative but near zero, indicating no significant difference in the effects of online or face-to-face learning.

These meta-analytic studies tend to confirm the findings of extensive compilations, such as by T. Russell's (1999) annotated bibliography of 355 studies, ranging from Crump (1928) through studies published in 1999. They support the conclusion that distance education is *as effective as* conventional education in terms of academic outcomes, rather than more or less effective. However, one recent meta-analysis suggests distance education is "better." Shachar and Neumann (2003) included 86 studies in a meta-analysis of distance versus conventional study. Using final academic performance as the outcome variable, they found a moderately positive effect size for distance education. It appears that most of the 86 studies selected were among the mix of 232 higher education and K–12 studies used in the Bernard et al. (2004) meta-analysis.

In reviewing these five meta-analyses related to K–12 online learning, it appears that different applications of meta-analytic methods may yield somewhat differing results. Based on these available findings, one conclusion seems clear: On average, students seem to perform equally well or better academically in online learning. Because of the very small number of high-quality quantitative studies available for review and synthesis (only 14 studies were completed between 1999 and 2004), this conclusion should be described as showing promise, but with the realization that we cannot have real "confidence" in these conclusions until there is much more support available from high-quality quantitative research.

The eight new quantitative research projects undertaken and completed under NCREL's support are, in effect, an effort to address this evident need for new quantitative research on K–12 online learning. All of the researchers who participated brought forth proposals to execute high-quality, field-based, experimental, and quasi-experimental studies.

Given the limited resources and constraints on time, it is understandable that many of their efforts fall short of being two-group, fully randomized experimental *educational experiments*. We believe that there is much contained in these eight new works that should be taken seriously and might considered to be the "best evidence available" at this point in time examining the impact of K–12 online learning.

Context for This Project

This brief review of the field establishes the context within which the eight research studies summarized in Section 2 were conducted. The general topics explored by the studies—student academic performance; characteristics of successful online students; qualities of effective online courses; professional development for effective online teaching and learning; challenges of online learning; and online learning, school change, and educational reform—are enduring issues in the relatively brief existence of the field. Each study is grounded in the literature and represents an attempt to contribute new findings to guide further research and practice.

Section 2
Eight Research Studies: Summaries and Synthesis

Introduction

The primary intent of the NCREL K–12 Online Learning Research Initiative is to significantly advance the body of research informing the practice of online learning. This section provides detailed summaries of the eight research studies funded by the initiative and then presents a synthesis of common themes across the studies. Following are simple one-sentence descriptions of the studies.

Study 1 (Dickson, 2005): Looks at what kinds of courses are effective for what kinds of learners, in terms of learner outcomes, and also explores the bimodal nature of an online learning population and its relationship to the purposes of a virtual school.

Study 2 (Lowes, 2005): Considers whether or not online teachers' instructional practice is transformed by teaching online and whether or not online teachers act as education reform agents in the schools where they also teach face-to-face classes.

Study 3 (Leu, Castek, Hartman, Coiro, & Henry, 2005): Examines whether science learning improves with online collaborative learning and Internet Reciprocal Teaching used to develop online reading-comprehension skills.

Study 4 (Ferdig, DiPietro, & Papanastasiou, 2005): Compares learner outcomes for online and conventional education in specific content areas, and considers whether online learning success can be predicted.

Study 5 (Hughes, McLeod, Brown, Maeda, & Choi, 2005): Tests the "no significant difference" hypothesis regarding student perceptions of their learning environment in online and conventional mathematics courses using similar curriculum; also studies whether variances in online teacher staff development lead to differences in learner affective outcomes.

Study 6 (Kleiman, Carey, Bonifaz, Haistead, & O'Dwyer, 2005): Examines the effectiveness of an online learning and teacher mentoring program designed to provide effective Algebra I instruction in high-needs schools while increasing the number of No Child Left Behind highly qualified teachers of mathematics in these schools over time.

Study 7 (Cavanaugh, Bosnick, Hess, Scott, & Gillan, 2005): Compares learner outcomes in conventional algebra classes with those in classes designed by the virtual school but taught either by its own instructors or by franchise instructors; also studies the performance of learners who use an embedded digital graphing tool in their course and those who do not.

Study 8 (Zucker, 2005): Examines online student and instructor attitudes toward online interaction; attempts to experimentally determine if one form of encouraging student-to-student

interaction does increase interaction, thereby improving such factors as retention, student performance, and student satisfaction with the course.

Table 2.1 provides a quick cross-reference of the topical areas addressed by the studies.

Table 2.1 Topical Areas Addressed by Online Learning Synthesis Research Teams

Study Number and Research Team Lead	Student Academic Performance	Characteristics of Successful Online Students	Qualities of Effective Online Courses	Professional Development for Effective Online Teaching and Learning	Challenges of Online Learning	Online Learning, School Change, and Educational Reform
1. Dickson	X	X	X		X	X
2. Lowes				X	X	X
3. Leu	X		X		X	X
4. Ferdig	X	X			X	X
5. Hughes	X		X	X	X	X
6. Kleiman	X			X	X	X
7. Cavanaugh	X		X	X	X	X
8. Zucker	X		X	X	X	X

Study 1 (Dickson, 2005)

Title: ***Toward a Deeper Understanding of Student Performance in Virtual High School Courses: Using Quantitative Analyses and Data Visualization to Inform Decision Making***

Researcher: W. Patrick Dickson, Michigan State University

Description: Looks at what kinds of courses are effective for what kinds of learners, in terms of learner outcomes, and also explores the bimodal nature of an online learning population and its relationship to the purposes of a virtual school.

Purpose

The purpose of this study was to "look in detail at the distributions of achievement scores within courses offered through the Michigan Virtual High School (MVHS) in order to seek a deeper understanding of the variability remarked upon in recent meta-analyses" (p. 11). Citing the Cavanaugh et al. (2004) meta-analysis (whose findings indicated zero average effect size, wide variability in effect sizes, and a lack of correlation of performance with plausible influences), the researcher argues for more detailed analyses that may reveal more than no significant difference.

Research Questions

It was understood that this proposed research would not employ an experimental or quasi-experimental design. The stated intent was to execute an analysis of five years' worth of enrollment data detailing the academic performance and persistence (completion and retention) of students enrolled in MVHS online courses. That broad intent can be stated succinctly as the following hypothesis: Extent data from five years of operations at the Michigan Virtual High School can be collected from the various participating state school districts, aggregated, cleaned, and analyzed to provide support for administrative decision making needed to optimize online students' academic performance and *persistence* (i.e., retention and successful completion of online high school courses).

Based on this analysis, the research questions addressed by this investigation were as follows:

1. What data elements relevant to participation in MVHS courses are routinely available in the participating Michigan high schools?
2. How can that data be analyzed and reported most effectively to support administrative decision making by MVHS leadership and by educational leadership in the Michigan General Assembly and Michigan Department of Education?

Methodology

Initial analyses of trends during the five-year period of enrollments by semester and location helped contextualize the next phase of analysis, in which detailed analyses focused on average

student performance by subject-matter areas (such as mathematics, science, and world languages). In this first phase, MVHS staff worked to organize the collected data. Through that task, they were able to understand differences in type and quality of existing data and therefore contributed to planning for procedures for routinely organizing such data in the future. The distribution of individual students' final scores within specific courses was the detailed focus of analysis within these subject-matter areas.

The study identified variation in students' final grades, which varied significantly across the different disciplines. In some cases, the distribution was bimodal, with certain students doing very well and others doing poorly and/or dropping out. Through data analysis, data visualization, and discussion with staff, the study identified the types of data displays that seem most valuable to decision makers. The researcher argued that these analyses began to unravel the first question of "What data, what decisions?" The intent of this question was to unravel what decisions might be better informed by working with existing data.

A second question asked within this study was "What decisions, what data?" This question is different from the first one in that it served to illuminate what kinds of decisions are available to administrators, teachers, and students that might be better informed if certain types of data were readily accessible. As an example of how visual data displays can inform educators and researchers, the researcher presents a scatter plot of a typical 30-student online course section (from among the dozens analyzed), in which total activity (clicks) in the discussion board had a positive relationship to final course grade ($r = .72$).

The researcher notes that "although the strength of the correlation between total clicks and final grade varies by course, in every case we examined it was strong and positive" (p. 41). The scatter plot provides intuitive evidence that some students participate more efficiently than others, and that the correlation will remain strong even if students with low or zero scores are excluded.

Findings

The findings of this study point out what seems obvious yet is often overlooked: When an organization, school, or business is in its start-up phase: *collecting and analyzing data is not often among the highest of priorities*. Deciding on computer management systems that would support the organized and consistent collection of student performance data often is not done in the early stages of start-up and therefore data are not collected in any consistent, interoperable format. This study supported MVHS in understanding how data ought to be collected, organized, and used.

Research Question 1 (routinely available data elements relevant to MVHS participation): The project provided resources that MVHS required in order to organize the data in a consistent and accessible database. It permitted MVHS staff the opportunity to "step back and look at the data in multiple ways previously not possible" (p. 4). It also ensured that the ways that data were analyzed and displayed were valuable to MVHS stakeholders.

Patterns in the statewide academic performance and persistence data that were previously obscured were uncovered. For example, the repurposing of data within the course management

system revealed a relationship between student participation in the online environment to measures of students' success in terms of final course grades. This understanding provides teachers with the ability to monitor student participation and offer early intervention when necessary.

Research Question 2 (effective analysis and reporting of data): The researcher concludes that visual displays of disaggregated data may suggest hypotheses to the researcher and provide instant feedback to the educator on how individuals in a class are doing. He suggests that although prior research comparing online and conventional learning has done a great service by demonstrating that there is no significant difference on average in achievement between online and traditional courses, this finding of "no significant difference" may mask variability due to bimodal achievement within online courses.

Conclusions

The apparently bimodal nature of achievement and retention/completion in online courses makes it difficult to establish comparable treatment and control groups. If conditions are controlled to eliminate students likely to be noncompleters from random assignment, the two groups may be unrepresentative of the populations purportedly being randomly sampled.

The exploratory evidence on differences in achievement based on course features suggests that there are substantial opportunities for models for experimental research that focus on within-course variance by planned comparisons among design features, using random assignment or other methods. Finally, the complexity in sources of variability in performance in online courses means there is little prospect of giving a definitive answer to the question of the relative superiority of online versus traditional courses.

The results of this study have important implications for K–12 online learning research as well as for the growing national-practitioner community concerned with understanding and improving learning in online and traditional courses. It identifies the need to provide online learning leadership in online schools and the need for states or other organizations supporting multischool alliances to provide ways of thinking and tools for analysis as well as the resources necessary to support collecting, analyzing, and using real-time data to positively influence students' performance in online courses.

Study 2 (Lowes, 2005)

Title: ***Online Teaching and Classroom Change: The Impact of Virtual High School on Its Teachers and Their Schools***

Researcher: Susan Lowes, Institute for Learning Technologies, Teachers College, Columbia University

Description: Considers whether or not online teachers' instructional practice is transformed by teaching online and whether or not online teachers act as education reform agents in the schools where they also teach face-to-face classes.

Purpose

The researcher used survey research to document the perceptions of Virtual High School Inc. (VHS) instructors about changes in their teaching practices and course design in moving from teaching face-to-face to teaching online, and to show how their experiences teaching online influenced their subsequent design and teaching of face-to-face courses. This exploratory study suggests additional research in several areas, including necessary and desirable components of online courses, sustainable improvements to teacher practice, adaptations of effective teaching strategies across learning environments, and impacts of online teaching.

Research Questions

The research questions that were proposed to be addressed by this inquiry were as follows:

1. How, and in what circumstances, does teaching an online course affect (or not affect) an individual teacher's face-to-face teaching, and what are these effects?
2. How, and in what circumstances, does having a teachers who teaches both types of courses affect (or not affect) the teacher's school as an educational institution, and what are these effects?
3. How, and in what circumstances, does having both face-to-face and online courses available in a school affect (or not affect) the school, and what are these effects?

Methodology

Both interview and survey methodologies were used in this study. A survey, based on interviews with six current and former VHS teachers, was developed and electronically sent to the entire universe of current and former VHS teachers with known e-mail addresses (N=464). Forty-six percent of those teachers responded, including 63 percent of those currently teaching. The VHS end-of-year teacher survey acted as a secondary research source. Half of respondents had completed advanced VHS training and developed a new online course, while the others had completed basic training and adapted an existing course.

The respondents were representative of the entire VHS population in terms of subject areas taught, with a concentration in the social sciences (including history and economics), science, and English language arts. This response supported an understanding of whether transforming from online to face-to-face teaching was more facilitative in certain disciplines than others. Further, there was an equal representation of teachers developing their first course and teachers who were adapting existing VHS courses.

Teachers also were asked to identify the learning models and pedagogical strategies with which they were familiar. Although most had familiarity with authentic assessment, problem-based learning, use of rubrics in assessment, and cooperative learning, many had little experience with Wiggins and McTighe's (1998) "backward design" approach, which is the pedagogical model used by VHS. However, after teachers had completed the online professional development course(s), their level of familiarity with backward design increased significantly.

Findings

Research Question 1 (impact on teachers' practice): In total, 158 teachers (74 percent of the survey respondents) said that becoming an online teacher changed the way they teach. In addition, 75 percent of survey respondents reported that teaching online had had a positive impact on their face-to-face teaching. Regarding those responses, an important caveat seemed to be that some teachers did not report making changes in their teaching practice because they reported already having made the specific changes in their practice before becoming an online teacher.

Research Question 2 (impact of teaching online on practice): The teachers generally reported that after teaching online, their practice supported increased student participation in classroom learning, greater emphasis on independent learning, more effective use of questioning strategies, and more reliance on learning strategies utilizing metacognition and reflection.

Research Question 3 (impact of available online courses on schools): Teachers reported an expanding range of available course options, students receiving an expanded range of technology mediated and online learning experiences, noticeable increases in independent or self-directed learning among participating students, and increased sharing of ideas and knowledge building among students.

The following discussion explores some of the important details that emerged according to the major questions addressed by this study. When the survey data were analyzed, three identifiable and distinct foci emerged with importance for understanding the impact of online teacher preparation on virtual praxis.

The first focus of the study was online course development. Teachers who had adapted a face-to-face course for online delivery were asked whether they added, deleted, or retained 14 specific components. For example, 78 percent added online readings and resources, while 34 percent took out worksheets. Similar but less extensive changes were made by those adapting an existing online course. Those creating a new course were less likely to include some of the activities that others removed during adaptations, such as worksheets.

The second focus was teaching the online course. Teachers noted a number of issues with which they were concerned, including effective communication, increased time for student reflection and open-ended questions, pacing courses, and appropriate assessments that encourage academic honesty.

