PERSONALIZEDLEARNING

THE NEXUS OF 21ST CENTURY LEARNING AND EDUCATIONAL TECHNOLOGIES

FOR THE LAST YEAR, DURING THE COURSE OF CONVERSATIONS WITH KEY STAKEHOLDERS ACROSS THE U.S., PEARSON'S LEADERSHIP HAS RECOGNIZED FOUR PREVAILING TOPICS OF INTEREST OR CONCERN. THE LEVEL OF THIS INTEREST COMPELLED US TO TAKE A DEEPER LOOK INTO THESE TOPICS; AS A RESULT, WE DEVELOPED FOUR ISSUES PAPERS THAT EXAMINE THE UNDERLYING RESEARCH AND DEFINE EFFECTIVE SOLUTIONS. THESE THEMES OR ISSUES—COLLEGE READINESS, TEACHING QUALITY, ASSESSMENT, AND PERSONALIZED LEARNING: THE NEXUS OF 21ST CENTURY LEARNING AND EDUCATIONAL TECHNOLOGIES—HAVE SIGNIFICANT IMPLICATIONS FOR THE FUTURE PROSPERITY OF THE UNITED STATES.

Our issues papers are not intended to be exhaustive overviews of the current state of American education. Rather, they outline the issues and associated challenges, and point to potential solutions that exhibit demonstrable results.

The papers offer the reader, whether a legislator, administrator, school board member, teacher, or parent, a scan of the existing literature and a perspective on approaches that have demonstrated progress. For example, the discussion about teaching quality, perhaps the single most significant variable that influences student achievement, will consider the return on an investment in effective teaching and professional development. The college readiness paper focuses on factors that contribute to a student's ability to succeed in higher education. This paper, "Personalized Learning: The Nexus of 21st Century Learning and Educational Technologies," takes stock of developments and challenges in this new century and makes a case for personalized learning as a powerful driver in 21st century teaching and life-long learning. In this view, educational technologies including formative assessments linked to instruction, learning management systems, longitudinal data systems, flexible and adaptive content delivery, interoperability standards, teachers, professional development, and institutions themselves must essentially serve the learner in a more personalized way if we are to realize our greatest aspirations.

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PEARSON

STUDIES ALSO SUGGEST THAT more frequent and rigorous evaluation of technology implementations in schools, by schools, can contribute to a knowledge base that can serve the entire educational community.

"We have seen our world change around us and now need to retool our education system to respond. Part of our challenge has been that technology has been applied to the outside of the education process, rather than as a critical tool in revamping the process itself. Personalizing instructional delivery through the strategic use of technology is a key part of that transformation."

This was the view of the Department of Education in 2008. The same position paper[1] also stated:

"Harnessing the power of innovation for the good of our schools is not just a novel enterprise. The nation's health and prosperity depend on it. By leveraging technology, schools can customize instruction and ensure that children who need extra help get it."

The current administration is even more determined to use technology and other innovations to improve the educational experience and outcomes. While there are many differences in opinion on how this might be done, there is broad agreement on several principles:

a) Schools and school systems need transformation
b) Technology when applied effectively can aid this transformation
c) Transformation and technology in the service of personalizing the educational experience is a powerful goal, essential to our future in the 21st century

WHAT THE RESEARCH SAYS

The research going back several decades—including the most rigorous treatment and control designs—has consistently shown that technology is capable of providing small to moderate gains—effect sizes—when appropriately implemented. While it has been pointed out that the number of studies (especially rigorous ones) is relatively few, this is also a criticism of the research base in education generally, and should not be construed as a de facto judgment on the ability of technology to produce results.

Many analyses of the effectiveness of technology in education highlight the need to carefully consider the educational goals of the technology being studied; to carefully match the research design to outcomes of interest; and to factor in fidelity of implementation. Studies also suggest that more frequent and rigorous evaluation of technology implementations in schools, by schools, can contribute to a knowledge base that can serve the entire educational community. This holds true for any interventions, reforms, and school programs — whether or not they are technology-based.

