RETHINKING EDUCATION IN THE AGE OF TECHNOLOGY:
THE DIGITAL REVOLUTION AND THE SCHOOLS[1]

By

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The world of education is currently undergoing a massive transformation as a result of the digital revolution. This transformation is similar to the transition from apprenticeship to universal schooling that occurred in the 19th century as a result of the industrial revolution. In the apprenticeship era, most of what people learned occurred outside of school. Universal schooling led people to identify learning with school, but now the identification of the two is unraveling.

All around us people are learning with the aid of new technologies: children 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 consulting Wikipedia. New technologies create learning opportunities that challenge traditional 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 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.

Who will benefit ultimately from this revolution? In America there is a commercial push to sell educational products to consumers who are looking for an edge up in the race for success. This means that technological products and services are popping up all over the American landscape. Education, once viewed as a public good with equal access for all, is now up for sale to those who can afford specialized services and computer programs.

We think schools have served America and the world very well. We greatly admire the teachers who have dedicated themselves to helping 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 it is time that educators and policy makers start to rethink education apart from schooling. Education is a lifelong enterprise, while schooling for most encompasses only ages five to 18 or 21. Even when students are in school, much of their education happens

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[1] This article summarizes arguments in the forthcoming publication: Collins, A. & Halverson, R. (2009). *Rethinking Education in the Age of Technology: The Digital Revolution and the Schools*. New York: Teachers College Press.

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. And yet technology has been kept in the periphery of schools, used for the most part only in specialized courses.

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 Technology

There are 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. This belief stipulates that everyone should learn the same things at the same time. But one of the great advantages of 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 the teacher is an expert, whose job is to pass on their expertise to students. Teachers do not like to see their authority challenged by students who find contradictory information or who ask questions beyond the teacher's expertise. In contrast, video and computers provide many different sources of expertise. Often teachers feel threatened by these views because they undermine their authority.

- *Standardized assessment vs. Specialization.* The assessment technology employed in evaluating students uses multiple-choice and short answer items, in order to provide objective scoring. But this form of testing requires that every student learn the same things. To the degree technology encourages students to go in their own direction, it is in direct conflict with the standardized assessments pervading schools.

- *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 adult life, where technology supports people's use of outside resources. In the workplace you are often judged on how well you can mobilize resources to accomplish some task.

- *Coverage vs. The knowledge explosion.* School pursues the goal of covering all the important knowledge people might need in the rest of their life. As knowledge has grown exponentially, textbooks have grown fatter and fatter. It has become difficult to cover all the important material, and so curricula have become 'a mile wide and an inch deep.' Given the explosion of knowledge, people cannot learn in school all they will need to know in later life. So they need to learn how to learn and how to find the information and resources they need.

- *Learning by acquisition 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. In contrast, technology fosters 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 "acquisition of cultural knowledge" view of education that permeates schooling.

By way of summary, school fosters just-in-case learning while technology fosters just-in-time learning. There are many reasons why schools are uncomfortable with new technology. But technology is becoming central to all of life. We think this means that school will become less important as a venue for education. We already see the seeds of a new system emerging in the burgeoning movements toward home schooling, workplace learning, distance education, learning centers, adult education, and lifelong learning generally.

The Seeds of a New System of Education

Schools will not 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. But as the seeds of a new system begin to emerge, education will occur in many different, more adaptive, venues and schools will have a narrower role in learning.

Home schooling has been booming in America over the last 30 years. Based on a survey in 2003 the US Department of Education 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. As more curriculum materials are developed for computers, they can take over more of the content burden leaving parents to act as facilitators. There are upsides and downsides to the spread of home schooling. It may indeed lead children and parents to take more responsibility for their education, but at the same time it means that children will not be learning common content and values.

Workplace learning has been rapidly expanding over the last 30 years as companies have realized they need to educate their workers to handle complex equipment and solve novel problems. Motorola has been teaching statistical analysis and other complex skills, and even basic reading and computing when needed. The consulting firm *Accenture* has been developing courses and simulation programs where employees perform the kinds of tasks they will encounter in the field. Xerox has developed an online system containing stories of difficult problems to diagnose that *tech reps* have compiled. More and more of workplace education is addressing complex skills and learning to learn. Workers may spend their whole lives learning in order to survive in a changing workplace.

Distance education over the Internet is exploding at the collegiate level. 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. 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 programs, 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 enroll students from across the state. Although

distance education has a head start in adult education, the development of virtual K-12 schools provide challenges for brick and mortar public schools.