The third focus was teaching face-to-face after teaching online. Of those who reported teaching face-to-face while teaching online or subsequently, three in four reported a positive impact on their face-to-face teaching. Respondents rated 40 possible changes in the way they subsequently developed a face-to-face course. The highest levels of reported change included adding student peer reviews (69 percent) and eliminating lessons that now seemed poorly designed (67 percent). The third most reported change was integration of backward-design principles learned through VHS (66 percent).

Teachers were more likely to report use of strategies for organizing and conducting the course, such as providing more detailed instructions (65 percent), and less likely to report integration of technology activities. They reported many examples of modifying online strategies to make them effective in a face-to-face setting.

In open-ended responses, some noted changes in their general approaches to teaching, such as setting higher student expectations, encouraging independent learning, using more open-ended questioning, encouraging reflective writing, and spending more time facilitating. The 144 respondents who marked all 40 items were given a point for each item showing at least moderate change after teaching online, to calculate a "change score."

Respondents with scores of 21 to 40 were categorized as "major changers." Major changers in core content areas ranged from math (63 percent) to language arts (46 percent). Major changers were more likely to have developed an online course (50 percent) than to have adapted an existing online course (38 percent).

The researcher also explored effects on the school. Asked if they had seen positive changes in their schools as a result of their teaching online, about 65 percent of the 132 teachers who responded said yes. The percentage was not higher in schools with multiple VHS teachers. The most commonly cited positive change for the school was an expanded array of courses offered (33 percent). Providing online course and independent learning experiences also were commonly cited benefits, but changes in teacher technology skills were not.

Participating teachers identified several barriers to online teaching and learning, but they indicated that teaching an online course provided them with the flexibility to communicate individually with students to help ensure appropriate grading and pacing, and to support generally uniform and equitable instructional practices. Some of the teachers went on to share their opinion that this increase in individualization from online communications can support broader improvements in teaching and learning practice in the face-to-face learning environments where the vast majority of their teaching still takes place.

The researcher points out what could be an important caveat for increasing the understanding of how different course-development models and different delivery models fundamentally change

the way students and teachers interact in online learning environments. She notes that the VHS course design and delivery model assumes online courses have fixed beginning and ending dates (as with regularly scheduled conventional face-to-face courses) and place an online teacher and a class of online students together in a virtual "classroom" for one or possibly two semesters together.

This assumption is very different from online schools that operate on an entirely "self-pacing" or "anytime, anyplace" schedule. Online schools using an unscheduled "independent study" approach generally permit students to enroll and complete courses online without experiencing any significant student-student online communication or interaction. The researcher points out that the effects of this type of course may be very different from the effects of the VHS model.

New Questions for Online Learning Research

Based on the findings from this present study, the researcher poses the following new questions concerning the apparent effects of professional development for online teachers:

- How much change can be attributed to the constraints of online learning, such as the need for explicit directions? How much can be attributed to teacher perceptions of effective online practices (affordances), such as opportunities for independent learning and for providing reflective exercises?
- To what extent are the changes attributable to the professional development model that VHS uses, and to what extent are they due to the personal characteristics of teachers attracted to online instruction?
- Would teachers of more self-paced online courses show similar changes?
- How can we best capitalize on the changes teachers made in face-to-face teaching as a result of online teaching? Are there ways to encourage the transfer of the more successful aspects of online pedagogy back to the face-to-face classroom? Could experienced online teachers act as expert resources for their face-to-face colleagues?

Study 3 (Leu, Castek, Hartman, Coiro, & Henry, 2005)

Title: ***Evaluating the Development of Scientific Knowledge and New Forms of Reading Comprehension During Online Learning***

Researchers: Donald J. Leu, Jill Castek, Douglas K. Hartman, Julie Coiro, Laurie A. Henry, University of Connecticut

Description: Examines whether science learning improves with online collaborative learning and Internet Reciprocal Teaching used to develop online reading-comprehension skills.

Purpose

This study focuses on integrating the Internet within content-area classrooms and examines new online reading comprehension skills required to learn science content online. The researchers argue that this is often not an easy task because teachers perceive their role as one of teaching content, not the new literacies required to use information and communication technologies (ICTs) effectively (International Reading Association, 2002).

Theoretical Framework

The study is framed in a new literacies perspective (Leu, Kinzer, Coiro, & Cammack, 2004). According to this theoretical perspective, reading comprehension on the Internet requires new literacies to "identify important questions, locate information, analyze the usefulness of that information, synthesize information to answer those questions, and then communicate the answers to others" (Leu, Kinzer, Coiro & Cammack, 2004, p. 1570).

Research Questions

This study addresses three general research questions relating to the effects of Internet use on reading comprehension and on concept attainment in science classes:

1. (a) Do students who receive different intensity levels of Internet integration during science class have different profiles, over time, of online reading comprehension compared to students who receive regular classroom instruction, without the Internet?
   (b) Do students who receive different intensity levels of Internet integration during science class perform better on a test of online reading comprehension compared to students who receive regular classroom instruction without the Internet?
2. Do students who receive different intensity levels of Internet integration during science class perform better on measures of science content learning?
3. (a) Is there a significant relationship between performance on an assessment of traditional reading comprehension and performance on an assessment of online reading comprehension?
   (b) Do students who receive different intensity levels of Internet integration during

science class perform better on an assessment of traditional reading comprehension compared to students who receive regular classroom instruction without the Internet?

Methodology

As online programs and schools continue to develop and expand, students will require new online reading comprehension skills that are required to effectively navigate, critically evaluate, synthesize, and communicate in these new learning environments. In order to understand the development of new forms of reading comprehension during online learning within classroom science instruction, the intensity of Internet integration by duration of Internet access as well as by the duration of instruction in the new literacies of online reading comprehension were evaluated. The consequences of this integration of online reading comprehension, science learning, and traditional reading comprehension also were evaluated.

Online reading comprehension was evaluated using two different assessments, each with strong psychometric properties, grounded in a new literacies perspective; science learning was measured using measures of declarative knowledge and deeper conceptual understanding for human body systems. Ongoing skill development and differences between treatment conditions were measured by administering theses measures over the course of the study. An adaptation of Reciprocal Teaching referred to as Internet Reciprocal Teaching was used as an intervention intended to enhance participating students' online reading comprehension.

This study focused on a middle school with approximately 416 students in a suburban/rural New England district with a minority enrollment of 4 percent. Of the teacher populations, 82 percent possessed a master's degree. Further, less than 4 percent of students were eligible for free or reduced-price lunch in 2001, and 1 percent spoke a primary home language other than English. The average class size in the seventh grade was 23.8 students, and approximately 12 percent were enrolled in special programs.

Grade 7 classrooms and students were selected because of the increasing attention on reading and learning of adolescent youth. Science was chosen as the target discipline of this study because science education has become increasingly important in the global context and particularly because more recent policy initiatives note the need for the integration of science learning with online information resources, simulations, and modeling.

In January 2005, the Degrees of Reading Power (DRP) test was administered to participating Grade 7 students. The mean total raw score of reading achievement was 50.31 (SD = 12.95), while the mean $p = 90$ conversion scores for independent reading level on the same test was 53.67 (SD=14.98). The results indicate that students are able to read, independently, an easier middle school resource such as Scott O'Dell's *Island of the Blue Dolphins* (Touchstone Applied Science Associates, 2004).

Four conditions were identified in this study representing four levels of intensity of Internet integration in the classroom: (1) Internet use with intensive strategy instruction, (2) Internet use with moderate strategy instruction, (3) Internet use with no strategy instruction, and (4) no Internet use and no strategy instruction but regular classroom instruction (control).

An adaptation of Reciprocal Teaching was used as an instructional strategy for teaching the new literacies of the Internet. This instruction model has proven efficacy at teaching reading comprehension strategies and improving reading comprehension, especially among adolescents.

Traditional reading comprehension was measured as a means of correlation with online reading comprehension and also to test the hypothesis that instruction in the new literacies would improve not only online reading comprehension but also traditional reading comprehension. Finally, the evaluation of the consequence of varying the intensity of integrating new literacies was undertaken to understand how much time should be devoted to Internet use and strategy instruction to improve scientific learning and increase reading comprehension and whether there was a minimum level of Internet use and instruction required to achieve gains.

Participants included 89 seventh-grade students (42 males and 47 females) in suburban and rural New England settings. All students were taught by the participating teacher, who had an undergraduate degree in science education, a teaching credential, and 3.5 years of previous teaching experience in science education, but had minimal skills in online learning. This teacher taught cooperatively in three conditions but taught independently in the control condition using the classroom science text as the exclusive resource.

The methodology included four groupings: (1) one classroom had a face-to-face instruction for 12 weeks using high-intensity Internet integration and Internet Reciprocal Teaching (IRT) strategies; (2) one classroom used moderate-intensity Internet integration with no reciprocal teaching for 5 weeks and then with IRT for 7 weeks; (3) another classroom used low-intensity Internet integration for 5 weeks with no IRT; and (4) the control group used no Internet and no IRT. Intact classes were randomly assigned to one of the four conditions.

Findings

Three sets of research questions were studied: questions related to changes in online reading comprehension performance, questions related to science content learning, and questions related to traditional reading comprehension performance:

Research Question 1a: *Do students who receive different intensity levels of Internet integration during science class have different profiles, over time, of online reading comprehension compared to students who receive regular classroom instruction, without the Internet?*

The results of this analysis show that, generally, students in the three Internet conditions increased their online reading comprehension performance on the Online Reading Comprehension Assessment with Instant Messaging (ORCA-IM) more than the control group, which did not use the Internet and did not receive strategy instruction in online reading comprehension.

Research Question 1b: *Do students who receive different intensity levels of Internet integration during science class perform better on a test of online reading comprehension compared to students who receive regular classroom instruction without the Internet?*

In summary, students in the three Internet conditions had significantly higher achievement levels in online reading comprehension than control students. This result was true for both ORCA-IM and Online Reading Comprehension Assessment with Blog (ORCA-Blog), two assessment instruments with good psychometric properties.

For example, an analysis of covariance (ANCOVA) treating pre-DRP scores as a covariate, classroom condition as an independent variable, and June ORCA-Blog scores as the dependent measure showed a significant difference in online reading comprehension scores as measured by ORCA-Blog, based on classroom condition ($F(3, 84) = 5.02$, $p < .003$, MSe = 52.22, partial eta2 = .16).

The traditional reading comprehension (developmental reading assessment or DRA) score was not a significant covariate, so it was eliminated from the analysis. Post hoc comparisons indicated that all online instruction groups were significantly different from regular classroom instruction ($p < .003$), while online instruction groups did not significantly differ ($p > .05$).

Research Question 2: *Do students who receive different intensity levels of Internet integration during science class perform better on measures of science content learning?*

Internet integration resulted in lower achievement on simple declarative knowledge and greater conceptual knowledge in science learning.

Research Question 3a: *Is there a significant relationship between performance on an assessment of traditional reading comprehension and performance on an assessment of online reading comprehension?*

New literacies theory (Leu et al., 2004) would predict a marginal relationship, or possibly no relationship, between measures of these two types of reading comprehension. In Pearson Product Moment correlations, neither the January nor the June score on the traditional reading assessment (DRP) was significantly associated with the online reading assessment (ORCA-Blog). This result supported theory predictions.

Research Question 3b: *Do students who receive different intensity levels of Internet integration during science class perform better on an assessment of traditional reading comprehension compared to students who receive regular classroom instruction without the Internet?*

No association was found between students' performance on either of the measures of traditional reading comprehension (January and June DRP) and their performance on the measure of online reading comprehension (ORCA-Blog).

An ANCOVA treating January traditional reading comprehension (DRP) scores as a covariate, condition as an independent variable, and June DRP scores as the dependent measure showed no significant differences among the adjusted means for the four classroom conditions ($F(3, 74) < 1.03$, $p > .38$). However, there was a tendency toward lower DRP scores as the intensity of the Internet Reciprocal Teaching increased.

Conclusions

The researchers suggest the following:

> "Partial implementation of Internet integration, as is typical of most classroom settings, may in fact decrease science or other discipline-based concept learning and reading comprehension. It may be better to fully integrate the Internet with continuous *and* consistent access along with consistent online reading comprehension strategy instruction or *not integrate the Internet at all* [italics added]." (p. 23)

This study served to demonstrate the need for more comprehensive research in the area of new literatures. To that end, an IES Reading Comprehension Grant as well as an Adolescent Literacy Grant have been awarded to the University of Connecticut's New Literacy Research Center, which provides the resources required to support expansion of this work during a three-year funding period.

Study 4 (Ferdig, DiPietro, & Papanastasiou, 2005)

Title: ***Teaching and Learning in Collaborative Virtual High Schools***

Researchers: Richard E. Ferdig and Meredith DiPietro, University of Florida; and Elena Papanastasiou, Intercollege, Cyprus.

Description: Compares learner outcomes for online and conventional education in specific content areas, and considers whether online learning success can be predicted.

Purpose

This study focuses on three groups of research questions: (1) questions about the effectiveness of virtual high school classes compared to their face-to-face counterparts, as measured by student achievement; (2) whether it is possible to predict student success or failure for virtual students taking online high school courses; and (3) what factors differentiate between students taking online versus face-to-face classes and whether these factors are related to achievement outcomes, both within and between groups.

Hypotheses

The groups of questions described above may be stated as the following three hypotheses:

1. Students' academic performance in online high school courses will be equal to or better than the achievement assessed in traditional (or face-to-face) high school courses with nearly identical content and objectives.
2. It is possible to predict the academic success of new online high school students using the Educational Success Prediction Instrument (ESPRI) (Roblyer & Marshall, 2002–2003).
3. Students in online high school courses will display significant differences on the What Is Happening In This Classroom (WIHIC) instrument (demographics and classroom activity inventory) when compared to students in traditional (face-to-face) high school courses with nearly identical content and objectives.

Methodology

The methodology included participants in two collaborative online high schools: the Appleton eSchool, an online charter high school in the Appleton Area School District in Appleton, Wisconsin; and Kiel Integrated Electronic Learning Charter School, or Kiel eSchool, in Kiehl, Wisconsin. The mission of the Appleton eSchool is to "utilize new and emerging technologies to provide students access to high-quality standards-driven curriculum, in an environment that is self-paced and able to accommodate students' varying physical locations and time frames" (Appleton Area School District, n.d.). The Kiel eSchool was established to provide additional and/or alternative learning opportunities, in whole or in part, for students whose educational needs may be better met outside the traditional school setting.

The study provides an understanding of why students take online courses. The most significant difference between the two learning environments is that the Appleton school district is approximately 10 times the size of the Kiel district; both schools, however, have similar online agendas, and both were awarded addition funding in 2003 to continue their exploration of collaboration in virtual schooling.

The data collection period was bound within a six-month time frame. Data were collected from students enrolled in the five classes that were offered in both face-to-face and online courses: Algebra I, Algebra II, Geometry, Health–Life Management Skills, and Personal Financial Management. All of these classes had similar overall learning objectives. Only the Algebra I course had the same online and face-to-face teachers. A total of 410 students were in the sample; 68 students took online courses, and 342 students took face-to-face courses.

