

The second educational revolution: rethinking education in the age of technology

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Abstract

This paper drew upon a recent book (*Rethinking Education in the Age of Technology*) to summarize a number of prospects and challenges arising from the appropriation of digital technology into learning and educational practice. Tensions between traditional models of schooling and the affordances of digital media were noted, while the promise of these technologies for shaping a new system of education was reviewed. It was argued that new technology brings radical opportunities but also significant challenges. The urgency of seeking a coherent model for the future of education in a technological age was stressed.

Keywords

computers and education, educational technology, future of education, history of education, life long learning, schools and technology.

The world of education is currently undergoing a second revolution. Digital technologies such as computers, mobile devices, digital media creation and distribution tools, video games and social networking sites are transforming how we think about schooling and learning. All around us, people are learning with the aid of new technologies: people of all ages are playing complex video games; workers are interacting with simulations that put them in challenging situations; students are taking courses at online high schools and colleges; and adults are engaging in social networks and online learning environments to manage their professional lives. New technologies create learning opportunities that challenge the traditional practices of schools and colleges. These new learning niches enable people of all ages to pursue learning on their own terms. People around the world are taking their education out of school and into homes, libraries, Internet cafes and workplaces where they can decide what they want to learn, when they want to learn and how they want to learn.

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School systems organized around age-grading, traditional curricular sequencing, accepted professional accreditation and long-standing funding models have struggled in adapting to new, learner-directed technologies. We often think that our current educational institutions have always been here, and have always struggled to adapt to change. However, the genesis of our current schooling system occurred in response to a similar technological and economic tumult – the industrial revolution. Our current model of schooling grew out of the technologies and social practices of the industrial revolution.

The rise of the public schools moved from an apprenticeship era to a world of nearly universal schooling that came to identify learning with schooling. The current technology revolution differs from the industrial revolution in one important way. While the industrial revolution gave rise to a universal schooling system where none had previously existed, the information technology revolution presses a very real, active system to reconsider its fundamental practices. Our paper highlights some of the challenges involved when a technology movement seeks to redefine learning in the face of a vibrant, pre-existing institutional structure.

Who will ultimately benefit from this contest between the new technologies and schooling? We think schools have served the world very well. We greatly admire the teachers who have dedicated themselves to help children from different backgrounds to learn and thrive in a changing world. Schools have made invaluable contributions to the world's development and we think they will continue to do so well into the future. However, we think educators and policymakers need to rethink the relation between education and schooling. Education is a lifelong enterprise, while schooling for most encompasses only the ages from five to 18 or 21 years. Even when students are in school, much of their education happens outside of school.

We all know that technology has transformed our larger society. It has become central to people's reading, writing, calculating and thinking, which are the major concerns of schooling. The consumer market for new technologies has exploded as companies explore how to create and sell the next generation of products to consumers who are looking for an edge up in the race for success. This means that technological products and services for learning are popping up all over the educational landscape and also that schools are being left out of the big picture. The longer schools stay out of the technology discussion, the more that education, traditionally viewed as a public good with equal access for all, will be up for sale to those who can afford access to specialized services.

The central challenge is whether our current schools will be able to adapt and incorporate the new power of technology-driven learning for the next generation of public schooling. If schools cannot successfully integrate new technologies into what it means to be a school, then the long identification of schooling with education, developed over the past 150 years, will dissolve into a world where wealthier students pursue their learning outside of the public school.

Incompatibilities between schooling and information technologies

The opposition between schooling and information technologies is a development of the recent history of schooling as an institution. The growth of a late 19th and early 20th century system of universal schooling was sparked by new information technologies such as textbooks (Kliebard 1989), bureaucratic information

systems (Callahan 1962) and assessments (Lagemann 2002). However, as the current 'one best system' (Tyack 1974) began to take shape, it became less tolerant of fundamental changes to core practices. Information technologies pose direct challenges to how schooling operationalizes learning. These challenges illustrate the deep incompatibilities between schooling and the new technologies.