A 2006 research review entitled "Technology in Schools: What the Research Says" (Meteri Group, sponsored by Cisco Systems) concludes: "The research on the effect of technology in learning is emerging. Overall, across all uses in all content areas, technology does provide a small, but significant, increase in learning when implemented with fidelity." It goes on to say: *"Most educators are looking for the value proposition that will significantly advance learning, teaching, and school system efficiencies. Taking advantage of these leverage points requires serious review of specific research studies that specifically address the needs and challenges of specific schools and serious attention paid to leadership development, professional development for teachers, school culture, curricular redesign, and teacher preparation."*

While careful to say their review was not exhaustive, the report examined and categorized a variety of technology research studies. Studies were categorized by "LEARNtypes" (learning outcomes, e.g., content expertise and knowledge, automaticity of basic knowledge and skills, etc.); "TECHtypes" (e.g., TV and/or video, virtual learning, etc.), and level of rigor. **Figure 1** is a summary chart drawn from their report which

Figure 1: Summary, "Technology in Schools: What the Research Says"

LEARNtype	Automaticity of Basic Knowledge and Skills		Content Expertise and Knowledge		Information Processing and Visualization		Higher-Order Thinking and Sound Reasoning		Authentic Learning	
TECHtype										
	Descriptive Studies	Rigorous Research	Descriptive Studies	Rigorous Research	Descriptive Studies	Rigorous Research	Descriptive Studies	Rigorous Research	Descriptive Studies	Rigorous Research
Television or Video	+	+	+	+	+	+	+	+	+	
Calculators or Graphing Calculators	Mixed Results		+	+	+	+	+	+		
Engagement Devices	+		+		+		+			
Portable ICT Devices	+	Inconclusive	+		+		+			
Virtual Learning	+	**	+	**	+		+	**	+	
In-School Computer Use	+	+	+	+	+	+	+	+	+	
1:1 Computing	+	+	+	+	+		+		+	

The chart above shows trends and research findings related to educational technology across various types of learning. A "+" under the Descriptive Study column indicates that qualitative or correlational studies are promising. A "+" under the Rigorous Research column indicates at least one rigorous, experimental, or quasi-experimental design study shows positive results. A "-" indicates flat or negative results, and mixed or inconclusive results are so noted. A blank cell indicates that the authors have located no studies on that topic.

shows that less rigorous (descriptive) studies are more numerous, but consistently show positive impacts from technology and they are corroborated by a considerable number of more rigorous (treatment and control design) studies.

In 2003, Learning Point Associates (NCREL), under a contract from the Institute of Educational Sciences, conducted a meta-analysis of 42 research studies that included roughly 7,000 students and 282 effect sizes focused on students' cognitive, affective, and behavioral outcomes. The average effect size across studies was .410. The report concluded: *"The result from the present study indicates that the overall effects are nearly twice as large as other recent meta-analyses conducted in the area of instructional technology. This finding suggests that the overall effects of technology on student outcomes may be greater than previously thought." The report also points out that "the overall findings suggest that the results do not differ significantly across categories of technology, instructional characteristics, methodological rigor, characteristics of the study, and subject characteristics."*

A research review on the effectiveness of technology was conducted in 2000 by Interactive Educational Systems Design (Bialo and Sivin-Kachala) on behalf of the Software Information Industry Association. The authors selected 311 studies from an original set of 3,500, based on their rigor and focus on learning outcomes. They found ample support for their conclusion that *"technology is making a significant positive impact on education."* Beginning with the earliest studies of computer assisted instruction (CAI) and spanning K12, higher education, and adult education and training, the report examined studies across a range of curriculum areas. Many of the studies cited the benefits of technology in adapting to learner needs, flexing to learner traits, and allowing multiple modes of learning and pathways to learning.

The RAND Corporation (Glennan & Melmed) also conducted a review of the research on technology's effectiveness for education as part of its Critical Technologies Institute in 1996. As they concluded: *"Research and practice suggest that, appropriately implemented, computer and network based technology can contribute significantly to improved educational outcomes. Most of this experience is in small trials in one or a few settings, but research has aggregated these experiences into a significant body of literature that illuminates the potential of technology in a variety of settings."* They called for more focused research capable of measuring the specific outcomes that educational technologies are designed to impact.

Each of the reports described above contain additional citations of research that has helped demonstrate the effectiveness of educational technology. The more useful studies for educators also describe the conditions and factors that contribute to that effectiveness, including the importance of sound instructional design based upon clear learning goals, adequate training, equitable access to the technology, and integration into the rhythms and culture of schools.