Four online instruments were implemented, including the ESPRI predictive survey instrument, two versions of the WIHIC instrument, and a parent survey. Only students enrolled in an online course during the data collection period were asked to take the ESPRI, and these data were used to answer the second research question about the possibility of predicting student achievement. Face-to-face students received a 56-item WIHIC online survey containing demographic questions, while online students received a modified 98-item online survey that included the demographic questions given to the face-to-face students with the addition of 42 course-evaluation questions. The WIHIC was used to support the comparative analysis of student reaction to the same course. Although 248 face-to-face students responded to the WIHIC, only 18 online students responded. The study does not explain the low return rate among online students, but presentations note that most facilitators did not require completion. SPSS was used to organize and record the data.

The study also provides an understanding of the challenges inherent in the rigorous examination of virtual schooling. These challenges included but were not limited to high attrition rates providing small *n* samples and jeopardizing reliability and/or validity, and the fact that virtual schooling is almost never completely random as students self-select and are enrolled by parents or school personnel.

Findings

Hypothesis 1 (comparison of student achievement): Findings indicated that there were no significant differences between overall results of combined face-to-face versus combined online achievement scores. But when the final course grades and assessments were analyzed by content area, online students showed some higher scores.

Hypothesis 2 (ESPRI predictions): The findings indicated that 100 percent of the students were classified correctly. The ESPRI scores were significant in predicting course grades for a group of 202 online students who took the ESPRI surveys in 18 online courses.

Hypothesis 3 (WIHIC profile): Significantly different results were found in the subscales relating to student cohesiveness and cooperation. The face-to-face students scored higher in the areas of

classroom collegiality and collaboration in work efforts than their online counterparts. The task orientation subscale was found to be significant in predicting final course grades.

Conclusions

In this study, the researchers argue for more research that specifically investigates the affordances and constraints of online and face-to-face learning settings, not a blind comparison between past and present. The study suggests that the focus of future research should investigate what is happening inside online and face-to-face learning environments so that *factors* accounting for differences in achievement can be analyzed. These future analyses might focus on indications that content area has a significant relationship with the medium used to deliver the content and that the comparative studies are in fact a "perfect experiment" when comparable classrooms are examined.

The researchers recommend that future research not only should focus on the how and why of the differences between online and face-to-face teaching and learning but also must take into account the fact that content area may make a significant difference in understanding the affordances and constraints of each medium. The research should also include qualitative data that might corroborative scientifically designed research findings.

The Roblyer and Marshall (2002–2003) instrument was recommended by the researchers to serve as a counseling tool available for virtual high school administrators and mentor teachers. It could support the understanding of what perspective online students require in order to be successful in the online environment. The WIHIC instrument was recommended as a posttest measuring quantitative classroom differences.

Other recommendations of this study included the following:

- Further examination of the role of collaboration in funding future online initiatives.
- Development of a comprehensive approach to researching education in virtual high school.
- Development of a codebook or heuristic system for analyzing online learning in virtual high schools.
- Funding and development of continued opportunities for existing and future teachers to learn to teach online.
- Additional exploration of social, emotional, and other affective outcomes of learning online.

Study 5 (Hughes, McLeod, Brown, Maeda, & Choi, 2005)

Title: ***Staff Development and Student Perception of the Learning Environment in Virtual and Traditional Secondary Schools***

Researchers: Joan Hughes, Scott McLeod, Rachel Brown, Yukiko Maeda, and Jiyoung Choi, University of Minnesota.

Description: Tests the "no significant difference" hypothesis regarding student perceptions of their learning environment in online and conventional mathematics courses using similar curriculum; also studies whether variances in online teacher staff development lead to differences in learner affective outcomes.

Purpose

This study was designed to explore the connections between professional development and student affective outcomes, specifically student perceptions of learning environments, in online and face-to-face learning. The researchers reviewed the literature, noting that prior meta-analyses showed similar academic achievement but less satisfaction for online students, and summarized the limited research on online student satisfaction and perceptions.

Given the issues identified in the literature, they proposed to systematically explore online and face-to-face students' perceptions of their learning environment using the validated assessment What Is Happening in This Classroom (WIHIC) (Fraser, McRobbie, & Fisher, 1996). WIHIC measures several components of student perceptions of learning environments, with subscales on student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, and equity. The researchers documented WIHIC's high score reliability on each subscale. WIHIC surveys were administered to students by their teachers in May 2005.

Research Questions

The research questions addressed according to the above purposes are as follows:

1. Are there significant differences in online and face-to-face students' perception of the learning environment?
2. How much and what types of professional development and training do online and face-to-face teachers receive, and does the professional development and training differentially impact the students' perception of the learning environment?

Methodology

The methodology included comparative analysis of four virtual classes with three traditional classes whose Algebra courses were most closely matched in terms of curriculum, student population, and location (same state). The schools in this study were located in three different

states. The WIHIC surveys (Fraser, McRobbie, & Fisher, 1996), which requested information about students' demographics and their perceptions of their learning environments, were distributed to and completed by students in May 2005.

Online surveys were administered to students enrolled in online courses, while teachers in traditional classrooms were given the option to administer the survey in an online or paper format. In April 2005, all participating Algebra I teachers took an online survey regarding their teacher preparation, career history, and professional development experiences.

Descriptive statistical analysis was performed on both the student demographic information as well as on the WIHIC data to examine if any patterns existed in the scores. Differences in perceptions of learning environments between online and face-to-face students were examined with inferential analyses. Finally, characteristics of professional development of online teachers were descriptively compared with traditional course teachers.

In their literature review, the researchers also noted the dearth of research on connections between professional development and student outcomes. Therefore they proposed to study differences in professional development experiences of online and face-to-face teachers (N=7) through a researcher-developed survey, including items on their preparation, career history, and professional development experiences, but primarily focusing on their self-reported mathematics knowledge, mathematics-related teaching strategies/pedagogical strategies, and online instructional pedagogy. The teachers were surveyed online in April 2005. The student and teacher surveys together with student demographic data were used to study whether staff development differentially impacted student perceptions of learning environments.

Extensive efforts were made to match a virtual and a conventional school in each of four states in terms of Algebra I curriculum and student characteristics. School pairings were achieved in three states. While individual school pairings varied in terms of student demographics and survey response rates, t-tests showed that the overall samples of online (N=31) and face-to-face (N=85) student respondents were fairly similar, with the exception of age (online students tended to be older).

Findings

Based on independent-sample t-tests that showed significant differences (p <.001 to p <.015), the researchers identified two main findings.

Research Question 1 (comparing student perceptions of the learning environment): The first finding revealed that "Algebra I students in traditional face-to-face courses perceived significantly higher cooperation, student cohesiveness, and involvement in their classes than the students in the online Algebra I courses" (p. 36).

Research Question 2 (effect of online teacher professional development on student perceptions of the learning environment): The second finding of this study indicated that "students in online Algebra I courses perceived significantly more teacher support than students in face-to-face courses" (p. 37). The researchers also noted a tendency toward a relationship between the

teachers' hours of professional development for mathematics content and students' WIHIC teacher support scores, and between teachers' professional development in "teaching with technology" and students' WIHIC cohesiveness scores, but the small teacher sample size (*N*=7) precluded conclusions about statistical relationships.

Conclusions

The limitations of this study include an inability to control for student differences such as academic track between treatment conditions, a low response rate from the sample, the small number of teachers and classrooms, and no control for prior academic achievement. Referring to this last limitation, the researchers concluded that use of prior achievement measures valid across multiple states and access to prior academic records was impossible to achieve given the grant timeline and is an "important methodological consideration for large-scale, national-level, inter-state research methodology" (p. 39).

Study 6 (Kleiman, Carey, Bonifaz, Haistead, & O'Dwyer, 2005)

Title: ***A Study of the Effectiveness of the Louisiana Algebra I Online Project***

Researchers: Glenn Kleiman, Rebecca Carey, Alejandra Bonifaz, and Elizabeth Haistead, Education Development Center, Center for Online Professional Education (COPE); and Laura O'Dwyer, University of Massachusetts at Lowell.

Description: Examines the effectiveness of an online learning and teacher mentoring program designed to provide effective Algebra I instruction in high-needs schools while increasing the number of No Child Left Behind highly qualified teachers of mathematics in these schools over time.

Purpose

Due to the shortage of qualified mathematics teachers in the state of Louisiana, and particularly in schools that serve low-income rural communities throughout the United States, this investigation focused on the study of the effectiveness of the Louisiana Algebra 1 Online Project. The goal of this project is to improve educational opportunities for students by providing them with a high-quality, standards-based curriculum delivered online by a certified mathematics teacher, also serving as a mentor to a classroom teacher who is not certified to teach mathematics. This project is a Louisiana Department of Education learning initiative supported by the State Board of Elementary and Secondary Education and offered through the Louisiana Virtual School. Since the program has been in operation for three years, the researchers had already established connections with study sites; control groups were in place and participating students had completed pretests.

This project is distributed in a model integrating online learning within conventional teaching and learning practice. Students, each with a multimedia, Internet-connected computer, participate in a face-to-face class that meets synchronously. Students who have an Internet connection at home or access to Internet outside of the school environment can access their coursework outside of the school day. Students have access to textbooks (online and conventional); use animations, solve problems, and e-mail teachers; post to a discussion board; participate in activity days; and do math activities with online readings and instant feedback. The project uses curriculum designed by the Louisiana Center for Educational Technology and the Louisiana School for Math, Science, and the Arts. It aligns with the National Council of Teachers of Mathematics standards and the Louisiana state content standards, benchmarks, and grade-level expectations.

Each classroom has two teachers: the online teacher is an experienced secondary-certified mathematics teacher; the classroom teacher is not certified as a mathematics teacher but is generally working toward certification. The role of the online teacher is to serve as the primary instructor to the students using computer-mediated communication and to serve as a mentor and model to the in-class teacher. The in-class teachers in the Algebra I online program must meet eligibility requirements and complete an application. Although there is no charge for

participation in the program, the district or school pays for the in-class teacher and provides the necessary technology. Districts with the highest need for credentialed mathematics teachers are given priority, as are teachers who require professional development in order to obtain certification in secondary mathematics. The in-class teachers "follow the curriculum guide to facilitate face-to-face learning activities and collaborate with the online teacher in guiding and supporting the students" (p. 2). This is an innovative professional development model that provides ongoing and consistent support to nonexperienced, noncredentialed mathematics teachers.

The teachers in the program are required to take a two-day summer orientation session providing the collaborating teacher teams an opportunity to start planning how they will manage the year. The session includes an overview of course organization and expectations, grading, review of teacher roles, classroom setup and management, and technology tools. Classroom teachers are required to take a four-week online course called "Orientation to Online Algebra I" and are expected to spend two hours per week on the course.

This course trains teachers on how to (1) use the learning management system (LMS) and e-mail to communicate efficiently and effectively; (2) manage files in a Windows environment; (3) use the required graphing calculator, Calculator Based Laboratory (CBL), and selected sensors; (4) use the software to capture handwritten work digitally; (5) identify and address major management issues in the online mathematics classroom, including backups and documentation of work and electronic communication; (6) help the online teacher plan for daily activities in the algebra classroom; and (7) develop a class schedule for fall and spring semesters.

The "Topics for Algebra Leaders and Instructors" (TALI) course is presented over a 10-month period and is available to both in-class and online teachers. Teachers are required to spend a minimum of two hours per week on course activities. TALI includes an overview of administrative, instructional, technological, and pedagogical issues of the online Algebra I classroom. Teachers successfully completing TALI receive 3 hours of math credit or 45 continuing learning units (CLUs) toward "highly qualified" status.

Research Questions

This study attempted to address the following research questions about the Louisiana Algebra I Online Project:

1. How does the mathematics learning of students in the Algebra I online classes compare with students in traditional algebra classes?
2. Is the Algebra I online class implemented differently in different classrooms? Are there relationships between the way in which the course is implemented and the effectiveness of student learning?

Methodology

A quasi-experimental design approach was implemented. Research instruments included a teacher characteristics survey, an Algebra I in-class teacher survey, an Algebra I online teacher survey, classroom observation, telephone focus group with both in-class and online teachers,

student pretest and posttest, the Louisiana Educational Assessment Program (LEAP) for Grade 8 students and the Iowa Tests of Basic Skills for Grade 9 students, student grades, online student surveys, and control student surveys. The control groups were created by the school district using a traditional teaching and learning approach.

The researchers found the existing 25-item measure already administered by Louisiana as a pretest to be insufficient as an instrument to measure student growth. Therefore, they used the pretest data to check whether the online and control students started the course with comparable skills and knowledge but developed a new assessment for the posttest. They designed a 25-question, multiple-choice test for the posttest. The reliability (Cronbach's Alpha) for the pretest was 0.69, and the reliability for the posttest was 0.81.

It was not possible to obtain data from statewide standardized tests of mathematics in Grades 8 and 9 within the report time frame, and in any case disaggregated responses specific to algebra would be unavailable from these sources. While the existing pretest is more useful for holding constant prior student achievement, these standardized tests would have provided data on student characteristics necessary to disaggregate treatment and control groups by gender, ethnic group, and special education status for analysis.

Students selected to take the online course were not required to have any prerequisite, although the course was intended for students taking the course for the first time and teachers were provided with recommendations that they were asked to consider when selecting students for the Algebra I online course. These characteristics include the ability to learn independently, effective written communication skills, self-motivation and discipline, and efficient time-management skills.

The study population included 31 schools from six school districts. Sixteen schools—13 public schools, 1 charter school and 2 private schools—offered online courses. The control group comprised 15 schools: 12 public schools, 1 charter school, and 1 private school. A total of 37 teachers participated in the study: 10 online teachers, 13 in-class teachers, 11 teachers in the control group, and an additional 3 teachers who taught both an Algebra I online class and a control class. A total of 257 students successfully completed the Algebra I online program in 2004–05, and all students were in either Grade 8 or 9. The control group mostly comprised Grade 8 and 9 students, although one section comprised a combination of Grade 9 and 10 students.

Findings

Research Question 1 (comparison of outcomes in online and traditional algebra classes): In comparing the mathematics learning of online and traditional Algebra 1 students, the researchers found an advantage for online learning in three different analyses: (1) posttest scores were higher for the treatment group, with a borderline statistically significant difference ($p = .051$); (2) a comparison of differences between pretest and posttest scores was significantly different ($p = .024$), with the treatment group showing a larger gain; and (3) a regression analysis showed that when pretest scores were statistically held constant, group membership was a significant

predictor of students' posttest scores, with the treatment group scoring higher than the control group ($p = 0.023$).

The researchers concluded that students in the Louisiana online Algebra I course demonstrate, on average, at least as much or somewhat more achievement gain than students in comparison classrooms. This result suggests that this model is a viable approach to providing Algebra I instruction when a certified teacher is not available.