Uniform learning vs. customization

Deeply ingrained in the structure of schooling is a mass production notion of uniform learning. Age-grading and common assessments, for example, emphasize the belief that everyone should learn the same things at the same time. However, one of the great advantages of information technology is customization. Computers can respond to the particular interests and difficulties that learners have and provide content on any topic of interest.

Teacher as expert vs. diverse knowledge sources

Schooling is built on the notion that knowledge is fixed and that the work of the teacher is to present what is known to students. Teachers serve as experts whose job is to pass on their expertise to students. Hence, most teachers do not like to see their authority challenged by students who find contradictory information or who ask questions beyond their expertise. In contrast, information technologies provide access to many different sources of expertise. It is easy to find activities, such as web communities or online discussion forums, where students themselves can serve as experts or can develop knowledge to challenge prevailing views. Schools have found it difficult to similarly decouple expertise from authority.

Standardized assessment vs. specialization

The assessment technology employed in evaluating student knowledge uses multiple-choice and short-answer items in order to provide objective scoring. Recent education policy initiatives, such as the No Child Left Behind Act (2002) in the US, have only increased school reliance on common assessment instruments. However, this form of testing requires that every student learn the same things. Information tech-

nologies emphasize different approaches to assessment. For example, video games and simulations provide excellent examples of how performance-based assessments can be integrated into learning environments. Similarly, reputation measures in participation forums (such as the product reviews at Amazon.com, or the advice forums at Yahoo.com) provide a community approach to assessing knowledge. Whereas information technologies press us to think of new approaches to authentic assessment, standards-based reforms in schools have instead sought to reinforce a single, traditional path towards measuring what students know.

Knowledge in the head vs. reliance on outside resources

There is a deep belief among teachers and parents that to truly learn something, it is critical to internalize it without any reliance on outside resources. Therefore, on tests, students are usually not allowed to use books or calculators, much less computers or the web. The opposite is true of the information technology world, where the measure of knowledge is more about how and where to find relevant knowledge. In the workplace, you are often judged on how well you can mobilize resources to accomplish some tasks. Information technologies, such as social networking, Google or mobile GPS tools, provide a living example of how cognition is distributed across people and networks.

Coverage vs. the knowledge explosion

Schools have long been interested in conveying all the important knowledge people might need for the rest of their lives. When schooling equals learning, then schools must regularly review what they include and exclude from the curriculum. As knowledge has grown exponentially, the coverage-based response of schools has resulted in fatter textbooks and longer years in school. The trade-off between coverage and relevance has resulted in curricula that are ‘a mile wide and an inch deep’. The Internet, for example, has permanently redefined the relation between learners and knowledge. Information technologies have made the criterion of ‘what is worth knowing’ increasingly difficult to uphold in recent years. Being able to discern which questions are worth asking, for example, take on a new meaning for which schools currently do not provide adequate

preparation. People need to learn how to ask good questions in order to find the information and resources they need.

Learning by absorption vs. learning by doing

Deeply embedded in the culture of schooling is the notion that students should learn a large body of facts, concepts, procedures, theories, and works of art and science that have accumulated over time. Schooling has its roots in ancient traditions of teaching in which knowledge was a scarce and sacred resource. Readily accessible public libraries and museums opened the door to a new conception of learning as exploration. However, information technologies have pushed us to a radical, learner-oriented understanding of knowledge acquisition. Information technologies foster a more hands-on, activity-based education. Computers are highly interactive and provide a variety of tools to accomplish meaningful tasks. Hence, they are more aligned with the ‘learning by doing’ view of education, than with the ‘absorption of cultural knowledge’ view of education that permeates schooling.