Adult education is growing with more adults taking courses in the evening at adult education centers, 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 in America. 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 centers run by Kaplan, Sylvan, and others have arisen, where people can go to learn particular skills and knowledge they need. They most commonly serve to prepare students for national tests, such as the SAT or ACT, and to tutor children who are having problems in school. In the 1990s the U.S. Department of Education launched an initiative to support non-profit community technology centers to serve communities, where access to computers and other technologies is limited. There are now over 1000 centers in different locales, such as housing projects, storefronts, community organizations, and libraries. Most of the participants are minorities, who go to learn job skills, take classes at the centers, and use the Internet facilities. In time learning centers might evolve as an alternative to school at the high school level and beyond. Teenagers and adults might go to the centers to study particular subjects of use to them.

Educational television and videos for children have spread widely since the start of Children's Television Workshop in the late 1960s. The impact of television on learning has been greatly expanded by two developments: 1) the growth of the public television network (PBS) and 2) the advent of cable television. At the same time there has been a proliferation of videos for kids that emphasize learning, which many toddlers watch over and over. Videos and television for young children provide an access to education that is an entirely new phenomenon. And so much have been produced in the last thirty years, that most kids are getting a head start on their school education.

Computer-based learning environments have proliferated with the advent of home computers. The most famous of these are the Sim series, such as SimCity and the Sims. 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 interactive books and kid's websites. Online Multi-User Virtual Environments (MUVEs) have proliferated, where people from all over the world can converse or explore places that others have created for them. The next generation of MUVEs are graphic-enhanced Massively Multi-Player On-Line Games (MMOGs) that have led to an explosion of participation in virtual worlds. Gaming may help kids 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 has suggested, the gamers of today may become the leaders of tomorrow.

Technical certifications are a new phenomenon. Until recently schools and colleges had a monopoly on the certification business. The growing use of the GED 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 comprise the fragments of a new system of education in which schools have a less central role, as in the apprenticeship era. But for now, these elements have developed independently of one another. They do not in any sense form a coherent system of education. That is where the need for visionaries is most apparent. It will take energetic visionaries to do the kind of work Horace Mann did during the first educational revolution -- that is to figure out how to build an equitable and coherent system from these emerging pieces.

A Comparison of the Three Eras of Education

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 elements 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 learning basic skills 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 to children, having them read

texts and practice doing tasks, and testing to see if they have learned what was taught. The pedagogy of the current era is evolving toward 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 like the assessment in the apprenticeship era than the testing in school.

- *Location: Centered in the home vs. centered in the school vs. centered in multiple venues.* In the apprenticeship era most work was comprised of household and domestic industries. Children learned to read at home and 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 centers, 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 toward computer environments, learners will be interacting with systems that are responsive to what they do, but that have no understanding of them as individuals. But 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. But 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

The revolution in education will alter not just the lives of students, but the entirety of modern society. As with any revolution, there are will be both gains and losses. Pessimists see

people becoming subservient to their technologies and being left behind as technology comes to dominate our lives. Optimists see a golden age of learning opening before us, where people will be able to find resources to pursue any education they may want. We don't envision a future that is either bleak or idyllic, but where elements of both are present. We first want to raise our major concerns:

- *Equity.* Schools have been the means by which many immigrants and minorities gained access to the mainstream. Despite widespread tracking and segregation, the public schools are the institution that fosters equity more than any other institution. If education fractionates and the states relinquish responsibility for giving students an education, then poor children are likely to suffer. Public schools may become dumping grounds for poor and uninterested students, while parents who want to give their children a good education avail themselves of home schooling, private schools, and learning centers.

- *Citizenship and Social cohesion.* In Jefferson's and Horace Mann's vision, education would prepare people to be good citizens and assimilate them to a common culture. Mann was very concerned about educating immigrants and developing social cohesion. This may be lost as parents and individuals take over responsibility for learning. We can anticipate not only Christian conservatives developing curricula, but many different interest groups, such as environmentalists, Muslims, and Mexican Americans, developing curricula that address their concerns about raising children. In such fractionation by interest groups, citizenship and social cohesion goals may be undermined.

- *Diversity.* As education fractionates, people may learn less about people from other backgrounds and cultures. As David Brooks argues, we are settling into our own little "cultural zones" where like-minded people cluster together. Hence, we may find it difficult to get along with people from different backgrounds or with different views.