Research Question 2 (performance outcomes by planned variations in implementation): Using Through observations, focus groups and surveys, the researchers found great variability in the role played by the in-class teacher in the Algebra I classroom in the online treatment, where this teacher is paired with an online teacher.

The findings showed that the frequency with which the in-class teacher worked with small groups of students and observed individual student work related positively to student achievement. When online and on-site teacher teams collaborated frequently on planning, their students had larger achievement gains.

Conclusions

This study recommended that the in-class teachers should (1) increase their instructional role to serve students more effectively and efficiently, (2) revise courses to incorporate new tools and technologies in order to maintain student interest and motivation, (3) conduct additional research on local implementations to determine what are the most effective practices, and (4) provide guidance to future classroom implementation to support the standardization of teaching strategies across classrooms.

In examining the test items, it appears that most items in which the control group scored significantly higher than the online group assessed the ability to simplify and solve equations, while items on which online students scored higher tended to be word problems and problems presented with a graph or pattern. The evidence did not permit the researchers to suggest that these findings represent a trend or pattern having implications beyond this particular investigation.

Study 7 (Cavanaugh, Bosnick, Hess, Scott, & Gillan, 2005)

Title: ***Succeeding at the Gateway: Secondary Algebra Learning in the Virtual School***

Researchers: Cathy Cavanaugh and Jan Bosnick, University of North Florida; Melinda Hess and Heather Scott, University of South Florida; and Kathy Jo Gillan, Florida Virtual School.

Description: Compares learner outcomes in conventional algebra classes with those in classes designed by the virtual school but taught either by its own instructors or by franchise instructors; also studies the performance of learners who use an embedded digital graphing tool in their course and those who do not.

Purpose

In this study, the researchers argue that learning algebra could be less burdensome with the use of technologies that might assist students in manipulating abstract symbolic representations underlying mathematical concepts. Because algebra is a gateway course, it is critical that teachers find and implement innovative strategies that have the contingency of improving student achievement in this curricular area. Again, in a comparison of face-to-face and online learning, (Cavanaugh et. al., 2004) have found that there are no significant differences in the achievement of students taking algebra.

The researchers describe the quality of an online algebra course in terms of its effectiveness, development, implementation and "evaluation of interactive tools for a particularly complex and abstract component of the course" (p. 2). They cite several research studies providing an understanding of mathematics achievement in the United States, suggesting that although K–12 mathematics scores are on the increase, many students still have not yet been provided with the educational opportunities they require to achieve success in mathematics; this gap correlates with the likelihood of students attending college. They further cite the U.S. Department of Education's call for a more congruent approach to the study of mathematics in the K–12 context, with the current global state of affairs requiring economic leadership and security in the Information Age using scientifically based methods.

The researchers argue for the need to identify and overcome obstacles to learning algebra. As admirable as the "algebra for all" movement might be, it cannot be realized without innovative approaches that support the transition from school arithmetic to school algebra resplendent with symbolism, equation solving, and an emphasis on relationships among quantities. They call for interactive tools that would serve to overcome obstacles to learning algebra and support an increase in student learning. The researchers also cite studies that verify positive effects on student mathematical achievement and learning with technology (e.g., computer applications, graphing tools, virtual manipulatives) (Waxman, Lin, & Michko, 2003; Weglinsky, 1998). They also argue that it is the learning management system (LMS) that serves as the predominant technical tool for enabling communication in online courses and that all of the online courses in this study were supported by an LMS.

Research Questions

The two primary research questions addressed by this study were as follows:

1. How does the algebra achievement of virtual school students compare to that of public classroom-based students in the same state?
2. How effective is an interactive module for helping students learn graphing linear equations? (Performance of students using the module was compared to the performance of students who did not use the new tools.)

Methodology

The online portions of this two-part study were set in the Florida Virtual School (FLVS), which was selected for its successful history in offering online high school courses. A brief background description on FLVS is provided, with the explanation that each course has been developed by a certified and qualified school staff member and has the ability of being repurposed (e.g., adapted, modified). All students in the online algebra course were taught by Florida-certified mathematics teachers using state standards and approved materials.

The investigation was undertaken in two parts. The first focused on a comparative analysis of mathematics achievement between online school students and public classroom-based students in the same state. The second focused on the component of the online algebra course with which students had the most difficulty, graphing linear equations.

The first part of the study included participants from three types of schools: virtual school students, virtual franchise students, and public classroom-based students. Study participants included 123 virtual school students, 16 virtual franchise students, and 98 public classroom-based students. Although all participating online students were demographically profiled prior to the commencement of the study, the classroom-based students were not, and the academic background information was unavailable for either group. Therefore, entering characteristics of participants could not be taken into account in the analysis.

When students had completed 70 percent of the online course, the Assessment of Algebraic Understanding (AAU) was administered. The FLVS students reaching 70 percent on the online algebra course received a copy of the AAU examination, answer form, and consent form by mail; the examination was administered on-site by teachers in the classroom-based comparison group. Students were not required to complete the AAU examination to complete the course.

The second part of the study focused only on the online FLVS students, who were assigned to a section that used a digital graphing toolset (treatment) or did not use the toolset (comparison). For this part of the study, a research-based interactive toolset was designed and developed and then used by a sample of online students to support learning in these areas of difficulty. A total of 101 online students were included in this phase. Of these, 30 students did not use the graphing toolset, while 71 did. These students were distributed over eight teachers. The interactive tools for graphing linear equations were created by a multimedia instructional designer using specifications developed by content-area specialists to address the objectives of the course module. Both groups of online students completed an assessment of their skill in graphing linear

equations. The alignment of this assessment with instructional objectives and lesson materials was reviewed by two external university-based reviewers for alignment using established criteria.

Findings

Research Question 1 (algebra achievement of online students compared with classroom-based students): All but one of the classroom-based students in the comparison group completed the AAU exam. Means for the AAU full score were 24.08 for the virtual group (*N*=12) and 19.43 for the classroom-based group (*N*=97).

Note: For methodological reasons (primarily the small number of subjects), readers should exercise caution drawing conclusions from the overall higher scores in the virtual group compared to the classroom-based group. Extenuating circumstances included the following factors: (1) of the total 123 virtual school students who participated in the first part of the study, only 11 completed the AAU exam; and (2) 1 of 16 franchise virtual school students completed the first part of the study, and these students were summarily collapsed into one test group.

Research Question 2 (algebra performance of students using the graphical tool compared with students without the tool): Online students using a graphing toolset (*N*=33) scored 15.02 on their pretest and 18.08 on their posttest, a gain of 3.07 points. Online students not using a graphing toolset (*N*=14) scored 17.50 on their pretest and 19.21 on their posttest, a gain of 1.71 points. Therefore, gains of online students using the graphical tool (3.07 points) compared to gains of online students without the graphical tool (1.71) indicated that use of the graphical module may improve student performance in online Algebra 1 classes.

In the second part of the study, 81 of the 101 participating online students took the graphing pretest, while only 57 took the graphing posttest. Those students who had not taken both the pretest and posttest were removed from the analysis; therefore, a total of 47 online students, distributed among seven teachers, were included in the final analysis. Fourteen of these students had not used the graphing tools, while 33 had used the graphing tools.

Repeated-measures ANOVA did show a significant difference in graphing pre-post test performance for online students overall ($F(2, 90) = 122.43$, $p = <.0001 < \alpha = .05$). ANOVA did not demonstrate a significant difference between student groups that did (*N*=33) or did not (*N*=14) use a graphing toolset, in terms of their pre-post test performance. The interaction of pre-post test type and graphing/no-graphing group was not statistically significant ($F(2, 90) = 1.51$, $p = .23 > \alpha = .05$).

Note: The ANOVA findings must be interpreted with caution because of inequity in the sample size and the generally small numbers of students participating in the study.

Conclusions

The findings were articulated with the stipulation that because of the small sample size, and the inconsistent numbers of participants in treatment and comparison groups in both parts of the

study, study results should be interpreted with caution. For these and other reasons, this study should be viewed as an exploratory investigation requiring further investigation with larger sample sizes, comparison groups from more than one face-to-face school, information on characteristics of all participating students, and methods for ensuring that all participants take a pretest and posttest.

Despite these limitations, findings from this study suggest that online algebra courses and interactive tools may have the potential to reach any student with access to the necessary technology and that the courses with these tools can be effective on a large scale.

The researchers argue that algebra can be learned effectively online; but in order to definitively argue that point, greater openness of schools and teachers to work with researchers is required, as is extended in-depth research that identifies the promises of technological tools that can increase student learning in the area of algebra.

Teachers too, need professional development on the skills required for research and for diffusion of curricular innovations so they can effectively and efficiently coparticipate and work along side school-based researchers and assist with collecting, analyzing, and *understanding their data*; "just in time."

Study 8 (Zucker, 2005)

Title: ***A Study of Student Interaction and Collaboration in the Virtual High School***

Researcher: Andrew Zucker, The Concord Consortium

Description: Examines online student and instructor attitudes toward online interaction; attempts to experimentally determine if one form of encouraging student-to-student interaction does increase interaction, thereby improving such factors as retention, student performance, and student satisfaction with the course.

Purpose

This study investigated student-student interaction in eight online courses offered by the Virtual High School (VHS) in the spring semester of 2005. The researcher argues that along with the growing demand for online learning is the need for quality control in online courses as well as the need for more rigorous research to understand the impact on teaching and student learning. The focus of the study was to ascertain whether the benefits of online interaction and collaboration by students can be identified and measured using randomized experimental research methods in which some students were awarded more points for more interaction.

VHS believes that student-student interaction is an essential component in online courseware if positive outcomes—such as an increasing student achievement, increasing students' engagement in school, fostering attitudes in favor of doing well academically, and other positive outcomes—are to be realized. A primary question addressed in this study was whether encouraging online student participation through grading incentives will increase student interaction and thereby will increase the value of the course for students.

By assigning more points in the treatment classes, the researchers expected student-student interaction in those classes to increase (as compared to the control group), which would, in turn, affect a variety of dependent variable. These variables included the number of postings made by students, overall and in the student lounge area; the quality of online discourse as rated by the teacher; students' self-reported perceptions of the importance of student-student communications; students' reported satisfaction with the course; and student-earned grades and retention rates. As the study progressed, it became clear that another important purpose of the study should be to explore teachers' and students' beliefs about interaction in VHS courses.

Research Questions

Two research questions about interactivity in online high school courses guided this study:

1. Does encouraging online student participation through grading practices increase student interaction and thus increase the value of the course for students?
2. How do teachers and students assess and value the role of interaction in online courses?

Methodology

The methodology included student interaction by assigning a certain point value to students' grades based on the nature and extent of their participation. In the experimental group, teachers doubled the point value given to student-student interaction. All participating teachers encouraged students to interact with each other using a variety of methods. The study focused on the identification of the quality of online discourse and its impact on outcomes, including the number and quality of student-to-student postings; earned grades of the students; retention rate of students in the courses; students' self-reported perception that communications with other students were an important part of their learning in the course; increases, if any, in postings to the student lounge area; and students' reported satisfaction with the course.

The data were analyzed based on students' gender and year in high school. The researchers were looking for correlations with the approach in promoting student-student interaction. Eight pairs of teachers volunteered, and eight pairs of randomly assigned classes were included in the study. One teacher in each pair was randomly selected to be the experimental teacher while the other teacher in the pair was assigned to the comparison group. The researcher used the instructor's access to the learning management system (LMS) to examine class assignments and discussions online. Further, teachers also used the LMS statistics about each course, which provided important data about the frequency of students' class participation.

Surveys also were administered to both teachers and students. A Web-based service (SurveyMonkey.com) was used to conduct both surveys. Both student and teacher surveys were conducted online in May 2005. Response rates were excellent: 82 percent for the students (230 respondents from among the 282 students who were enrolled in the 16 sections at the time of the survey) and 100 percent for the teachers.

Findings

The findings indicated that 50 percent of the students were seniors in high school, 35 percent were juniors, and 11 percent were sophomores. Only 4 percent were in the lower grades; for 58 percent of these students, this was their first online course. Seventy-two percent of students were female, and 38 percent were male.

Research Question 1 (grading practices that increase student interaction): Although the hypothesis that student satisfaction with the course might be greater for students in the experimental classes (where students were given additional points for student-to-student interaction) was not confirmed, this finding could be attributed to the fact that in the first four weeks of the study, three teachers were not weighting student interaction more highly than their counterparts in the comparison groups. A second factor complicating clear analysis of this hypothesis was that awarding "points" was not implemented uniformly in the classes chosen to use the experimental *treatment*, leaving the relative weight and significance of their impact inconsistent.

Research Question 2 (students and teachers valuing the interaction): More than 90 percent of students responding to the survey agreed or strongly agreed that participation in the VHS course

was a valuable experience, while 90 percent of students and 88 percent of teachers were somewhat satisfied or very satisfied. Twenty-nine percent of surveyed students thought the VHS course was better than face-to-face courses, while 50 percent thought they were of the same quality.

Approximately two thirds of students agreed or strongly agreed with the statement that "communications with other students [were] an important part of [their] learning in [the] VHS course." Seventy-seven percent of surveyed students reported that interaction with other students was valuable because it gave them the ability to know other students and their points of view; 46 percent thought it valuable in its ability to support learning of the course material, while an additional 32 percent agreed that interaction helped motivate them.

All 16 participating teachers found value in the student-to-student interaction. Ninety-four percent of participating teachers agreed that it provided the opportunity for students to get to know each other and their points of view; 75 percent felt it assisted students in learning the course material, and 69 percent agreed that interaction helped motivate students. Further, three fourths of students found group work very or somewhat valuable and 68 percent of teachers agreed or strongly agreed that group work was valuable. Overall, the fundamental finding that emerges from the survey data is that student-to-student interaction is highly valued by the majority of teachers and students.

In the analysis of the LMS discussion area, it became apparent that interaction varied significantly between courses. The experimental or control section made more postings in three of the eight courses, while the comparison group posted more often in five of the other courses. Although the findings indicate that there was no significant differences in postings, the issue of the definition of "points" and the inconsistency of weight and significance of points leaves this finding questionable. This quandary jeopardizes the findings specific to the benefit that the points might have on students' grades and attrition.

Further, the researcher argues:

> [Although] random assignment to conditions was employed, it is possible that the intact classes are composed of students who vary significantly on such variables as academic motivation and prior achievement (a strong indicator of present and future achievement), or that one teacher was much stronger and more successful with students than his or her counterpart who taught the lower-scoring group. Such variables are not accounted for in [the] analysis. (p. 14)

Persistence did not differ between students in treatment and control conditions, both of which had a 9 percent attrition rate. Independent-sample *t*-tests showed no significant differences in achievement between treatment and control in Term 1, Term 2 or final scores. Final scores were almost identical between treatment (Mean=79.66, SD=17.71) and control students (Mean=79.50, SD=22.86). In two of eight courses, both in computer science, achievement varied significantly, favoring the treatment group in one and the control group in the other. Examination of Term 1 and Term 2 scores revealed that performance differences between groups in final scores emerged early in the semester.