There is also considerable informal evidence of the impact of technology that should not be ignored. For example, in a survey of 1:1 technology implementations among the nation's largest districts, America's Digital Schools 2008 (Hayes & Greaves) found that 79% of respondents believed that moderate or significant academic improvement could be attributed to the 1:1 implementation (33% significant). In the prior year's study, this proportion was 64%, again a considerable vote of confidence for the effort.[2]

TECHNOLOGY IN HIGHER EDUCATION

Technology is also playing a transformational role in higher education, where online and blended learning have exploded in the last decade. For-profit online universities such as the University of Phoenix and Capella University have enjoyed significant growth by using online learning to accommodate the needs of adult learners who are often holding down jobs during the day. Many traditional universities are also embracing online or blended models of instruction as well as the other rich opportunities for learning that technologies can make possible. Duke University's Center for Instructional Technology has documented technology implementations in classrooms across its campus, demonstrating the various ways that faculty infuse technology into their instruction.

The National Center for Academic Transformation (NCAT) has been researching and promoting redesign of the post-secondary enterprise through transformative course redesign using technology. NCAT's Program in Course Redesign features a number of success stories showing that redesign with information technology can help higher education institutions save money and time, improve access, better leverage faculty and other resources, and improve the educational experience for students. Between 1999 and 2003, twenty of the thirty course redesign projects under NCAT demonstrated significant improvement in student performance and all of them saved money—a staggering 37% on average over traditional delivery. With the rising costs of post-secondary education and the troubled economy, it seems clear that course redesign that exploits educational technologies can make a huge difference in preparing learners to compete in the global workplace.

impact of technology

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Technology's promise and effectiveness are also evident in other large-scale implementations. For example, as the State Educational Technology Directors Association (SETDA) describes in a recent publication "Technology-Based Assessments Improve Teaching and Learning," many schools, districts, and even states are putting into place systems designed to link formative assessments to differentiated instruction. Some employ Learning Management Systems and similar technologies to accomplish this. In one example, the paper describes the Virginia Algebra Readiness Initiative (ARI), which employs a computer-adaptive test (CAT) that allows teachers to individualize intervention content for students in grades 6–9 who are at risk of failing the Algebra I end-of-course test.

> **"Teachers reported that the ARI helped determine the learning styles of the students and ultimately modified the teaching accordingly. Some students like formulas, while others relate to examples, scenarios, and hands-on activities."**

LONGITUDINAL DATA SYSTEMS and Student Information Systems

Longitudinal Data Systems and Student Information Systems are other examples of the large-scale application of technology in education with installations in entire schools, districts, and even states. These systems have gained traction in recent years as educators, policy makers, and parents recognize the need to be able to better understand and track student progress, especially when students move from district to district. The organization Data Quality Campaign, with many supporters, has been actively promoting the benefits of high quality data and longitudinal systems to improve student performance not just in the K12 environment, but from a K16 perspective too.

For example, quality data is needed to help understand how K12 performance may indicate college readiness and predict college performance. High school transcripts, and even ACT and SAT scores, are not sufficient predictors of success and do not carry sufficient information about the individual student's K12 experience, knowledge, skills, and learner characteristics. This information can be gathered throughout the K12 years, but usually it isn't. If it is, it may be lost due to a lack of connection between the K12 and post-secondary school systems. With enrollment in community colleges growing rapidly, this lack of information and connectivity is becoming an urgent concern, especially given the high cost of remediating unprepared college students, and the costs associated with a college drop out rate believed to be greater than 50%. Recently, it was announced that Illinois will begin tracking its schoolchildren as they progress from preschool through college. They will build the data system using a $9 million (pre- American Recovery and Reinvestment Act) grant from the U.S. Department of Education. This kind of development is likely to become much more common, with states even working together in consortia to mange the process more efficiently and cost-effectively.

Longitudinal Data Systems offer instructors the ability to view and interpret data on learner traits such as prior experience, knowledge, and learning style, and use that data to customize student experiences and their own instructional approaches. Some Learning Management Systems, which can work in sync with Longitudinal Data Systems and Student Information Systems, are also capable of delivering customized content automatically. The abilities of these systems, along with the other approaches and applications described above, represent key benefits afforded by well-designed and well-implemented technologies.