Schools have integrated the state-of-the-art information technology practices of their genesis into a robust universal system of education. However, the new technology revolution has called these practices into question. Schools foster just-in-case learning; information technologies foster just-in-time learning. It is no wonder why many schools are uncomfortable with new technologies, just as these technologies are becoming central to all walks of life outside schools. Thus, schools are in a precarious position. Continuing to commit to the technologies of bureaucracy, assessment and print literacies may mean that school will become less important as a venue for education. Proponents of the information technologies are at work to develop new approaches to learning outside the traditional purview of schooling. We see the seeds of a new system emerging in the burgeoning movements towards home schooling, workplace learning, distance education, learning centres, adult education and lifelong learning in general.

The seeds of a new system of education

We do not suggest that schools will disappear anytime soon. Schools were prevalent in the era of apprenticeship, and they will be prevalent in whatever system of

education that comes into being. However, as the seeds of a new system emerge, we will continue to see that education will occur in many different, more adaptive venues. This may mean that schools will have a narrower role in learning and that we will be forced to redefine the identification of schooling with learning.

Home schooling has been booming in the US over the last 30 years. Based on a survey in 2003, the US Department of Education (National Center for Education Statistics 2006) estimated there were 1.1 million children being home-schooled and that the number had increased by 29% in four years. The survey also found that 21% of the families engaged in home schooling hired a tutor and 41% used distance learning. The availability of online content and social networks has fuelled this growth. As more curricula are developed for computers, they are likely to take over more of the content burden, leaving parents to act as facilitators. Social networks link parents to groups of other home schoolers for the social aspects of schooling and to collaborative spaces where parents and children can share the home schooling problems and experiences. Home schooling remains a controversial option. It may indeed lead children and parents to take more responsibility for their education, but at the same time, their exclusion from public education means that children will have limited exposure to diverse content, values and most of all, people.

Workplace learning has been rapidly expanding over the last 30 years as companies have realized that they need to educate their workers to handle complex equipment and solve novel problems. Motorola, for example, has developed programmes to teach statistical analysis and other complex skills, and even basic reading and computing when needed (Wiggenhorn 1990). The consulting firm Accenture has been developing courses and simulation programmes where employees perform the kinds of tasks they will encounter in the field (Nowakowski 1994). Xerox has developed an online system that contains stories of difficult problems to diagnose that tech reps have compiled (Brown & Duguid 2000). Other efforts, such as LinkedIn.com, provide independent opportunities for workers to build social network connections for professional interaction and research. More and more of workplace education is addressing complex skills and access to networks needed for learning to learn.

Distance education over the Internet is exploding at the collegiate level, and growing at the K-12 level as

well. The Open University in Britain was one of the first distance education efforts to become widely successful. It currently has about 180 000 students and was rated the top university in England and Wales for student satisfaction in the 2005 and 2006 UK Government National Student Satisfaction Survey (Wikipedia 2009). The University of Phoenix is the most successful online university in America. It has over 100 000 students altogether, including over 30 000 online students (Maeroff 2003). As busy people realize they need more education, they increasingly opt to take distance education courses. Many states and districts are also experimenting with virtual high school programmes, where teachers at different schools in the system offer online courses to students at other high schools in the state. Utah, with 35 000 online students, and Florida, with 21 000 online students, are farthest along on this path. Some virtual high schools are organized as charter schools that enrol students from across the state. Although distance education has a head start in adult education, the development of virtual K-12 schools provides challenges for bricks and mortar public schools.

Adult education is growing, with more adults taking courses in the evening at adult education centres and older people returning to get graduate or undergraduate degrees. Many people now go onto the Web to learn about particular topics they are interested in, such as how to invest in stocks. Adults often go on vacations with an educational purpose, such as a retreat to discuss books or a trip with an expert providing guidance. Adult education is one of the major growth industries. While much of the learning that goes on is recreational, it still provides valuable knowledge that sometimes may lead to a second career or the pursuit of a long-term interest. Perhaps it will turn out that some of our most productive citizens are older people, who use their free time to keep learning.