Conclusions

The findings suggest that although student-to-student online interaction may promote a cohesive American society by bringing together children from diverse backgrounds and encouraging them to interact in online learning environments, more conclusive findings will be required to support the hypotheses. The researcher identifies the predictable difficulties implementing field-based, experimental designs as being problematic for this investigation examining the impact of strategies intended to support and regulate interactivity in online courses. He identifies a need for an improved methodology and for additional research examining the impact of interactivity on academic performance and/or refinement of the initial research questions to achieve clearer findings.

Synthesis

Analytical Approach

In reviewing the eight research projects, the authors of the research synthesis served as qualitative analysts directing their efforts at uncovering patterns, themes, and categories in a creative process that required "making carefully considered judgments about what is really significant and meaningful in the data" (Patton, 1990, p. 406). Project summaries were analyzed and synthesized to identify, code, and categorize the primary patterns in the data. The patterns, themes, and constructs used to organize this synthesis "emerge[d] out of the data rather being imposed on them prior to data collection and analysis" (Patton, 1990, p. 390). The authors' analysis attempts to balance logical construction and the integrity of events as reported in the evidence.

In this synthesis, the data from the interviews, observations, surveys, and conclusions based on the eight studies were organized by grouping related themes. Themes were further simplified and subsumed under more general constructs by looking for similarities or differences. The research literature reviewed in the first section of the synthesis also was used to triangulate findings and conclusions based on the eight individual studies.

Analysis and Synthesis of the Eight Research Reports

The research literature confirms the argument that online approaches to communicating, interacting, collaborating, marketing, and learning are finding their place in the global context of educational delivery systems. New online delivery models for teaching and learning are effectively increasing productivity; providing anytime/anyplace opportunities; bridging geographic distances between diverse societal groups; demonstrating new efficiencies affecting costs and time; and changing the structures of business, political, social, and educational contexts.

The increasing use of online learning has been both welcomed and rebuffed because it requires new ways of thinking that challenge traditionally accepted educational constructs and redefines the notions of place and time that historically have been linked to participation in formal education. Although the global, high-tech community generally embraces computer-mediated communications, acceptance of the same systems for instructional purposes is more problematic. The tensions resulting from apparently divergent findings on the efficacy and impact of online learning contributes to a growing debate over educational priorities in a time of scarce resources.

As discussed in Section 1, new educational research on online learning illustrates multiple issues contributing to these increasing tensions, including the growth of online learning, educational level, course quality and offerings, models of virtual schools, equity and access, learner characteristics, progress in the implementation of e-learning and online learning, funding, and quality measure and accreditation standards for e-learning that mirror those required for course credit.

The eight new research studies address a range of topics, including professional development, mentorship programs, sustainability, reform agents, differences between online and conventional teaching and learning practices, reasons why students select online learning, distributed learning opportunities, profiling of students, collaboration, definitions, and research on the "no significant difference" phenomenon. These research studies offer new evidence of both concern and promise within the K–12 online learning context in the United States.

The synthesis is organized around six descriptive categories that emerged from the analysis of the eight new K–12 online learning research projects:

- Student Academic Performance
- Characteristics of Successful Online Students
- Qualities of Effective Online Courses
- Professional Development for Effective Online Teaching and Learning
- Challenges of Online Learning
- Online Learning, School Change, and Educational Reform

Student Academic Performance

Many complex factors influence and impact student academic performance in online courses: (1) program effectiveness (e.g., pedagogical approaches, including student-centered teaching, constructivist learning models, collaboration, problem-based learning, authentic performance-based assessment, principles of differentiation); (2) socioeconomic status of participants; (3) school climate; (4) parental involvement; (4) teacher qualifications; and (5) learner characteristics. Learner characteristics represent a very complex array of emotional and cognitive variables—including but not limited to motivation, cognitive ability, and affective attributes—and are among the various and diverse elements affecting students' academic performance.

In almost all of the eight studies included in this synthesis, online schools or programs served diverse student populations. Questions were asked concerning what interventions, variables, controls, or support systems might be used to improve student academic performance. Although some of these eight studies cited the "no significant difference" research showing comparable academic achievement of online students to traditional face-to-face students, Dickson (2005), in particular, argues that often the findings include no mean difference, wide variability, and the inexplicability of that variability. He suggests that a much deeper analysis of what is going on within these online programs and schools is required. Ferdig, DiPietro, and Papanastasiou (2005) reinforce this argument by suggesting that "face-to-face and online courses are comprised of differing components and thus comparing the two on certain levels is similar to comparing apples and oranges" (p. 2).

Many of the eight studies offered evidence that student academic performance increased in online programs and schools. Lowes (2005) concludes that staff development supporting teachers in understanding and implementing effective online pedagogical and methodological approaches holds great promise for potentially increasing student academic performance in

online courses. Hughes et al. (2005) report that staff development provides teachers with high levels of proficiency in understanding when and how to integrate information technologies within their teaching practice, therefore impacting student understanding and academic performance. Ferdig, DiPietro, and Papanastasiou (2005) also argue that in order to increase student academic performance, the focus must be on "educating the educator in facilitating online learning, creating instructionally and pedagogically sound curricula, and of course, creating and maintaining strong technology infrastructures" (p. 46).

Lowes (2005) contends that the recent advances in online courseware incorporating effective pedagogical approaches that "emphasize student-centered teaching, collaboration, problem-based learning, small-group work, and authentic performance-based assessments" (p. 3) all contribute to improving student academic performance. Zucker (2005) states that online courseware should include student-student interaction facilitating metacognition and a culture of reflection, which also impacts student academic performance.

The studies also identified other factors that have apparent potential to increase student academic achievement. Hughes et al. (2005) report that students tend to have more favorable perceptions of online "teacher support" than their face-to-face counterparts, and indicate that students in online programs felt they were more involved in their school-related work. In addition, Hughes et al. argue that "individual feedback increases communication opportunities for students who are less likely to speak up in a traditional classroom and facilitates the development of closer relationships between an instructor and those students" (p. 3). Generally, the eight studies indicate that more communication, more feedback, and more student-teacher interaction have an apparently positive affect on student academic performance.

In the study by Kleiman et al. (2005) on the Louisiana Algebra I Project, no findings were reported or conclusions drawn concerning the broad impact of professional development on student performance. But their research shows preliminary evidence that through participation in the Algebra I online classes, "group membership was a significant predictor of students' posttest scores, with the treatment group scoring higher than the control group ($p = 0.023$)" (p. 71). For this reason, the Louisiana Algebra I online courses seem to support academic performance that is apparently equivalent to traditional face-to-face classrooms. The online Algebra I course offers a possible solution to Louisiana's scarcity of "highly qualified" Algebra I teachers. A combination of findings reporting nearly equivalent student performance with increased availability of "highly qualified" Algebra I teachers suggests that this innovative project has potential as a promising new "research-based practice" that is worthy of consideration in other contexts and settings.

Cavanaugh et al. (2005) point to the ability of online programs to provide immediate feedback. In this study, strategies included mathematical visualizations, virtual manipulatives, graphing tools, and computer applications that contributed to reducing cognitive complexity of mathematical calculations, permitting students to focus on conceptual understanding and thereby increasing student academic performance in mathematics. Ferdig, DiPietro, and Papanastasiou (2005) concluded that simulations may make the learning of algebra and geometry easier than in face-to-face classrooms where simulations are more difficult to implement or not available, again positively impacting student academic performance. Ferdig, DiPietro, and Papanastasiou also

suggest that online programs have the ability to improve student performance because students can take these classes for remedial purposes or as advanced classes that meet the needs of highly able or gifted learners.

Although there is a substantial need for additional research examining the effects of K–12 online learning on student academic performance, these eight new studies provide new evidence supporting the apparent effectiveness of online programs and schools and generally demonstrating the potential of online learning as a promising instructional intervention that, when implemented judiciously and with attention to "evidence-based" practices, apparently can improve student academic performance.

Characteristics of Successful Online Students

Teachers, administrators, and parents indicate that online learning may be particularly well suited to the learning styles of an identifiable subgroup of students within the general population (Smith, 2001). Research has identified characteristics of successful virtual school students: intrinsic motivation; independent learning skills; liking computers; reading and writing at grade level; consistent parent support and guidance; self-direction; ability to work well in their own time frame without the structure of a conventional classroom; involvement in outside school activities, hobbies, and relationships; ability to learn well from visual materials and tests; positive attitude; comfortable asking for help (Smith, 2001).

Hughes et al. (2005) note that extroverted students may do best in collaborative learning. They therefore suggest that students who are choosing a virtual school or course "should consider the type of instructional delivery used within the course, such as an independent study approach or an approach that is more cooperative and encourages interactions among students in virtual classroom" (p. 37). Students would presumably select an online course or a virtual school or program based on their individual learner styles and needs.

Because virtual schools draw upon particular learner characteristics and skills, students who lack such characteristics and skills set may find it difficult to learn in this environment. Also, detecting learning disabilities may be more difficult in online settings; unlike conventional classrooms, where visual cues might provide some understanding of a student's capability of dealing with a task, in the virtual school this is not available. Kleiman et al. (2005) recommend that students who are being selected for virtual schools should demonstrate "the ability to learn independently, effective written communication skills, self-motivation and discipline, and efficient time management skills" (p. 6). Further, Kleiman et al. argue that virtual schools and programs should avoid selecting prospective students on the basis of prior mathematics achievement.

Dickson (2005) states that virtual school students are a diverse population of learners, including students who are homebound, students with learning disabilities, gifted and talented learners, adjudicated youth in institutions, and homeschooled students. He also states that "for some self-disciplined, high-achieving students, a course may be an ideal environment for educational enrichment and acceleration, while other students may enroll in the same course because they were previously unsuccessful in a traditional version of the course, hoping that perhaps this

different approach might help them succeed" (p. 6).
In the research studies of both Hughes et al. (2005) and Zucker (2005), the researchers argue that students choose virtual schools or programs because these environments offer courses that might otherwise not be available to them in face-to-face traditional schools. Both Hughes et al. and Zucker further claim that some students select an online learning environment simply because it provides an alternative to the traditional face-to-face school, which for a variety of reasons is not meeting their independent learner needs or interests.

In the Ferdig, DiPietro, and Papanastasiou (2005) study, some of the students took "online classes for remedial purposes, to repeat a class they failed, or to fulfill graduation requirements" (p. 8), while others took more challenging or more advanced courses as a means of accelerating their learning. Ferdig, DiPietro, and Papanastasiou also note that adult learners who are stay-at-home parents may take an online course because a course of interest or need is not available in face-to-face learning or as a dual registration course. Further, Ferdig, DiPietro, and Papanastasiou suggest that some students take online courses because they have been suspended or removed from traditional schooling environments, for personal factors including teen pregnancy or illness, and/or because they have a conflict in schedules. They concur with Dickson (2005) when he says that part of the virtual school population is made up of homeschooled students. Finally, Ferdig, DiPietro, and Papanastasiou claim that "online students are self-selected or enrolled by a parent or school personnel" (p. 14), which supports the understanding that student diversity abounds in virtual schools and programs.

The diverse nature of students choosing virtual schools indicates that although lists of characteristics of online learners can and have been created, just as in face-to-face settings, students with varied academic and affective needs register in these programs.

Ferdig, DiPietro, and Papanastasiou (2005) echo the Roblyer and Marshall (2002–2003) recommendation that the ESPRI instrument should not be used to discourage or disallow students from enrolling in an online program or school; instead, this instrument should be used to build an understanding of the features, strategies, and supports that prospective students require in order to become successful online learners. In other words, Ferdig, DiPietro, and Papanastasiou suggest that the Roblyer and Marshall instrument be used as a predictive tool to determine a learner's locus of control, internal versus external motivation, self-confidence or self-esteem, responsibility, degree of experimentation (risk taking), time management skills, ability to set goals, achievement, and self-reported computer or technology skills. They state that this instrument was used in 13 virtual high schools and was "found to discriminate with high accuracy and reliability between groups of successful and unsuccessful students" (p. 241).

Ferdig, DiPietro, and Papanastasiou (2005) state that the Roblyer and Marshall instrument predicted passing grades (A, B, or C) with 100 percent accuracy and failing grades (D, F, or withdrew) with 95 percent confidence. They also recommend that preparation and orientation sessions be required of every student registering in an online school or program. They argue that various virtual schools have instituted these types of sessions to introduce students to online learning and also have requested presurveys, precounseling, face-to-face mentoring, and trial periods to ensure student success in these environments.

Findings within the eight new studies point out that students in online learning environments are just as diverse as their counterparts in face-to-face schools and classrooms. For this reason, additional research is needed to further define and clarify the optimal conditions supporting online students' success.

Qualities of Effective Online Courses

K–12 virtual learning programs and online courses suffer from a perception that they hold less value than face-to-face learning. Ongoing debate relative to asynchronous versus synchronous, interactivity, building immersive environments, and creating effective online pedagogical opportunities continues to proliferate the literature and discourse of educators. Historically, K–12 content development has lacked any consistent emphasis on active or engaged learning[4], has consistently shown little real integration with discipline-based content standards, and has generally been ineffective at integrating evidence-based knowledge about effective teaching and learning with most educators' instructional practices.

Support for both effective content development and the development and implementation of effective professional development to ensure the effective online delivery of instruction is critical to e-learning in both the K–12 and the higher education contexts. Effective online and traditional teaching and learning, supported by "highly qualified" online and face-to-face teachers, must be effectively supported by ensuring that only the highest possible quality professional development opportunities are available to teachers everywhere.

One of the most important questions related to online course quality is whether the instructional design includes sufficient emphasis on providing models of effective teaching practices and also supervised opportunities to practice these important performance skills. Lowes (2005) notes that advances in courseware incorporate effective pedagogical approaches that "emphasize student-centered teaching; collaborative, problem-based learning; small-group work; and authentic performance-based assessment." (p. 3)

Ferdig, DiPietro, and Papanastasiou (2005) maintain that "online learning may be very effective provided it is designed with pedagogical strategies in mind, is constructed on research-based principles and practices for certain online elements (i.e., discussion forums), and has instructors that are qualified in terms of teaching online, teaching the content, and teaching the content online" (p. 44). Further, Zucker (2005) states that the instructional design of online content should include student-to-student interaction facilitating metacognition and a culture of reflection, while Kleiman et al. (2005) argue that the inclusion of principles of differentiation is essential in meeting the diverse needs of online learners. Kleiman et al. say that after the "honeymoon" period, students may perceive online content as boring and redundant.

The growth in online learning, discussed in the findings of Lowes (2005), Dickson (2005), Cavanaugh et al. (2005), Ferdig, DiPietro, and Papanastasiou (2005),and Leu et al. (2005) all point toward the real need to identify models of sustainability. Further, although research continues to identify models of sustainability, what also is required is "enacting policy that results in the most accessible, equitable, high-quality education system that is feasible with the

[4] NCREL, "Meaningful, Engaged Learning" (www.ncrel.org/sdrs/engaged.htm).

resources that are available" (Cavanaugh et al., 2005, p. 21). Policy will support the leaders in their efforts to sustain online learning within organizational structures that would be directed by guiding principles.