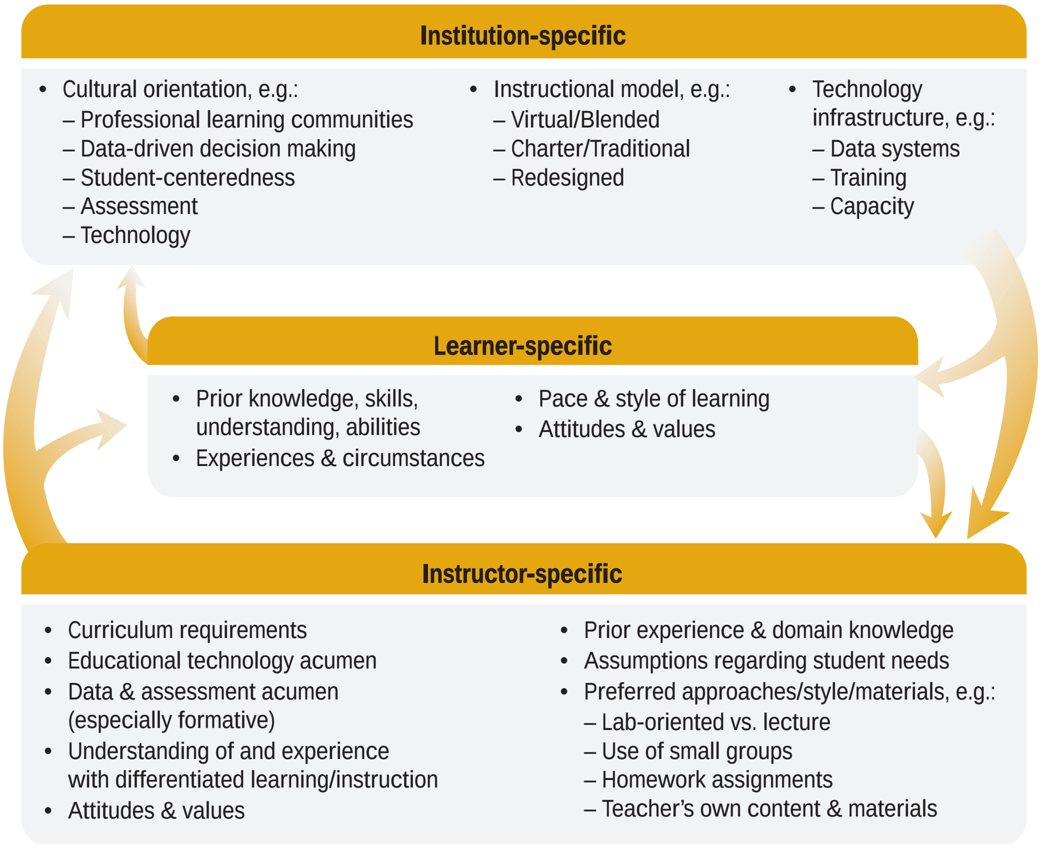
PERSONALIZED LEARNING EXPLAINED

The term Personalized Learning has been growing in use in recent years, but as yet there is no consensus on its meaning. As many of the previous examples of research and technology implementations imply, Personalized Learning has a focus on the individual learner and employs some mechanism of adaptation, with the goal of improving the educational experience, outcomes, or access.

But the means for achieving this varies greatly. In some cases, for example in the rollout of data systems and/or formative assessments within a district, the "personalized" impact on the student is a second- or even third-order effect. There are a number of interrelated dependencies that must be addressed, such as system installation and service support, teacher professional development, and the development of a culture of data-driven decision-making. This illustrates the complexity involved in the success of any educational implementation, and the need to view implementations systematically and within context.

WHAT TECHNOLOGY ADDS IS THE ability to consider multi-layer models with more variables than were possible in the past and to do this simultaneously for many more learners than an individual instructor can do.