Learning centres run by Kaplan, Sylvan and other companies have risen, where people can go to learn the particular skills and knowledge they need. They most commonly serve to prepare students for national tests, such as the Scholastic Aptitude Test (SAT) in the US, and to tutor children who are having problems in school. The No Child Left Behind Act (2002) called for K-12 districts to provide tutoring for students in failing schools, which has also contributed to the growth of the learning centre industry. In the 1990s, the US Department of Education launched an initiative to support non-

profit community technology centres to serve communities, where access to computers and other technologies is limited. There are now over 1000 centres in different locales, such as housing projects, storefronts, community organizations and libraries. In time, learning centres might evolve as an alternative to school at the high school level and beyond, where teenagers and adults can go to study particular subjects of use to them.

Computer games have proliferated with the advent of home computers. The *Sims* series, such as *SimCity* and the *Sims*, have introduced generations of students and adults to complex system simulation-based game environments. In the best selling game *Civilization*, players have the opportunity to relive the development of global social and economic history. Players must plan, choose to negotiate or fight, acquire and allocate resources, and make decisions to advance their civilization. There are also many computer-learning environments for younger children as well, such as handheld games, interactive books, and kid's websites. As the early online multi-user virtual environments proliferated, people from all over the world began to converse or explore places that others have created for them. Today's graphically enhanced massively multiplayer online games have led to an explosion of participation in virtual worlds. Gaming may help young people learn a variety of leadership skills, such as resource allocation, negotiating with friends and adversaries, manipulating situations and environments, actively pursuing their goals and recovering from failures. As John Seely Brown and Douglas Thomas have suggested, the gamers of today may become the leaders of tomorrow (Brown & Thomas 2006).

Web communities have arisen to support every possible interest people may have. Often, young people are joining these web communities in order to pick up skills and knowledge that might enable them to pursue particular interests. For example, Michele Knobel (2008) describes a teen whose passion was Japanese animé. This led him to participate actively in the AniméMusicVideo.org web community where he learned remixing skills from fellow members. The community liked one of his works enough that he put it up on YouTube as the 'Konoha Memory Book'. Similarly, Brigid Barron (2006) describes a middle school girl who became interested in digital art. She joined the web community xanga.com where she

studied the techniques and the source code of the digital artists on the site. By their active participation in web communities, these young people are gaining skills and knowledge that may be very useful to them in later life.

Technical certifications raise questions about how we determine the adequacy of the knowledge gained apart from formal schooling experience. Until recently, schools and colleges had a monopoly on the certification business. The growing use of the general educational development test in the US as an alternative to the high school diploma has begun to cut into the high school monopoly on certification. In recent years, a host of companies, such as Microsoft and Cisco, as well as technical societies, have developed exams that certify that a person has a particular level of skill in some occupational niche, such as creating web pages or maintaining computer networks. Because the certifications are more specific than diplomas, they are more meaningful to potential employers.

Internet cafes are springing up all over the world, where people can go and log on to the Web for a small fee. These are perhaps the libraries of the future. They particularly attract young people who spend hours on the Web, engaging in conversations and games, reading about what is happening in the world, learning how to program, or exploring different sites that relate to their interests. In much of the world, schools have been resource-poor. The opening of the Internet to the world gives people who have been deprived of an education a way to compensate, if they have the initiative.

The cumulative effect of these innovations is to extend learning throughout life and over many venues. With time, these pieces might come to make up the fragments of a new system of education, in which schools have a less central role, as in the apprenticeship era. However, for now, these elements have developed independently of one another. They do not yet form a coherent system of education. This is where the need for visionaries is most apparent. It will take energetic visionaries to do the kind of work Horace Mann and his colleagues did during the first educational revolution – which is to figure out how to build an equitable and coherent system from these emerging pieces.

A comparison of the three eras of education

One way to consider the present state of schools is to contrast where we are with where we have been and

where we are going. We are now entering the lifelong learning era of education, having experienced the apprenticeship and schooling eras. These three eras differ in many aspects. In some ways, the lifelong learning era reflects a return to some of the core features of the earlier apprenticeship era.