These new research also suggest that models of online content be developed with the ability to share, repurpose, and multipurpose existing content. Lowes (2005) states that rigorous online content should have the ability to be "shaped and reshaped" to meet diverse educational learning environments and student needs; she also argues that the ability to adapt existing content "forces [teachers] to reexamine the course's organization, content, and pedagogy" (p. 7) and enhance, enrich, and develop the instructional design. The research reports identify elements of instructional design that support effective teaching and learning practice and that offer both students and teachers the ability to construct knowledge.

Instructional design and learning strategies such as active learning and the social construction of knowledge can support online teachers as they help their students become more effective learners. These strategies have the potential to improve academic performance in both online and traditional learning environments.

The value of *all* educational strategies and instructional delivery should be established by measuring the relative impact on students' academic performance. Part of that impact is related to content, educational materials, and delivery methods. But another significant factor contributing to effective teaching and learning is having good teachers available to work with the students. Without "highly qualified" online teachers, online learning may not have any positive impact on students' academic performance.

Professional Development for Effective Online Teaching and Learning

One of the NETP action goals for improving the use of educational technology is to "support e-learning and virtual schools" and one of the strategies within this goal is to "enable every teacher to participate in e-learning training." (U.S. Department of Education, 2005b, pp. 41–42). The context of research on K–12 online learning confirms that the quantity and quality of staff development vary significantly and that likely less than 1 percent of all teachers nationwide are trained as online teachers. Many of the teachers currently teaching in online environments lack both the theoretical and practical understanding and are "learning on the job." To further complicate the issue, teachers are provided little if any release time, no extra funding, and little acknowledgment for their efforts; they often are overwhelmed by the enormity of the enterprise. To date, the characteristics of effective online teachers have been the topic of limited research. Some of the research in K–12 e-learning does identify some of these characteristics, although policy and standards have not been adopted jeopardizing quality assurance.

Study researchers identify staff development as an important element in the success and sustainability of online learning. Lowes (2005) states that teachers need to engage in staff development to support an understanding of online course development, online pedagogy, and methodology. Hughes et al. (2005) state that changes in innovations, curriculum, or policy require staff development "to develop new knowledge and practices to be applied in the K–12 classroom" (p. 9). Leu et al. (2005) argue that time has to be built into teacher schedules to

engage in staff development and that teachers should not be mandated to take staff development programs but should have the opportunity to "buy into" available choices.

Lowes' (2005) study provides several indicators of success within online learning, including the following:

- The ability of teachers to have much closer supervision of the students they serve.
- The understanding that the constraints and opportunities afforded by online environments lead to positive transformations in conventional teaching and learning practice in terms of content and pedagogical approaches (e.g., assessment strategies).
- Indications that experienced online teachers were influential in transforming traditional learning environments upon their return to those settings.
- The availability of online courses to diversify the curriculum—courses that might not have been available otherwise.
- School districts that recognized the positive impact of online learning and began to implement the "kind of curriculum planning that is required" (p. 36) in the online staff-development courses that were offered to online teachers.

Hughes et al. (2005) identified specific online learning features that increased communication opportunities for students who were less likely to speak up in traditional classroom settings and that facilitated the development of closer relationships between an instructor and his or her students. Zucker (2005) also identified this situation as a positive learning feature by arguing that online student-to-student interaction is more equitable and more democratic than traditional classroom discourse. Hughes et al. (2005) identified online learning features that provide students with the ability to control their own learning by permitting review of new content and that facilitate greater understanding and opportunities to connect the new information with previously learned content. Other features identified by Hughes et al. included the use of more open-ended questions, less constructivist teaching methodologies (e.g., lecturing), more constructivist or student-centered learning approaches, and the flexibility to learn anytime/anyplace. One of the strategies, identified by both Lowes (2005) and Hughes et al. (2005) that is inherently built into online learning instructional design is the reflection or metacognitive time integrated in assignments.

Cavanaugh et al. (2005) identify immediate feedback, visual tools, virtual manipulatives, graphing tools, and computer applications that promote cognitive complexity as constructive features within online learning opportunities. They also note that online learning offers teachers the ability to electronically score tests and that this feature permits immediate feedback that can be used to inform instruction.

The study of Kleiman et al. (2005) illustrates that online mentorship programs can increase the quality and number of certified mathematics teachers, which holds great promise for states lacking certified teachers in various disciplines. Finally, Ferdig et al. (2005) suggest that the student achievement and understanding of algebra and geometry can be increased through the use of online simulations, a feature they argue is more difficult to implement within face-to-face classroom learning.

Kleiman et al. (2005) also found that more online teachers strongly agreed that ongoing staff development is beneficial and applicable to their teaching experience. Ferdig, DiPietro, and Papanastasiou (2005) point out that in order to create successful online programs and content, "educating the educator in facilitating online learning, [and] creating instructionally and pedagogically sound curricula" (p. 46) is necessary. Although none of the eight research studies speaks to the "model(s)" of staff development that should be embraced, teachers within these studies, in most cases, completed one or more online course supporting an understanding of either/or pedagogical and technological methodologies and strategies necessary to become a successful online teacher.

The research studies also identify factors that could improve staff development, including adding more technology training on how to use the materials and equipment; customizing staff development, depending on the teacher needs; adding more lab activities; including staff development on test development; providing more understanding of how to use learning management systems; and differentiating staff development for new and returning teachers different. The No Child Left Behind Act requires that teachers be certified in their content areas; online staff development offers an alternative system supporting the delivery of the content-based courses needed to ensure that every child in American schools has a "highly qualified" teacher by the end of the 2005–06 school year. Specific findings from these eight new studies provide new evidence for the efficacy and utility of online professional development as a potentially important strategy for achieving this important national educational objective.

The context of research on K–12 online learning confirms that online learning is an emerging but rapidly growing phenomenon in K–12 education. Although the research on K–12 online learning does offer some understanding of the promises and barriers of this approach, the findings are limited. In an effort to be responsive to the 20 or more states currently offering online learning programs or schools, further research is needed. Scientifically based research is necessary to identify the specific issues relating to discovery of the most effective combinations of media features, instructional methods, interaction, and collaboration to obtain the greatest benefits for student achievement and satisfaction. The eight research studies within this synthesis provide baseline data that should serve as the framework for continued investigations into features and strategies of online learning that demonstrate both promise and challenge.

Challenges of Online Learning

Although many of the identified features and strategies of online learning within the eight research studies demonstrate promise, some serve as potential barriers to learning and to the sustainability of this environment. There was an indication that the present demands on virtual school teachers were burdensome to reasonably assume within the available instructional time (Hughes et al, 2005; Kleiman et al., 2005; Lowes, 2005).

Many of the eight studies reported comments from teachers about their continual learning needs related to the use and maintenance of school-based educational technologies. Teachers also noted that constant changes in curricular content resulted in ongoing pressures to develop and revise assignments and assessments that truly reflect student learning and achievement. Hughes et al. (2005) maintain that keeping online courses current, communicating with parents and students,

and engaging in professional development requires a vast time commitment. The difference between the teaching demands of the conventional school teacher and the online school teacher is that the latter is required, along with all of the other teaching demands, to keep up with the constantly changing technology that is required of this delivery system.

Technology in itself apparently can become a barrier to educators who are embracing online teaching. Lowes (2005) describes that the frustrations of teachers "with a new and frequently cranky technology" (p. 6) that was time consuming, dispiriting, and challenging. The online system lacked the functions to include hands-on aspects of learning (e.g., science labs, drama performances). Many were not used to planning an entire course prior to implementation, and some missed the ability to adapt a course on a "just in time" basis.

Lowes (2005) found that teachers expressed dissatisfaction because they apparently felt a less personal connection to their online students. Possible reasons for this lack of connection included the fact that they could not see the facial expressions and therefore missed the verbal and nonverbal cues of online learners. As a result, assessing student affective reactions was a more difficult task. Lowes also argues that strategies specific to pacing a course, scaffolding lessons, or breaking content into manageable pieces was more difficult within online course development and delivery than in face-to-face content development and delivery. Lowes further notes that there seemed to be notable differences in the professional development experiences of face-to-face and online teachers, in that online teachers seemed to have more technology professional development than their counterparts.

In the University of Connecticut study examining new forms of reading comprehension, Leu et al. (2005) found that in classrooms and schools where the Internet is superficially used under the generic rubric of "Internet research" without the benefit of full technology integration, reading comprehension scores appeared to be negatively correlated to Internet use in the classroom. They suggest that for reading comprehension to be positively effected by Internet usage, high-intensity integration should be implemented, as was the case with the Internet Reciprocal Teaching intervention that was used as an experimental condition in their study.

Both Zucker (2005) and Kleiman et al. (2005) reported that increased course interaction between students seemingly had counterintuitive effects. Zucker tested a hypothesis that students would have greater satisfaction in courses where more points were awarded for higher levels of student-student interaction, yet he discovered that this hypothesis was not supported by his findings.

Kleiman et al. (2005) noted that in online courses where the online teachers worked to support and encourage students to be "self-sufficient" and to solve problems and reach understandings through student-student interaction during online collaboration, the students reported they perceived the online teacher to be less involved, less supportive, and less concerned about their individual progress as were the face-to-face classroom teachers. This perception of increased online teacher "distance" persisted even though the students who were encouraged by online teachers to engage in collaborative work showed evidence of improved academic performance.

Ferdig, DiPietro, and Papanastasiou (2005) also found that when comparing face-to-face and online students on attitude subscales concerned with cohesiveness and cooperation, the face-to-

face students scored higher in the areas of collegiality and collaboration than their online counterparts. So with regard to student interactivity, it would appear that although academic performance may show improvement when student-student interactivity increases, students seemingly report less satisfaction with their work and apparently perceive that their online teachers are somehow less interested in their individual progress.

Online Learning, School Change, and Educational Reform

As noted in Section 1, those who understand the potential of technology are optimistic about the future of online learning. The rapid growth of online learning in the K–12 learning environments is generating significant insights about educational practice and new ideas for how online learning can reshape cognition, mold job-related skills, and support knowledge acquisition so the education community can fundamentally begin to reshape formal education and improve the effectiveness of schools. Online learning can support a focus on the level of a learner's cognition, and social and emotional development rather than on age- and place-based learning. It has the potential to facilitate assessment of individual learning needs and ongoing feedback for improved outcomes.

Some online learning advocates make the case for online learning environments foreshadowing the future of public and private educational delivery systems. Some even say that in the future, fully online schools may embrace multimodal, differentiated, learner-centered, multidisciplined, multiaged, and inquiry/constructivist teaching and learning practice, thereby globally transforming teaching and learning.

The emerging research within the eight studies supports the congruency of online learning to the global context through learning gateways that are flexible, accessible, equitable, and democratic and that embrace learner diversity and diversity in learning opportunities. Professional development for online teachers is frequently embedded and can be shared anytime/anyplace. Content development is being planned and created through collaborations among and between schools and school districts. Online learning appeals to a growing and even "global" community of students and teachers who can help reshape and redesign teaching and learning.

The No Child Left Behind Act supports the goal of improving schools and providing "highly qualified" teachers for every child. Online learning allows educators to look beyond mortar and bricks and consider new strategies to meet these goals. The eight research studies in this synthesis confirm that online learning may serve as a catalyst for educational change and instructional reform within the greater educational K–12 learning context. Lowes (2005) contends that "immigrants leave the cultures and social practices [just as] those who teach online leave the familiarity of the face-to-face classroom for the uncharted terrain of the online environment, which has constraints and affordances that lead to very different practices" (p. 1). Leu et al. (2005) argue that different practice is required:

> This rapidly emerging area of work suggests that online learning is mediated by students' ability to read and communicate in online environments and that this requires new skills and strategies that go beyond what is required to read and communicate with traditional print technologies. Locating information and reading search engine results, for example,

> requires additional strategies and inferential reasoning skills not seen in traditional textbooks (Henry, in press)." (p. 2)

Cavanaugh et al. (2005) cite research by Waxman, Lin, and Michko (2003) concluding that "teaching and learning with technology has a small, positive significant effect on student outcomes, including math learning" (p. 3); and also research by Weglinsky (1998) that "the use of computers to teach higher-order thinking skills was positively related to academic achievement of 8th graders in mathematics, while the use of computers to teach lower-order thinking skills was negatively related to academic achievement" (p. 3). Most of the research within the context of online learning demonstrating no significant difference (T. Russell, 1999) compares achievement results of students in online learning environments versus students in face-to-face environments.

Literature on education reform does not limit its definition of student achievement to results on achievement tests. Essential measures to learner success within the current global realty include a learner's ability to demonstrate process-oriented skills; evidence of a collaborative spirit; and a willingness to dialogue, share, and create in a cooperative manner (Moore, 1973); other skills include leadership, independence, creativity, motivation, ambition, and desire to be a lifelong learner (Anderson, 2004); still other skills include risk-taking skills, investigative and research-oriented learning practice, and the capacity to respect diverse points of view. Research into online learner achievement does point to improved results in some of these areas.

However, Ferdig, DiPietro, and Papanastasiou (2005) point out that "face-to-face and online courses are comprised of differing components, and thus comparing the two on certain levels is similar to comparing apples and oranges" (p. 2). Their statement confirms the need, as does the literature review in Section 1, to clearly define the goals of distance (Cavanaugh et. al. , 2004) to apply design-based and mixed-methods research methodologies that may serve to enlighten understanding and inform practice. This type of research may have the greatest impact on transforming teaching and learning practice.

Dickson's (2005) study confirms that data on student performance taken from year-end high-stakes examinations are after the fact, do not impact student performance, and do not provide any measure of early intervention; yet they do contribute to a pass/fail mentality. He calls for a reform in data collection and analysis that would target broader factors contributing to student learning and achievement. Leu et al. (2005) also call for reform in research and argue that "unless we quickly begin a systematic series of investigations to better understand the effects of instruction in online reading comprehension, the growing gap in reading achievement is likely to present a fundamental challenge to any society that professes egalitarian ideals and equal opportunity for all its citizens" (p. 5). Leu et al. further identify critical thinking skills and searching and communicating information as factors that require scientifically based research that might increase learner achievement.

Zucker (2005) asks whether "the proposed reform [regarding student-to-student interaction will] promote a cohesive American society by bringing together children from diverse backgrounds and encouraging them to get along" (p. 2). Cavanaugh et al. (2005) cite the National Research Council's Mathematics Learning Study Committee (Kilpatrick, Swafford, & Findell, 2001),

which reported that although mathematics scores in K–12 schools in the United States have improved in recent years, "many students are still not being given the educational opportunities they need to achieve at high levels" (p. 4) and indicated that equity can be achieved only with the implementation of innovative practice for the "haves and have-nots," arguing that policy reform is required to ensure this equity.