Figure 2: Adaptive dimensions for personalized learning



The technologies and systems that can "personalize learning" tend to be adaptive along one or more Learner, Instructor, or Institutional specific dimensions shown in **Figure 2**. These adaptations are often interrelated and afford greater flexibility in the teaching and learning enterprise, supporting the following kinds of objectives:

- Providing access to education for those that cannot gain it through traditional means, or for whom another option is necessary or preferable, e.g., online credit recovery programs, virtual schooling, blended virtual and on-campus programs, education for prisoners and juvenile hall residents
- Delivering content and developing skills in ways that are more sensitive to the learner—and thus more effective for them—such as:
  - Providing pathways to content that are suited to the learner's style of learning, e.g., through the use of multi-media
  - Adapting the pace of instruction to a learner's capability, e.g., frequent formative assessment linked to adaptive content delivery, second language assistance
  - Providing flexibility of place and/or time, e.g., allowing learning off campus/at home
  - Increasing the relevance of the content to the learner's interests and goals
  - Delivering content in ways that increase interest, time-on-task, and perhaps critical thinking, e.g., games, project-based learning, etc.
  - Adapting the delivery of content based on the learner's prior knowledge and/or misconceptions, e.g., diagnostic testing and formative assessment

- Providing opportunities to personalize and socialize the experience through the development of unique social networks, peer learning and collaboration
- Allowing instructors to more fully customize instruction to individual students by adding, removing, or re-sequencing content in a program or course of instruction

- Fostering motivation and building self-direction skills among learners by providing frequent self-checks on progress and other meta-cognitive help
- Helping learners grow through the acquisition of new learning styles, as well as scaffolding using content adapted to their dominant learning styles

In traditional K12 and college classrooms, where there is typically a heterogeneous mix of students, there are many situations where students face unproductive time as the teacher addresses others' needs. Personalized learning, powered by technology along the dimensions described above allows for more productive time-on-task. This can greatly improve and accelerate learning for students and reduce boredom, a common complaint of students at all levels. Researchers have noted that boredom and frustration, and the factors that cause it—lack of relevance and unproductive time—while not the biggest drivers, can contribute to drop-out behavior among some students.[3]

Moreover, as demonstrated through NCAT's work in post-secondary course redesign, well-designed and implemented information technologies can also enhance productivity, saving time and scarce resources and increase access.

The concept of adapting to the learner is not new, and has probably occurred to some extent for much of human history. It is well documented in modern education and is not confined to learning with technology. The venerated educator and thought leader John Dewey, in his 1902 essay, "Child and Curriculum," eschewed the idea of a single type of curriculum scope and sequence; a common practice at the time that he felt was too inflexible. Lee & Park[4] define adaptive instruction as: "Any instructional approach or technique, technological or otherwise, designed to accommodate the varying needs and abilities of individual students."

They identify a number of adaptive instructional approaches that have been implemented over the years, including several developed a generation ago such as:

- Keller's Personalized System of Instruction (PSI)
- Program for Learning in Accordance with Needs (PLAN)
- Mastery Learning Systems (developed by Bloom and Associates)
- Individually Guided Education (IGE)
- Individually Prescribed Instructional System (IPI)

As further examples, educators today will probably have heard of Carol Tomlinson's approach to Differentiated Instruction and Howard Gardner's Theory of Multiple Intelligences.

What technology adds is the ability to consider multi-layer models with more variables than were possible in the past and to do this simultaneously for many more learners than an individual instructor can do. Essentially, technology enables institutions of K16 education to deliver a *mass individualized experience* to the learner (Park & Lee, 2006).

Figure 3 lists several technologies, applications, or implementations that will continue to power personalized learning in the 21st century. Depending on how they are utilized, some have the potential to completely transform the current paradigm while others can more incrementally deliver personalized value to educators, learners, and/or institutions. More technologies will emerge as the impetus for personalization is found not only within the educational system but also throughout society as a whole. For example, Esther Dyson[5] described the phenomenon of the "user in charge." The trend towards user-created content is well-rooted now in consumer media and in some parts of education as well.

There is a symbiotic relationship between technology and user control such that as technologies' capability to provide more choice and options grows, so will user demand for control. This is evident in the category of Web 2.0 applications that are exploding in number, inventiveness, and ease of use. The pace of this change is increasing by most accounts, even in education. According to a recent study by the Consortium for School Networking (CoSN) and the MacArthur Foundation, there is enthusiasm from educators and technology directors for the possibilities of Web 2.0, but most schools still ban social networking and chat rooms, and more than one third deny students and educators the ability to share visual media or music or play interactive games.[6] Some of this has to do with the struggle to manage their broadband capacity, but it is also about heightened fears regarding safety and appropriate use. However, there is a great deal of ongoing experimentation in K16 education around how these technologies can be put to use to enhance learning and personalize the experience for students. Additionally, the degree to which technology-based instructional programs are user controlled (such as allowing the learner to adjust various preferences) versus system controlled (such as allowing adaptations or flexibility only to the instructor or to the program itself via diagnostic/prescriptive mechanisms) is in flux as learners, especially adult learners, seek more control.