- *Broader horizons.* When people select their own education goals, they pick things that interest them or that are occupation-oriented. Their choices are often narrowly focused. But a major goal of education is to expand people's horizons. Hence, there is the problem of parents steering children along narrow paths. This means that children may not be exposed to different views on issues and become more parochial in their ideas.

But there are also potential gains:

- *More engagement.* One potential gain is that education will be directed toward 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 topics they think will help their careers or that reflect their interests. And when people purchase educational videos, games, or simulations, they choose topics that interest them. So they are much more likely than school children to be engaged in learning.

- *Less competition.* Because school is competitive, a sense of failure overwhelms many students. Most cope by turning their energies to other activities, such as sports. Most students try to do as little as possible. The goal becomes to get grades that are good enough not to hurt one's future, with a minimum of effort. This attitude is inimical to learning and is a product of the competitive nature of school. If people pursue learning on their own, they will not feel the sense of failure that comes when everyone is supposed to learn the same thing at the same time.

- *Customization.* Another potential gain stems from the capability of computers to customize education to the particular needs and abilities of individual learners. Computer learning environments can be designed to provide hints and support to students when they need help. Hence, computer environments can adapt to the level of the student's ability and help all students to succeed.

- *More responsibility.* Parents who school their children at home try to instill a sense of responsibility in the children themselves. But 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. But people are not going to learn much unless they take responsibility for their own learning.

- *Less peer culture.* Another potential benefit is the diminution of peer culture. Putting young people into schools, where their main interactions are with peers, creates an unhealthy situation. Peer culture tends to devalue learning and foster drugs, sex, and violence. Peer-cultural values emphasize looks and strength rather than intelligence and hard work. To the degree that children are learning at home, in workplaces, in learning centers, or libraries, it will tend to undercut peer culture.

Rethinking Education

Education is flux and where it ends up depends on the decisions society makes. So this is a time of opportunity to determine the future direction of education in ways that we have not faced in 200 years. To be effective in this changing environment requires that the builders of the new education system understand the imperatives of the technologies driving the changes in education.

We encapsulate those imperatives in terms of *customization, interaction, and control.* Customization refers to providing people the knowledge they want when they want it and to supporting and guiding them as they learn. Interaction refers to the ability of computers to give learners immediate feedback and to engage learners through simulation in accomplishing realistic tasks. Control refers to putting learners in charge of their learning, so they feel ownership and can direct their learning where their interests take them.

A possible education reform is to develop national certifications that can be administered on computer or by assessors at any school or learning center. These certifications would be much more narrowly focused than a high school diploma. People 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 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. Some learners might obtain a large number of these certifications and some might obtain fewer.

When students become teenagers, we would trust them to 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 like AmeriCorps. 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. Ideally the state would pay for students' preparation for a certain number of certifications (perhaps 20 or 30). Then people could take courses whenever they are ready, at whatever age. This is far better than forcing unwilling teenagers to stay in school until they are 16. It would produce a mixed age population in the courses, filled with people who chose to be 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? These are questions about improving education outside of schools.

There are a variety of things we can do to support people to learn on their own: 1) we can provide machines for all toddlers that help them learn to read on their own, with books by writers such as Dr. Seuss. These machines could also have computational games to challenge kids. 2) We can provide tutoring programs on the web to teach a variety of topics that perhaps are tied to certifications. 3) We can provide computer-based games on the web that foster deep learning and entrepreneurial skills. These are things that governments should support if they want to be competitive in the technology age.

Technology is changing what is important to learn in a variety of ways. There are new literacies that are becoming important, such as creating videos, animations, and web sites. Computers can carry out all the algorithms taught through graduate school, and yet mathematical reasoning is more important than ever. Hence we should spend time teaching students to solve sophisticated problems using computers rather than executing algorithms that computers do well. 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.

People will be changing careers often and transitions are difficult. They need help going back and forth between learning and work. They should be assigned a personal counselor in middle school to help them think about what they need to learn for different careers and how to acquire that knowledge. If they leave work, a counselor could advise them on learning opportunities they can pursue. People will be going back and forth between learning and work throughout life and ideally they should be able to consult the same counselor as they make these transitions.

This is the time we need another Horace Mann to provide the vision for an educational system that can integrate all the different elements we see 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 especially needs to concern itself with issues of equity, given that elites can buy themselves many educational advantages.

Parents and citizens need to push for a more expansive view of education reform. School leaders and teachers need to understand how learning technologies work and how they change the basic interactions of teachers and learners. 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 make the new educational resources available to everyone.

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MAS.714J / STS.445J Technologies for Creative Learning
Fall 2009