Finally, Leu et al. (2005) argue that "as schools manifest different needs, it is likely that a variety of distance education models for instruction will become common" (p. 4), including distributed learning opportunities permitting students to take all courses online or to access the Internet as an integral part of a content area learning experience. Students would select which model best suits their learning styles, interests, and cognitive needs. Leu et al. identify the ability of online learning to serve as a flexible, student-centered approach to teaching and learning and suggest that it is distance education that will serve as the catalyst for the reform.

In summary, these eight new research studies examining online learning in American middle schools and high schools individually offer significant insights and important new evidence supporting the potential of online learning. The evidence generally supports the conclusion that online learning offers an alternative instructional delivery system with some potential for improving the quality, efficiency, and equity, and increasing the availability of "choice" within the American educational system and within the broader content of international and global educational systems.

The findings of the eight studies as a whole, as part of the growing body of research examining online learning, lead us to some recommendations for improving the impact and effectiveness of K–12 online learning in American schools and within the global context.

Section 3
Recommendations

In Sections 1 and 2 of this synthesis, six common themes prevail:

- Student Academic Performance
- Characteristics of Successful Online Students
- Qualities of Effective Online Courses
- Professional Development for Effective Online Teaching and Learning
- Challenges of Online Learning
- Online Learning, School Change, and Educational Reform

Section 3 moves from research to practice, making recommendations to inform and guide research, development, and implementation of online learning programs. First, recommendations based on the field review as well as the findings and caveats from the eight research projects are made, organized according to the six themes listed above. Next, recommendations for future research directions and methods are described. This section also addresses barriers to effective research and important questions for online learning researchers to consider. It ends with final conclusions relating to K–12 online learning.

Policy and Practice Recommendations

Recommendations Relating to Student Academic Performance

Academic performance in online high school courses and/or online high schools generally appears to demonstrate academic performance that is at least equivalent to participation in traditional or "face-to-face" courses (Cavanaugh et al., 2004). Findings on academic achievement in the eight synthesized studies are generally inconclusive for reasons discussed as "barriers" to effective research (see page 66). Practitioners seeking guidance in developing and operating online learning programs should consider the following:

- Professional development implemented with the intent of preparing "highly qualified" online teachers appears to have a positive effect on online student performance.
- Online instructional strategies designed to optimize student-student and student-teacher interaction show limited evidence of having a positive impact on students' performance. More rigorous, experimental research needs to be undertaken examining online interaction, with much clearer definitions of cause and effect, before clear and useful findings are possible.
- Online mathematics courses that provide immediate feedback and include visual tools, virtual manipulatives, graphing tools, and computer applications to reduce the cognitive load from computation and calculation apparently enhance students' academic performance. Increasing statewide availability of online mathematics courses having the characteristics discussed in the studies by Cavanaugh et al. (2005), Kleiman et al. (2005),

Hughes et al. (2005), and Ferdig, DiPietro, and Papanastasiou (2005) suggest a promising practice offers for broad improvement of mathematics instruction. It would be valuable to implement randomized, "design-based" experimental trials to test this implicit hypothesis.

- Online Algebra I courses pairing a "highly qualified" online teacher with a less-qualified classroom aide (uncertified or enrolled in a certification program) may offer a promising "research-based" instructional intervention that apparently works as well as or arguably better than traditional classroom instruction with a less qualified teacher in equivalent settings with equivalent curriculum. Collateral benefits of this intervention include the mentoring and eventual qualification of new Algebra I teachers and immediately increased capacity within the sponsoring state (Louisiana) to make "highly qualified" teachers available in schools that would not ordinarily have them.

Recommendations Relating to Characteristics of Successful Online Students

The studies reviewed in this synthesis begin to identify and define a constellation of features and student characteristics that show great promise for potentially optimizing students' potential for academic success and optimal performance in online courses.

- At least one valid and reliable predictive assessment is currently available. The ESPRI assessment (Roblyer & Marshall, 2002–2003) has apparent potential for predicting whether new online students will be academically successful. Using predictive assessments to optimize the potential for success with new or first-time students appears to be a promising, research-based best practice.
- Additional preparation of and/or counseling for "first time" online students, for the expressed purpose of supporting the success of students with identifiable characteristics or assessment scores indicating a low probability of online academic success, also appears to be a promising practice.
- Local and state education agencies should begin reporting accountability data describing academic performance in online courses by the five categories guiding disaggregate reporting of achievement by disadvantaged groups, as mandated under No Child Left Behind: major racial or ethnic groups, economically disadvantaged students, limited-English-proficient students, migrant students, and students with disabilities (Blomeyer & Dawson, 2005). This reporting should increase accountability and oversight for performance of disadvantaged students enrolling in online courses, ensure that disadvantaged students receive the support they need to become successful online students, and prevent online courses from becoming unsupported "dumping grounds" for at-risk students.

Recommendations Relating to Qualities of Effective Online Courses

Online high-school courses and "virtual schools" apparently suffer from the perception on the part of educational leaders, educators, and community members that they are in some way "inferior" to traditional instructional models and methods.

- Accountability data documenting the effectiveness of online courses and online schools, with attention paid to standardized measures of achievement that support comparisons of performance to national, state, and regional norms should be collected and made available for public review by all schools with online programs.
- Parties supporting the development and implementation of online learning should contribute to the development and validation of professional standards and guidelines supporting the implementation of highly effective online courses delivering standards-based content.
- Research-based standards for "best practice" supporting online teaching and learning need to be developed, validated, disseminated widely, and made available for public review.
- The instructional models and designs commonly used to develop and implement online courses should be more thoroughly documented and described, so that schools offering online courses (or online schools) can effectively communicate the variety and subtlety of these designs and models to the communities they seek to serve.
- Because discourse and interaction between and among students and teachers in online courses apparently lacks the nonverbal components that accompany spontaneous face-to-face verbal communications, students and educators should be supported to better understand how opportunities for online interactions can be optimized and enhanced.

Recommendations Relating to
Professional Development for Effective Online Teaching and Learning

All eight studies identify the situated and effective preparation of "highly qualified" online teachers as a crucial element in the implementation of effective online learning programs.

- State education agencies in all 50 states should work toward establishing performance-based qualifications for online teachers and require that all teachers assigned to online high school courses have appropriate subject area teaching certification.
- State education agencies should work toward developing and enforcing performance-based professional requirements for all online teachers.
- Completion of appropriate professional development experiences, based on professionally appropriate standards, should be required before any certified teacher is assigned duties as an online teacher.
- All newly qualified online teachers should be provided with mentoring by an experienced online teacher during their first online teaching assignments.
- The performance of online teachers should be periodically evaluated by supervisors or administrators who are themselves professionally prepared and experienced online teachers.

Recommendations Relating to Challenges of Online Learning

Some of the features and strategies identified in this synthesis may be interpreted as barriers to further diffusion and sustainability of online learning in K–12 educational systems. In particular, there are indications that the strenuous demands of virtual teaching and learning may make participation in online learning programs a relatively undesirable option for some teachers and school administrators.

- K–12 educators (teachers and leaders/administrators) participating in online learning projects must be emotionally prepared to accept and adapt to ongoing changes, including technological changes in hardware systems and changes in curriculum requiring periodic modifications to online courses.
- The loss of visual contact with students seemingly robs online teachers of queuing systems that are seemingly important to some dimensions of interpersonal communication. In particular, efforts should be made to provide additional support systems for online teachers that can help alleviate teachers' perceptions that students' attitudes and "emotional states" are less accessible to them in online learning environments.
- It seems that use of the Internet under circumstances favoring *limited* technology integration may correlate to lower tested reading comprehension. As such, increased resources should be provided to support teachers in implementing more fully integrated uses of the Internet to support teaching and learning.
- Increased teacher support for student-student collaboration and interactions in online learning environments seemingly increases student engagement and may have a positive impact on academic performance, but it may also show a paradoxical effect on students' perceptions of online teacher engagement and online teachers' perceived emotional commitment and willingness to individualize and meet students' needs. Accordingly, teachers should be supported to develop and maintain communication channels that work to compensate for this apparent emotional "distancing" in online environments where student-student collaboration is a significant instructional strategy.

Recommendations Relating to Online Learning, School Change, and Educational Reform

The institutionalization of e-learning or online learning in America's schools is not *about* establishing online learning as a delivery system "competing with" the traditional K–12 schools. It also is not *about* disseminating new or innovative instructional technologies. Rather, it is essentially about educational improvement, school reform, and improving academic performance in American's high schools.

- Online learning researchers should attend presentations and seminars organized by groups advocating education reform. Individuals and groups interested in online learning should invite advocates for education reform to become involved in the evolving national online learning community (e.g., the North American Council for Online Learning).
- The goals for online learning projects and programs should be intentionally stated in terms of systemic education reform and school improvement.

- The outcomes defined as targets for online learning programs also should be oriented toward school reform and educational improvement.
- Data management systems should be implemented for online learning programs that will fully support comparisons of the academic performance of students between online and traditional settings. If the national online learning community is going to aim high, it needs the assessment capacity to show that it is hitting the mark.
- Online learning data systems also should be designed and implemented with the capacity to disaggregate data according to the five categories for disaggregate reporting of AYP under the No Child Left Behind Act. This step is important to support the case that traditionally disadvantaged students are participating in online learning and can succeed in online learning environments.

K–16 Online Learning Research Recommendations

Recommendations Relating to Interpreting "Equal or Better" Achievement Findings

Stakeholders in online learning may interpret findings of "equal or better" quite differently. Cavanaugh et al. (2004) point to a lack of consensus among stakeholders about the goals of distance education. Stakeholders focused on expanding educational access may be satisfied with demonstrating that online learning is as effective as conventional education. Demonstrating "equally good" results serves to answer perennial questions about the acceptability and quality of distance education. When online learning is of equivalent quality, its use is justified as an No Child Left Behind school-choice option for homeschoolers, to help students finish high school, or to offer an expanded array of AP courses. Those seeking to meet No Child Left Behind "highly qualified" teacher standards through online teacher education or staff development programs can use "same as" findings to justify expanded training options.

However, stakeholders seeking to use online learning as a strategy for improving student achievement under No Child Left Behind through direct student instruction or staff development may not be satisfied with online learning programs that yield "equally good" results. Those seeking to justify the costs of an online learning program also would prefer to see evidence of improved results. Programs developed by those seeing online learning as an alternative form of education are likely to strive for equivalent outcomes. Those who see online learning as a strategy for improving achievement will do well to focus on how their programs can deliver outcomes that are superior.

Recommendations Relating to Student Persistence

A key metric or indicator useful for assessing the impact of online learning is the rate of retention or attrition in a unit of study, course, or program (Blomeyer & Dawson, 2005). The strategy of using online learning to help at-risk students stay on track to graduation cannot succeed if online students drop out or fail to complete coursework satisfactorily. No figures exist on attrition rates across virtual schools today. Different institutions use different criteria for determining who to count as a dropout or noncompleter. The meta-analyses summarized in Section 1 suggest that student persistence is lower in online learning than in video-based or face-

to-face study. Online learning students may drop out more frequently in high school than in college (Roblyer, 1999). Virtual schools may have high dropout rates in their early stages, with retention improving over time, according to program evaluations (Bigbie & McCarroll, 2000; Clark, Lewis, Oyer, & Schreiber, 2002). These evaluations also suggest students may have trouble self-pacing without assistance. Time or pacing issues play a role in student attrition in distance education (Kim, 2004). In synchronous video-based distance education, it is harder to fall behind because courses parallel convention instruction.

However, some large online learning providers report high course-completion rates. For example, both Florida Virtual School (FLVS) and the Virtual High School (VHS) claim 2003–04 course completion rates of 90 percent or higher, while Apex Learning, which provides AP and other courses nationally, reported a completion rate of 84 percent in 2002–03[5]. Large providers have the resources to develop strong course development and delivery systems. They may offer extensive training and mentoring for teachers who follow instructional models designed to engage, pace, and support students.

Recommendations Relating to Student Process Skills

Learner skills in critical and higher order thinking, collaboration, technology use, reading, writing, and other process skills have been the subject of some study. For example, scaffolding by the teacher appeared to influence the development of critical thinking skills by online college students in a qualitative study (Priya & Hannafin, 2004). Evaluators of a state virtual school found that the instructional model was effective in promoting higher order questioning from teachers and responses from learners (Bigbie & McCarroll, 2000). Meta-analyses suggest that use of computers improves the reading achievement of K–12 learners (Soe, Koki, & Chang, 2000) and can improve the quality of writing (Goldberg, Russell, & Cook, 2003).

Recommendations Relating to Student Satisfaction and Motivation

Meta-analyses discussed earlier suggest that when compared with conventional study, student satisfaction is the same or a little lower in online distance education, and lower in video-based distance education. As Simonson, Schlosser, and Hanson (1999) note, students may feel more "left out" at a distant videoconferencing site than in online learning, resulting in lower satisfaction rates. Distance education studies suggest that a lack of learner motivation is a primary cause of attrition, along with time issues. Given the higher levels of attrition in online learning, motivating learners is seen as an important focus for designers and teachers. However, little research has focused on motivation in online learning (Kim, 2004).

Recommendations Relating to Learner Characteristics

Data from state virtual schools suggests most K–12 learners are in high school, more females than males enroll, and a growing portion of enrollments are by minorities and students attending less affluent schools. However, relative success rates based on learner demographics generally are not available. Some researchers have sought to determine if students with certain characteristics are more successful, but they have focused primarily on postsecondary online

[5] Based on press releases and data posted to www.flvs.net, www.govhs.org, and www.apexlearning.com.

learners who may differ from K–12 online learners. Prior academic experiences appear related to success. Grade point average, class rank, previous courses completed online, and technology training courses were found to be correlated with student retention in a university's online courses (Dupin-Bryant, 2004). A screening test had some predictive validity, but cumulative grade point average was a much better predictor of achievement for 167 students in an online university course (Bernard et al., 2004).

Research focusing on predicting online learning success has yielded mixed results. Roblyer and Marshall (2002–2003) tested a success prediction instrument with 135 students in 13 virtual schools, concluding that it discriminated well between successful and unsuccessful students. This customized tool covers a range of issues, such as study and technology skills, time management, motivation, attitudes, cognitive style, and demographics. The research suggests standard screening tests of psychological characteristics such as cognitive styles may have limited value in predicting distance education outcomes (Price, 2004). In general, there has been little systematic study of how learner backgrounds, preparation, and screening influence online learning outcomes.