Responsibility: from the parents to the state to the individual and parents

With the Industrial Revolution, the state took over responsibility for educating children from their parents. There was a concern about immigrant children learning American values and language. In the present era, responsibility for education is moving away from the state to the parents for younger children and the individual among teenagers and adults.

Content: from practical skills to basic skills and disciplinary knowledge to generic skills and learning to learn

The content of education before the Industrial Revolution focused on the skills and crafts of their parents and relatives, which children would need as adults. After the Industrial Revolution, schools stressed the learning of basic skills that children would need to function as intelligent citizens and workers and on the knowledge in the different disciplines. With the digital revolution, the focus is more on generic skills, such as problem solving and communication in different media, and on finding resources and learning from them.

Pedagogy: from apprenticeship to didacticism to interaction

The pedagogy of apprenticeship involves observation, coaching and practice. The adult shows how to do things and then watches while the learner tries, fading support as the learner gains experience. The pedagogy of school involves lecturing children, having them read texts and practise doing tasks, and testing to see if they have learned what was taught. The pedagogy of the current era is evolving towards reliance on interaction. Sometimes this involves interacting with a rich technological environment such as a computer tutor or a game on the web and sometimes with other people by means of a computer network.

Assessment: from observation to testing to embedded assessment

In the apprenticeship era, the master observed learners and corrected them as they went along, giving them tasks they were ready for and seeing if they completed them successfully. In the schooling era, testing emerged as the means to see if learners had acquired the skills and knowledge taught, before passing learners on to the next level. In the lifelong-learning era, assessment usually occurs as the learner progresses through a computer-learning environment in order to provide support to carry out the tasks and determine whether the learner has accomplished the goals. This looks more similar to the assessment in the apprenticeship era than the testing in school.

Location: centred in the home vs. centred in the school vs. centred in multiple venues

In the apprenticeship era, most work was composed of household and domestic industries. Children usually learned to carry out adult tasks from parents or relatives. With the Industrial Revolution, children were gathered in schools to keep them off the streets and prepare them for industrial life. Schools are not very amenable to the customized education that is now sought, and so, education is moving into many different venues, such as homes, workplaces and learning centres, where learning materials can be accessed from computers and the web.

Culture: from adult culture to peer culture to mixed-age culture

Before the Industrial Revolution, children learned from the adults who were working around them. Peer culture arose with schooling and in many ways, adopted attitudes and beliefs that were opposed to learning. As learning moves out of a school setting, peer culture may weaken and there will be settings where children are working on tasks with their parents, other adults, peers and often in isolation from other people in a computer environment.

Relationships: from personal bonds to authority figures to computer-mediated interaction

In the apprenticeship era, children learned from adults they grew up around. With the advent of universal

schooling they were learning from adults they did not know well and who did not understand their personal needs and abilities. As we move towards computer environments, learners will be interacting with systems that are responsive to what they do but that have little understanding of them as individuals. However, at the same time, the systems will deal with them in a non-critical, impartial manner.

Perhaps the most striking change from the apprenticeship era to the schooling era was the state's assumption of responsibility for educating children. In the current era, people interested in getting ahead are taking back responsibility from the state. However, at the same time, what will happen to learners who are unable to take advantage of the technologies that are transforming learning?

What may be lost and what may be gained

Since we are in the midst of a technological revolution, it is difficult to estimate the effects that it will have on schooling and learning. However, it is safe to say that the revolution in education will be felt all across modern society. As with any revolution, there are will be both gains and losses. Pessimists predict that people will become increasingly subservient to their technologies and will lose more and more control as technology comes to dominate their lives. Optimists foresee a golden age of learning opening before us, where people will be able to use technologies to find new solutions for the educational and economic problems of our society. We do not envision a future that is either bleak or idyllic but where elements of both are present. Here, we describe the potential losses and potential gains to help us think about major concerns.

