Weigel, M, James, C and Gardner, H. 2009. Learning: Looking Backward and Peering Forward in the Digital Era. International Journal of Learning and Media. Vol 1, number 1. Pp 1-18.

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Learning: Peering Backward and Looking Forward in the Digital Era

Margaret Weigel
Project Manager
Project Zero
Harvard Graduate
School of Education
margaret_weigel@pz.harvard.edu

Carrie James
Research Director
Project Zero
Harvard Graduate
School of Education
carrie_james@pz.harvard.edu

Howard Gardner
Hobbs Professor of Cognition and
Education
Project Zero
Harvard Graduate
School of Education
hgasst@pz.harvard.edu

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Introduction

Both in common parlance and within the academy, the word "learning" has broad and varied meanings. On the street, we apply the same term to a child who, as a result of bitter experience, will no longer tease an older, tougher peer, and to those who achieve the highest Latinate degrees after many years of study at the University. In the field of psychology, "learning" was the major topic in America for fifty years, before it was replaced and almost consigned to oblivion, courtesy of the "cognitive revolution" of the 1960s (Gardner 1985). Now, with study becoming a lifelong enterprise, and with the advent of a galaxy of new media, "learning" seems once again poised to become all things to all people, be they lay or scholarly.

In this article we bracket our task by using a restrictive definition of "learning." We assume that in any society, certain information, knowledge, skills, beliefs, and values need to be transmitted to the younger generation. By the same token, there will certainly be new information, knowledge, skills, beliefs, and values that will be important in the future, though elders may not be willing or able to anticipate the specifics of these new competences. (We use "competences" as an umbrella term to cover this complex of information, knowledge, skills, beliefs, and values.) Some of the competences occur almost automatically: Young children will not survive unless they avoid steep drops, but no explicit instruction is necessary (Gibson and Walk 1960). At the same time, children are strongly disposed to be treated fairly, and have at least some inclination themselves to treat peers fairly (Damon 1988). We will not be concerned with such "natural" or "ready" or "highly predisposed"

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doi: 10.1162/ijlm.2009.0005

Volume 1, Number 1

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learning. Some messages are conveyed so powerfully in a society that formal instruction is unnecessary. American youngsters do not need formal instruction in the operations of the marketplace (i.e., buying, selling, consuming, competing, etc.), the rules of baseball or popular music, or navigation by automobile; Chinese youth, a half century ago, took for granted a socialist economy, agitprop works of art, and navigation of bicycles. We will assume and not comment further on "universal learning within a culture" (Feldman 1980).

Having thus restricted our terrain, our focus here falls on those competencies that require some kind of formal instruction, tuition, or scaffolding on the part of the individuals, organizations, and/or media of the ambient society. Put differently, we direct our attention to those forms of learning that do not occur automatically, readily, naturally, or by dint of simply living in a certain place at a certain time. (In this way, we also eliminate from consideration most of what is considered learning in organisms other than primates and higher mammals; cf. Hauser 2000.)

We begin with a consideration of how learning took place in the distant past; then turn to learning as it evolved in recent centuries; then direct our focus to the challenges and opportunities of learning going forward in the digital era. Our sketch of "learning past" will be just that—a cook's tour, perhaps necessary, at least brief. As shown in table 1, we will be cognizant throughout of who the learners are, where they learn, how they learn, what are the principal curricula, and how competences are purveyed via the media of the time. The grid itself contains generalizations about the past and present, and speculation about the future, thus providing a broad portrait of changes over time. While we do not discuss each entry in the grid, we hope that it aids in thinking about learning in formal and informal settings.

In this article we argue that, after millennia of considering education (learning and teaching) chiefly in one way, we may well have reached a set of tipping points: Going forward, learning may be far more individualized, far more in the hands (and the minds) of the learner, and far more interactive than ever before. This constitutes a paradox: As the digital era progresses, learning may be at once more individual (contoured to a person's own style, proclivities, and interests) yet more social (involving networking, group work, the wisdom of crowds, etc.). How these seemingly contradictory directions are addressed impacts the future complexion of learning. Throughout this article we draw upon a variety of resources to inform our arguments, including scholarly research, general interest articles, blog posts, and research in progress by our team at Harvard Project Zero, including The Developing Minds and Digital Media Project and The GoodPlay Project.