Recommendations Relating to Features of Online Learning Systems

A number of studies have focused on the structure of online learning, the design and functionality of online learning content and delivery systems, and the use of dialogue in online learning (i.e., usage patterns through various types of interaction). Saba (2004) seeks to validate aspects of Moore's (1989) theory of transactional distance by studying many variables in a dynamic systems simulation. He concludes that this kind of design-based research could lead to personalized, self-adaptive learning systems. In their meta-analysis of comparative studies, Bernard et al. (2004) found that the use of problem-based learning methods and computer-mediated communication had a positive effect on the achievement and attitudes of online learners. Cavanaugh et al. (2004) considered the relationship of distance education system factors (duration and frequency of use, role of the instructor, timing of interactions, learning pace) in K–12 online learning when compared with conventional study, finding no significant differences in achievement related to these factors. In Cavanaugh's 2001 meta-analysis comparing technology-enhanced study with conventional education, more positive effects were seen for programs using technology on a weekly rather than a daily basis, those using technology as a supplement, and those using online technologies.

Recommendations Relating to Educational Context

There is some empirical evidence about the extent of K–12 online learning from the large-scale descriptive studies cited earlier, but evidence is not being gathered in a regular, systematic manner, especially for online learning in isolation from other distance education methods. Some study of context issues may be related to achievement or other learner outcomes. Cavanaugh et al. (2004) found no significant difference in online and conventional K–12 study based on educational context factors (content area, school type, and grade level). Cavanaugh (2001) concluded that all content areas except foreign language instruction showed small but positive effect sizes in technology-based versus regular classroom study.

Efforts to study the impact of online learning on No Child Left Behind -required teacher qualifications and learning outcomes are embryonic. Researchers are studying some large-scale efforts to prepare K–12 online teachers and program staff as change agents in schools, such as the Teacher Education Goes into Virtual Schooling project (Davis & Roblyer, 2005). A number of studies have looked at changes in teacher practice through technology integration, an area related to online teaching. Policy research on online learning has been limited. Without an understanding of how resources, policy, and funding impact success, many programs may not survive. Watson (2005) and Watson, Winograd, and Kalmon (2004) provide useful policy research examples. Although there is some good descriptive research on successful virtual schools, how to scale up and sustain effective models while maintaining fidelity to treatment has not been a focus of much empirical research.

Barriers to Effective Research

There are numerous barriers to conducting effective research on K–12 online learning. Some of the barriers faced by online learning researchers are generic to conducting research in schools, and some are specific to online learning.

Barrier 1: Access to Critical Data

In a rigorous quasi-experimental study, researchers must control for prior academic performance in treatment and comparison groups. In any kind of empirical study, researchers need critical background data on students in order to document impacts relative to underrepresented students, as designated under the No Child Left Behind Act. Gaining access to critical disaggregated data from student records in schools often requires building trust with administrators and staff. Gaining such access can be challenging in practice, even when a data-sharing agreement is in place. In studies of online activities, researchers must obtain access to data from the learning management system, which can raise similar data-access issues.

Barrier 2: Distributed Nature of Online Learning

In a typical online learning course, students may be scattered across multiple schools and regions. This situation creates challenges in establishing comparable treatment and control groups and obtaining student background and prior outcomes data. A study with local classrooms of students in online and conventional treatments may create conditions significantly different from those typical in an online course. If the natural setting is used, with students scattered across schools, establishing a defensible comparison group for a rigorous quasi-experimental study is challenging. In many cases the virtual school is not the school of record and does not have access to the student file. Instead, numerous local schools that use the online learning program retain the student file. They may vary significantly in their ability or willingness to provide prior student data, and it may be time-consuming to obtain.

Barrier 3: School Culture and Educational Research

Researchers who come from nonschool backgrounds may have an advantage in maintaining an objective researcher role in schools, but they may find that school-culture issues they did not take

into account hamper their research. Administrators and staff often have apprehensions or misconceptions about conducting experimental research in schools. Experimental studies can be framed as fitting the mission of schools to serve all learners, since random assignment gives all children an equal chance to be selected to participate. Control group students may be given first access if an intervention is proven effective. Researchers should be prepared to determine whether an appropriate research design can actually be carried out in a particular setting and weigh the likelihood of success before proceeding.

Barrier 4: Assessments

State assessments often are inappropriate for studying achievement. Unlike elementary schools, the public high schools where most virtual schooling takes place do not have No Child Left Behind -mandated statewide assessments that can be used to study the general academic progress of online learners. The additional testing and time taken away from class can be a burden on the school. Standardized tests often cover broad content areas and may not be sensitive enough to measure changes in learning at the course or unit level. It is often necessary to locate and administer subject-specific tests that are valid and reliable with the learner group selected. Those who study online do better when the test also is online (M. Russell, 1999), but using different testing methods can confound results.

Barrier 5: Study Time Frames

Time frame-related issues such as funding cycles and school calendars can present challenges to setup and implementation of well-designed studies. Schools often make decisions on staff development or curriculum a year or more in advance. Multiyear time frames may allow full development of an intervention and sufficient lead time for research, but they often are not feasible. Inclusion of schools from the start in research planning can increase buy-in and regularize project activities, but often neither schools nor researchers are involved in planning until a project is under way.

Barrier 6: Funding

Online learning projects are frequently funded by grants or special funds, and funding for research may be limited or uncertain. Sufficient funding must be devoted to school partners to ensure they will be support compliance with the research activities and remain involved throughout the planned study.

Barrier 7: Focus of Staff Development Research

In studying the effectiveness of online staff development, student achievement is considered the primary outcome by U.S. Department of Education. Factors such as obtaining enough classrooms with treatment and control teachers for random assignment make experimental research challenging. Most research to date has focused primarily on educator outcomes or features and use of online professional development systems.

Important Questions for K–16 Online Learning Researchers

Questions suggested by this review are offered here. They are grouped into six topical areas from the eight studies examined in this synthesis. These areas apparently are related to the study variables derived from Cavanaugh et al. (2004).

Questions Relating to Student Academic Performance

What is the impact of K–12 online learning on student achievement? What factors can increase online course success rates? What impact does online learning have on learner process skills, such as critical and higher order thinking? How are learner satisfaction and motivation related to learner outcomes?

Questions Relating to Characteristics of Successful Online Students

What are the characteristics of successful K–12 online learners, and can success be predicted? How do learner background, preparation, and screening influence academic outcomes in online learning?

Questions Relating to Qualities of Effective Online Courses

What are the most effective combinations of media and methods in particular K–12 online learning settings? How do interaction, collaboration, and learner pacing influence academic outcomes? What is the impact of K–12 online learning when used as a supplement, in courses, or in full programs of study?

Questions Relating to Professional Development for Effective Online Teaching and Learning

What are the characteristics of successful K–12 online teachers? What are the most effective training, mentoring and support systems for these teachers? Is online professional development an effective method of training and credentialing K–12 educators?

Questions Relating to Challenges of Online Learning

Is online teaching significantly more demanding than traditional face-to-face teaching? How can online learning managers support the needs of online teachers for assistance in keeping up with constantly changing technologies? How can online teachers achieve a reasonable level of curricular flexibility while serving as instructors in professionally developed courses with a justifiable emphasis on "fidelity of implementation"? How can online students retain apparent academic benefits from increased student-student collaboration and communication without undercutting positive perceptions of the online teacher's roles in online courses?

Questions Relating to Online Learning, School Change, and Educational Reform

How can online learning best be used to improve learner outcomes in different content areas, grade levels, and academic programs? How can online learning help schools meet No Child Left Behind requirements? Can online learning teachers and programs act as change agents in schools? Does online teaching transform educational practice? How do resources, policy, and funding impact the success of online learning? Can effective models of K–12 online learning be scaled up and sustained?

Conclusion

Ultimately, the questions addressed by K–12 online learning research reflect and foreshadow the most crucial questions being asked today, in every part of the country where online courses and virtual schools are proliferating. Building and district-level educational leaders, school board members, staff members in state boards of education, chief state school officers, members of state congressional delegations, the distinguished members of the U.S. House and Senate, and a small legion of dedicated public servants employed by the U.S. Department of Education are probably asking questions such as the following:

> *Will the growing national investment in K–12 online learning, particularly implementing and expanding the use of online high school courses provide a basically sound, high-quality educational experience for online students? Or will this new investment in K–12 online learning be yet another waste of scarce national educational resources on today's newest educational technologies that is destined to be abandoned in some virtual tomorrow?*

Answering this predictable "bottom line" question about probable return on investment has repeatedly backed generations of educational researchers into the same corner. The usual strategy for attempting to exit from that now familiar corner has been to establish the efficacy and effectiveness of nearly 40 years of structural, conceptual, and technological innovations by implementing educational studies that have seemingly always asked variations of the same question:

> *Does Method X (experimental group) show evidence of supporting student performance that is better than or equal to Method Y (control group)?*

Over time, this question has consistently produced only one remarkably persistent finding: "no significant difference." In their critique of both "media research" and the then-new research on the instructional use of computers in schools and classrooms, Salomon and Gardner (1986) drew an important parallel between research on the instructional uses of television and research on the instructional uses of computers. In the research on instructional television, many investigators pursued questions about the "effectiveness" of TV as a delivery medium in comparison with other alternatives.

The overall lack of significant findings from this earlier research may not be because TV is ineffective as a medium. Rather, it may be due to the lack of sensitivity of experimental studies to concomitant changes in the schools and classrooms where TV was used.

Their central point is that research questions about relative "effectiveness" (as measured by comparisons of gains through testing) are plainly *inappropriate*. Salomon and Gardner recommended then that research on "instructional computer use" might be more productive if it were organized using an approach that could *more fully describe* the operational context of classroom computer use and provide information useful for discovering specific, outcome-related questions that can be tested as hypotheses in subsequent research.

We believe that this advice from Gabriel Salomon and Howard Gardner—from an article published in the *Educational Researcher* back in 1986—contains wisdom that should be heeded today and tomorrow in addressing the empirical issues that are central to determining whether or not the educational benefits available from participation in online learning truly warrant an ongoing public investment in diffusing and "institutionalizing" online learning within the K–12 educational system.

Findings from the eight studies on K–12 online learning summarized in this paper offer important insights about the context of online learning in use today and about the questions and issues that should be addressed by new research. These foreshadowed questions and issues include new information that leads us to question whether we are dealing with one generalized phenomenon that can be adequately described as being "K–12 online learning," or whether this description is more suited to an entire new *class* of phenomena. Such phenomena are related but also may be important variations having clear and identifiable characteristics as well as unique outcomes, benefits, and possible drawbacks.

Practically speaking, describing all the many structural, administrative, technical and theoretical variations (theories of learning) that characterize online learning today is a formidable challenge. If we were to wait until an adequate and inclusive descriptive framework were developed before starting to design new online learning research, we might be waiting for a very long time indeed.

Fortunately, research already has been done by NCREL that suggests practical guidance for implementing at least one new educational experiment to answer the following outstanding question:

> *Can "scientifically based research" examining online learning conducted* ***within*** *the school day, used as an alternative or "hybrid" instructional model (combining traditional or face-to-face instruction with online delivery) evidence greater academic gains for participating students than with online learning delivered in a purely online format?*

Simply stated, this question asks whether purely online instructional delivery of online learning, such as is characterized by educational programs conducted in virtual or online schools (or cyberschools) might show evidence of greater (or lesser) academic performance than online courses offered within the educational program offered in a "traditional" comprehensive high

school. The question is based on findings from two of NCREL's meta-analyses: Waxman, Lin, and Michko (2003) and Cavanaugh et al. (2004).

In 2003, NCREL published Waxman, Lin, & Michko's *A Meta-Analysis of the Effectiveness of Teaching and Learning With Technology on Student Outcomes*. Their work, based on a body of 42 studies, reported a mean study-weighted effect size of .410 with a 95 percent confidence interval (CI) of .175 to .644. The more recent NCREL meta-analysis, titled *The Effects of Distance Education on K–12 Student Outcomes: A Meta-Analysis* (Cavanaugh et al., 2004), examines the effects of K–12 distance education on students' academic performance, within the context of online or distance learning. The authors found a study-weighted mean effect size across all outcomes of -0.028 with a 95 percent confidence interval from 0.060 to -0.116, indicating no significant difference in performance between students who participated in online programs and those who were taught in face-to-face classrooms.

Why is it that the use of technology in classroom settings demonstrates a mean effect size of .410 in the Waxman, Lin, and Michko study while what could easily be interpreted to be "instructional technology use" within virtual and distance learning environments (online courses and schools) shows a study-weighted mean effect size of only -0.028, or essentially a *zero effect*? Could it be that learning environments within schools are in some way fundamentally more conducive to learning than courses offered in purely online schools or cyberschools? Might integrating online courses into the schedules of traditional high school students and delivering online courses as a curricular alternative during the traditional, scheduled school day offer online students instructional benefits and a possible academic advantage that cannot be duplicated in a fully online learning environment or cyberschool?

Based on our current and past research on educational technologies at NCREL, we believe that as additional, high-quality studies examining the effects of online learning on students' academic performance are published and establish eligibility for consideration in an expanded meta-analysis examining K–12 online learning, the virtual zero effect now reported for online learning will very probably grow and eventually even out with the effects currently being reported by Waxman, Lin, and Michko and others for technology use situated in classroom settings. But the opportunity that testing the "Waxman-Cavanaugh Hypothesis" would provide for examining the greater context of online or distance learning within the larger domain of educational technology research would be priceless.

We believe that the future of research examining online learning lies in the systematic examination of students' academic performance in contexts that invite measuring the impact of all those instructional and environmental variables that differentiate between the wide varieties of online learning environments in use today. The answer to this apparently simple question may not be as simple as it appears:

> *Does Method X (experimental group) show evidence of supporting student performance that is better than or equal to Method Y (control group)?*

To fully answer the question, we must first determine what the basic underlying similarities and differences are between Method X and Method Y and then accommodate for those differences so

that our findings will reflect the real character of the interventions and not just our prior assumptions about *all fruit being apples.*

The real challenge for online learning researchers is to determine the significant characteristics common all learning environments so that we are sure that we are not comparing *apples* to *oranges*. Then, we should continue to address the basic question common to all design-based research: "Does this instructional intervention work better than things did before?"

If we continue to ask that same question and account for the real similarities and differences between related interventions, we eventually will discover ways to optimize learning in all sorts of instructional contexts and learning environments, both traditional and online.

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Appendix

Contact Information for the Eight Research Studies

Study 1
Toward a Deeper Understanding of Student Performance in Virtual High School Courses: Using Quantitative Analyses and Data Visualization to Inform Decision Making

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Study 2
Online Teaching and Classroom Change: The Impact of Virtual High School on Its Teachers and Their Schools

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Study 3
Evaluating the Development of Scientific Knowledge and New Forms of Reading Comprehension During Online Learning

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Study 4
Teaching and Learning in Collaborative Virtual High Schools

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Study 5
Staff Development and Student Perception of the Learning Environment in Virtual and Traditional Secondary Schools

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Study 6
A Study of the Effectiveness of the Louisiana Algebra I Online Project

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Study 7
Succeeding at the Gateway: Secondary Algebra Learning in the Virtual School

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Study 8
A Study of Student Interaction and Collaboration in the Virtual High School

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