At conferences like the National Education Computing Conference (NECC), many sessions each year are devoted to educators sharing promising practices with educational technologies, including the new Web 2.0 applications. In California, the Association of Personalized Learning Schools and Services, APLUS+, is dedicated to charter schools built around Personalized Learning and claims 38 schools and 22,000 students in 2009.

Figure 3: Mechanisms for personalized learning in the 21st century

Technology	Purpose
Online adaptive assessment	More efficient formative and summative assessment that "learns" what students know and tailors content and/or assessment accordingly—often shortening assessment time
Online courses learning opportunities	Credit recovery, drop-out prevention, expanded access, extended
Open source/open learning	Broaden access, share content, provide free content, improve and create new content
Longitudinal data systems, learner models	Gather, house, and disseminate learner data for analyses, continuous improvement, and policy questions
Virtual schools, blended models	Broaden access, especially in instructor shortages, e.g., AP, foreign language, provide flexibility to learners as to "place" and "time"
District, state, and school portals	Share and manage content efficiently, foster communication and cooperation
Automated essay/writing tutors, speech recognition, speech-to-text conversion	Save time, increase opportunities for student writing, gain consistency over human scoring variation
1:1 Laptop programs	Content delivery, access to internet, inspire students to learn, build ICT skills
Integrated Learning Management Systems and Student Information Systems	Content and assessment delivery, data analysis, differentiated instruction, communication between home and school, sophisticated management of content, digital assets and knowledge of learners (characteristics, skills, achievement)
Handheld devices, including cell phones	Formative assessment, study and review, video, communication and sharing
Games/Serious Games	Knowledge and skills acquisition, collaboration, engagement
Web 2.0 applications including blogs, wikis, podcasting, video-podcasting, social networking, etc.	Collaboration, creating and sharing information and media assets, building community, learner engagement
Server virtualization, cloud computing, fiber optic broadband networks	Add to district/school capacity, reduce costs, maximize and manage digital traffic
Semantic search	More productive search and access to content, based on specifications, ontologies and taxonomies that more accurately describe the relationships between content pieces
SIF, IMS, and other interoperability standards	Enable smooth interoperability between systems, ease of use, and reduce development and implementation costs

There is little question that learners, especially young learners, gravitate to technologies. In a 2008 MacArthur Foundation study of teen behavior online, researchers conducted interviews, focus groups, diary studies, and 5,000 hours of observation of teen participation in networked communities.[7] The study found that through always-on networks and online relationships, "youth engage in peer-based, self-directed learning online," and that they are "often more motivated to learn from peers than from adults." The study suggests that "to stay relevant in the 21st century, education institutions need to keep pace with the rapid changes introduced by digital media."

As broadband capacity grows in communities and schools across the nation, and as students and instructors encounter personalized technology in other aspects of their lives, we can expect there will be greater and greater demand for technologies that personalize education. Our challenges will be to shape technologies to the needs of education, ensure greater relevance, more productive time-on-task, better access to resources, and more success for our learners in the 21st century.

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1 From "Harnessing Innovation to Support Student Success: Using Technology to Personalize Education." U.S. Department of Education, October 2008.

2 The sample frame for the two studies was not identical so these data should not be considered as representing growth over time.

3 From "The Graduation Rate Crisis We Know and What Can Be Done About It," Education Week Commentary, July 12, 2006 By Robert Balfanz and Nettie Legters Balfanz, et al, Johns Hopkins University.

4 Lee, J. and Park, O. (2008). Adaptive Instructional Systems. Chapter 37 in *Handbook of Research on Educational Communications and Technology*, Third Edition. Ed. J. Michael Spector, M. David Merrill, Jeroen van Merrienboer, Marcy P. Driscoll. Bloomington: AECT.

5 Esther Dyson, Release 1.0.

6 Leadership for Web 2.0 in Education: Promise and Reality, 2009.

7 The John D. and Catherine T. MacArthur Foundation Reports on Digital Media and Learning, November 2008.