Peering Backward

Traditional Learning

The invention of writing is crucial in any account of the history of learning. Until the invention of writing, we have no written and scant graphic evidence of how learning took place. Building on findings with primates, preliterate cultures (which are rapidly disappearing from the planet), and extrapolations from scattered tools and graphic artifacts, we can assume that most traditional learning took place by observation—presumably with oral linguistic accompaniment, though it is not clear how crucial a role was played by lexicalization (putting ideas or procedures into words) per se. Girls watched older women plant, gather, sew, swaddle, raise younger children, and play roles in decisions vis-à-vis the household; as soon as possible, the growing girls began to participate in these activities. Boys watched older men hunt, fish, engage in combat, and play roles in decisions vis-à-vis marriage and wider communal and extra-communal relations. More often in the case of boys, the transition to adulthood was marked by initiation rites, which often included introduction to hermetic knowledge, such as that involved in successful hunting or war making. With rare exceptions, we infer that in these learning environments, children were to be seen and not heard.

As skills within traditional communities became more specialized, there is likely to have been more explicit tutelage, perhaps for offspring of elite families, perhaps also for those young persons, of whatever social origins, who displayed special aptitude in one or several spheres. In considering possible occupational specializations, one might include knowledge of astronomy, ability to sail large distances, skills in healing, and the ability to perform music, dance, or graphic depiction at a high level of competence. It is doubtful that, for example, all young persons in a Paleolithic era were inculcated in the skills needed for

Table 1 Learning Over Time

Periods	WHO learners	WHERE	purveyors of learning	HOW dominant pedagogies	dominant instructional media	dominant cultural media	WHAT major content/curricula	implicit content/curricula
pre-literate era	all children	family, community, "bush schools"	family, community	participation, observation	indeterminate	oral	meaning-making in context	survival, documentation, ceremonial
pre-modern era (1439 - 18th c)	mercantile and elite males	apprenticeships and formal schools	experienced and knowledgeable adults	participation, observation, instruction	images, text	images, text	basic literacy, technical or specialized domains	commerce, obedience, religious education
modern era (19th c to 1950s)	w/rise of public education, most children ages 5–18	formal (classroom)	primarily female educators, teachers as experts, students as passive recipients	uniform schooling, received wisdom, one-size-fits-all learner/learning	print	rise of mass media - print, broadcast (radio/tv/film)	humanities and language/literacy, socialization, routine	preparation for work, discipline, citizenship
late/high modernity (1960 to 2000)	all children	formal (classroom)	teachers as experts, students as passive recipients (emergent: teachers as facilitators, students more active)	uniform schooling, received wisdom, one-size-fits-all learner/learning (emergent: early constructivism, early individualization/multiple intelligences, social learning)	print, some broadcast	mass media - print, broadcast (radio/tv/film) emergent: digital media	emphasis on science vs. humanities/literacy	consumerism
personal computing—digital age (1980–present)	all children	formal (classroom) (emergent - informal; classrooms persist but learning increasingly happening anywhere)	teachers as experts, students as passive recipients (emergent: teachers as facilitators, students as co-architects, self-directed learning, peer learning)	uniform schooling, received wisdom, one-size-fits-all learner/learning (emergent: constructivism, contextualized learning, social learning/distributed cognition)	print, broadcast (emergent: digital media)	mass media digital (internet/web 2.0) emergent: portable digital media	emphasis on science (emergent: interdisciplinarity)	diversity, consumerism
future—insufficiently supported	all (lifelong)	formal for all, informal for privileged	self learning, peer learning, teachers less relevant, students as unsupported, limited learning due to distractions	split between direct instruction and autonomous work, direct instruction, traditional pedagogies remain, autonomous work, constructivism, contextualized learning, social learning/distributed cognition	print, broadcast digital (internet/web 2.0), portable digital media, augmented reality	digital (internet/web 2.0), portable digital media	3Rs, disciplines, interdisciplinarity metacognition, new media literacies, globalization, ethics	global participation as a thoughtful producer, consumer, and citizen for some
future—well-supported	all (lifelong)	formal and informal for all	self-directed learning w/ supports peer learning w/ supports, teachers as facilitators, students as co-architects	balance of autonomous and scaffolded learning, supported constructivism, contextualized learning, social learning/distributed cognition	print, broadcast digital (internet/web 2.0), portable digital media, augmented reality	digital (internet/web 2.0), portable digital media	3Rs, disciplines, interdisciplinarity metacognition, new media literacies, globalization, ethics	global participation as a thoughtful producer, consumer, and citizen

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cave drawings of animals or for the use of herbs and prayers in healing. It is possible that certain individuals were deemed to be especially skilled teachers, over and above their own skills in the task at hand. Recent studies confirm that children as young as three years old understand the role of teacher and are able to take into account the knowledge of their "pupils" (Strauss 1997; Tomasello 1999); it stands to reason that, over and above the modeling done routinely by parents and other adults, certain individuals honed their skills in teaching the young.

Our best evidence suggests that the learning took place in so-called "bush schools"—convenient ad hoc loci where learners benefited from the examples, lore, and instructions of designated experts. It is likely that these settings were at or close to the places in which the knowledge was actually deployed—decontextualized learning had yet to emerge.