Equity

Schools have been the means by which many immigrants have gained access to the mainstream culture and economic status. Despite widespread tracking and segregation, the public schools have acquired widespread acceptance as the institution that can foster social and economic equity. Technological approaches to learning have begun to draw human and material capital away from our commitment to public schooling. Parents who want to give their children a good education avail themselves of options such as home schooling, private

schools, and learning centres. If this withdrawal of resources causes the education world to fragment, it may begin to relinquish responsibility for universal access to high-quality student education. In this world, the lives of the economically disempowered are likely to suffer the most, and public schools may become little more than the institutions of last resort.

Citizenship and social cohesion

Thomas Jefferson and Horace Mann felt that education should prepare people to be good citizens and assimilate them to a common culture. Jefferson thought that the people need education in order to make wise policy decisions. Mann was committed to common education as a path for developing social cohesion in an immigrant nation. Both goals may be lost as parents and individuals take over responsibility for learning from schools. Moving beyond a shared commitment to public education may increase the capacity for interest groups to break off pieces of the system to serve more narrowly defined educational goals. The home schooling and charter school movements, for example, will continue to accelerate the ability of interest groups to customize educational opportunities. Further fragmentation by interest groups may put the collective commitment to a school system that safeguards citizenship and social cohesion at risk. A key consequence of this erosion of commitment will be that people may have fewer opportunities to learn about people from other backgrounds and cultures. Technology-driven customization pushes us further into separate 'cultural zones' (Brooks 2004) where similar-minded people cluster together. This move towards self-segregation can reinforce local prejudices and make the goals for which Jefferson and Mann worked more distant.

Commercialization

Education has long been seen as a path to economic advancement. In recent years, however, the expectations of the education system have come to focus more on education as the engine for international economic growth and competitiveness. Perception of economic crisis is reflected in the growing disparity in income between college-educated and non-college-educated people (Murnane & Levy 1996). Hence, parents feel pressured to buy their children technology-based edu-

tional services, such as educational videos and games, computer-based resources, private schooling and specialized tutoring, so that their children will have an advantage. The gap between the ability of the haves and have-nots to participate in these new markets will exacerbate the educational inequalities that the public schools have tried to mitigate.

Broader horizons

When people select their own education goals, they pick things that interest them or that are career-oriented. The emphasis on interest-driven educational products, services and goals can privilege vocational and professional career paths, such as business, engineering and education, at the expense of traditional arts and humanities studies. However, a major goal of education is to expand people's horizons. Hence, there is the problem of parents steering children along narrow vocation-driven paths. This means that children may not be exposed to different views on issues and become more parochial in their ideas.

More engagement

One potential gain is that education will be directed towards what people want to learn and hence, more engaging. For example, parents who school their children at home usually encourage them to pursue topics they are interested in. Furthermore, in distance and adult education, people choose courses they think will help their careers or that reflect their interests, and when people purchase educational videos, games, or simulations, they choose things that are fun or exciting to them. So they are much more likely to be engaged in learning than school children.

Customization

Information technologies allow for the customization of learning environments to the needs of learners. Computer learning environments can facilitate creative expression, and can provide hints and support to students when they need help. Hence, computer environments can adapt to the level of the student's ability and can provide the kinds of individualized learning environments that allow all students to succeed.

Less competition

Because schools expect common learning outcomes for all, a sense of failure overwhelms many students who cannot reach grade level expectations. Many students cope by turning their energies to other activities, such as sports, music, video games or other social activities. A perception of failure often leads students to try as little as possible in schools. Information technologies allow students to cultivate and pursue their own learning goals. Facilitating intrinsic motivation may help students to access successful learning opportunities, and may surmount the sense of failure that comes when everyone is supposed to learn the same thing at the same time.

More responsibility

Parents who school their children at home try to instil a sense of responsibility in the children themselves. However, it is not just home schooling that fosters responsibility among learners. If people are learning at work or at home using distance education, they are forced to take responsibility for their own learning. When the state took over responsibility for education, families and individuals ceded most of the responsibility to the schools. Many school children seem to defy the schools to teach them anything. However, people are not going to learn much unless they take responsibility for their own learning.