The First Schools

While the Sumerians are generally credited with the invention of writing as we know it, the efflorescence of various graphic means of encoding knowledge occurred in several regions of the world starting about 5,000 years ago. Beginning with pictographs, then moving to rebuses, syllabaries and, finally, strictly alphabetic systems, the scribes of various civilizations succeeded in recording important events from the past, current events and concerns, prayers, and legal procedures and regulations in written form. At roughly the same time, the encoding of numerical and mercantile information also came into its own, as scribes recorded exchanges, possessions, and calendrical information in terms of numerical totals, estimates, and operations.

Probably for the first time in human (pre) history, the need for a more formal educational institution emerged. Most young individuals cannot learn to read and write on their own; nor can they handle more than the most elementary numerical totals and operations without some formal instruction and ample opportunity to practice, preferably with targeted feedback. With the rise of literate and numerate civilizations, fresh needs emerged, for locations called schools, and for adults—variously thought of as teachers, instructors, masters, models, coaches, or even tyrants—charged with the responsibility of educating the young. In the first centuries of schooling, the relevant learners were undoubtedly drawn from a relatively small population—the most promising male offspring of elite families. But in more highly elaborated civilizations, such as Imperial China, a formal examination system was set up. And at least in principle, talented males from different social strata had the opportunity to receive formal education and, ultimately, to become part of the ruling, managerial, or "mandarin" class.

The first schools existed for three primary purposes: to enable young persons to become literate and numerate; to inculcate in them the discipline of hard work, often carried out in settings remote from daily life; and to make sure that the principal religious and moral knowledge and values of the culture were transmitted to the elite who would, in the fullness of time, pass this lore on to succeeding generations. In the absence of officially designated courses, let alone schools of education, these educational milieus proceeded in a rough-and-ready way (with the emphasis on roughness). Through ceremonial rituals, often accompanied by sweets, young persons were enticed to enter the "house of learning." But once enrolled in schools, the regime was strict and unforgiving. Teachers ruled the roost. Students copied, memorized, and drilled. The rod was not spared. And except for a privileged few, formal schooling came to a predetermined end once the basic competences in literacies had been achieved and the student had shown that he or she was capable of obedience and informed about the major religious and social norms of the community.

Education in the Premodern Era

With the increasing division of labor in burgeoning civilizations, various specialties emerged. Those that were chiefly technical—tool making, shopkeeping, production of materials for daily living or of special objects for the elite—were transmitted primarily through apprenticeships, typically carried out in a quite unforgiving manner. In medieval Europe, these were institutionalized in craft guilds. In addition, however, specialties that were slanted toward the purely cognitive—astronomy, geometry, notated music, calligraphy, rhetoric, logic, copying and illumination of manuscripts, theology, and philosophy—also emerged in Buddhist, Christian, Hindu, Islamic, Jewish, meso-American, and other rising civilizations. These specialties required far more education than basic schooling. And it was for the inculcation of

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these specialties that lycees, universities, academies (including that ideal form described by Plato), and other institutions of higher learning emerged in the last two millennia.

Education in the Modern Era

Until the time of the Renaissance in the West (starting around 1400), most educational institutions around the world had a heavily religious patina. The leaders, the funding, and the curricula were dominated by the regnant theology, be it Catholic, Islamic, Jewish, or polytheistic. And except for a tiny elite, education typically stopped with the mastery of basic literacies as defined over the centuries. But with the rediscovery of the knowledge of the ancients (chiefly Greek and Roman), the rise of merchant classes, the exploration of the world beyond Europe and the Middle East, and, most importantly, the invention of printing, a slow but seemingly inexorable trend began toward the secularization and the universalization of education, at least for young people in the years before adolescence.

Accordingly, in most parts of the world, even today, the broad outlines of teaching and learning are strikingly similar to one another. Formal schooling begins at age five to seven; the preceding years include, at most, introduction to the forms of literacy, experience of working and playing with peers, and an inculcation of routine in a setting apart from the more familiar terrain of home, the streets, the playground, the open fields, or the forest/mountain/coast line. Formal preschools are a quite recent phenomenon, though they are becoming standard practice in several European countries.

In the early years of formal schooling, teachers—largely women—introduce students to reading, writing, and elementary arithmetic. This introduction is done in part by modeling and in part by imitation, with some oral recitation, and some exercises in workbooks or worksheets. There is increasing recognition of individual differences, including specific learning deficits. There may also be some adjustment in both curriculum and pedagogy for these varying constituencies. But by and large, the model followed is that of "uniform schooling." That is, there is a single way of teaching, a single way of studying and learning (chiefly copying and giving content back to the teacher), and a single way of assessing learning (through some kind of oral and/or written examination). Uniform schooling reflects both fairness and efficiency. It *appears* fair to treat all children in the same way; and it is also efficient, given classes of 20, 30, or even 60 charges in one room, sometimes arrayed by age, sometimes decidedly heterogeneous in composition.