Transformed peer culture

Another potential benefit is the redistribution of the effects of peer culture. Successful students often belong to peer cultures that support school learning goals. However, oppositional peer cultures emerge when students collectively feel incapable of success in school environments. These oppositional cultures typically devalue school learning and make it difficult for students to associate learning with desirable life outcomes. Information technologies, particularly web communities, create spaces for students to participate in interest-based affinity groups. These groups can provide opportunities for students to develop peer groups that reorient peer cultures around legitimate learning goals.

Rethinking education

Our current learning systems are in flux. We will make the policy and practical decisions in the upcoming years that determine the degree to which our schools will embrace the potential of information technologies. To be effective in changing the education environment requires that the builders of the new education system understand the imperatives of the technologies driving the changes in education. The seeds we described contain elements that may merge into a new system. This is the time we need another Horace Mann to provide the vision for an educational system that can integrate all the different elements that are developing. These elements do not form a coherent system, and few people know how to avail themselves of the opportunities that are out there.

Society should not assume that the only way to improve education is to improve the schools. There are other questions we need to consider, such as: how can we develop games to teach Mathematical reasoning? How can we make learning technology available to more people? What tools can support people learning on their own? What kinds of computer-based learning environments support the learning of 21st century skills? What role will social networking play in professional learning? These are all questions about improving education outside of schools.

A possible education reform is to develop national certifications that can be administered on a computer or by assessors at any school or learning centre. These certifications would be much more narrowly focused than a high school diploma. People would apply for as many as they like and can sit for them whenever they are ready. Certifications could be developed in three areas: academic skills, generic skills and technical skills. In the academic area, English competency might be assessed at the 3rd grade, 6th grade, 9th grade and 12th grade levels of reading and writing. If people wanted to take courses to prepare for the exams, they could, or if they wanted to study on their own, they could.

Certifications could trace a new path for rethinking high schools. For example, teens might follow a number of different paths. They might attend school, work, study at home to take certification exams or participate in some kind of youth organization. If they want to go to college, they might try to get all the certifications they need for college as soon as possible, and go off to

college at age 15 or 16. Others might work for a while and come back to school to prepare for college. People could take courses whenever they are ready, at whatever age, paid for by the state. This would produce a mixed-age population in high school and college courses, filled with people who chose to be there.

At the K-12 level, technology will continue to change what is important to learn in a variety of ways. There are new literacies that are becoming important, such as creating videos, animations and websites. Computers can carry out all the algorithms taught through graduate school, and yet, Mathematical reasoning is more important than ever. Teaching students to solve sophisticated problems with computers will be much more important than training them to execute algorithms that computers can do for them. Memorizing information is becoming less important with the Web available, but people do need to learn how to find information, recognize when they need more information and evaluate what they find.

At the post-secondary and professional learning level, many people will be training for multiple careers. They will need to develop skills that facilitate going back and forth between learning and work. Ongoing professional learning could lead to a new class of personal counselling networks to guide people to new learning opportunities. If they leave work, these counselling networks could provide advice on other vocational opportunities. People will be going back and forth between learning and work throughout their lives and ideally they should be able to consult the same counselors as they make these transitions.

We argue that parents, citizens and policymakers need to continue to push for a more expansive view of education reform. We already have a vibrant, highly charged discussion about the goals of education. Now, however, we need to push the discourse into addressing how new technologies can help us reshape these institutions that we have come to rely upon. We need our school leaders and teachers to understand how learning technologies work and how they change the basic interactions of teachers and learners. Our technology leaders need to work together with educators, not as missionaries bearing magical gifts, but as collaborators in creating new opportunities to learn. It will take a concerted effort to bring about such a radical change in thinking. If a broader view develops in society, leaders will emerge who can bring about the political changes necessary to

remake our schools in light of the new technological revolution.

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