In much of the world, schooling still ends with the mastery of the literacies. But in developed societies and in rapidly developing societies, preadolescents and adolescents are exposed to those subject matters or disciplines that are deemed most important for work and citizenship in the modern world. Almost everywhere, the curriculum features mathematics (algebra, geometry, and perhaps calculus or pre-calculus); science (with physics, chemistry, and biology the chief sciences); history or social studies (typically a focus on the history of the country or region, with a smattering of world history and culture and, possibly, some attention to current events); and in diminishing order of popularity, other sciences (e.g., geology, astronomy, social sciences like economics or psychology), geography, civics, physical education, and one or more art forms. In most societies, there is little attention to extracurricular activities (the United States, with its focus on sports, arts, publications, student government is an outlier here); budding scholars are expected to study hard, often aided by parents or by tutors if sufficient financial resources are available.

It would be an exaggeration to claim that formal education takes place without attention to what has been learned about the processes of successful learning, such as insights into student motivation, study habits, strategies, metacognition, and other approaches obtained from experience, or, more recently and systematically, from the psychological and cognitive sciences. But it would probably be accurate to say that such accumulated knowledge is used only spottily and sporadically in most parts of the world. Education—teaching and learning—changes very slowly. The texts, the teacher-dominated lectures, the stylized interaction between students and teachers, the examinations, the graduation requirements, are not that different from those that could have been observed a century ago. And given the previous changes in communication media—telegraph, telephone, radio, television, film, film strips—it is notable how little they have infiltrated into the core of the educational process. Whether the classroom and, more broadly, the learning process will prove equally

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unaffected by the new digital media—interactive and Internet-enabled technologies such as personal computers, mobile phones, game consoles, and the virtual spaces afforded by them—is open to question.

In most education around the world, the classroom is pointedly teacher-centric. The teacher is assumed to be the center, the fount, of all knowledge; the students are perceived as relatively empty vessels, into whom skills and information are to be deposited as efficiently and correctly as possible. Students are assumed to differ in native ability, and the purpose of school is to discover those destined to be quick learners, to give them the goods to advance, and to educate minimally, or even cut as losses, those who are not gifted in learning. The IQ test was devised as an instrument that could aid in this culling purpose (Gardner 1983; Gould 1981).

To be sure, counterthemes or counterforces have existed previously. Primary education has a strong strand, dating back to Pestalozzi and Froebel and culminating in Montessori, Dewey, and Malaguzzi, that emphasizes hands-on learning and the construction of knowledge by the child. Relatedly, though not identically, there has been recognition that not all children learn in the same way or benefit from the same kind of educational milieus. Progressive educators in Europe and the United States have tried, with some success, to draw on these ideas for later education (Aikin 1942; Bruner 1960, 1995; Cremin 1988; Dewey 1998, 2004). Yet, nowhere are these ideas dominant. Indeed, until today, one might say that the European classroom models of the 19th century continue to hold sway: Teachers give out information, students are expected to master it with little help, and the awards of the culture during the years of school go to those who can crack the various literate and disciplinary codes.

Over the course of a century, the major differences in teaching and learning can be summarized as follows:

l. Education is increasingly universal. Except in the undeveloped world, almost all boys and most girls get an education at least to the secondary level. The diversity of the student body is devious.
2. The hegemony once occupied by humanities and language is increasingly replaced by subjects related to STEM—science, technology, engineering, and mathematics.
3. In addition to the increasing nationalization of curricula (almost everywhere except the United States), there is growing focus on performance in the so-called international comparisons, especially the TIMMS and the PISA tests.

Looking Forward

Learning in a Postmodern, Digital Age

While the broad changes in education noted above are not insignificant, they have not dramatically impacted the nature of learning in many schools; the content, functioning, and organization of the typical European classroom model remains relatively unaffected despite major transformations in the world just beyond its walls, and the implementation of more meaningful changes remains stalled. In sharp contrast to the stasis of the classroom model, important changes proliferate in the world. To name a few, our global civilization must address climate change, the revolution in the understanding and use of genetic information, other biomedical breakthroughs, the power and ubiquity of financial markets, the exploration of space, nuclear power and nuclear weapons, massive immigration, and the emergence of powerful new communication media. Both the demands of the workplace and the demands of education have changed profoundly and promise to do so for the foreseeable future. This scientific and cultural environment, in which the products of technologies have jolted long-accepted notions of time, space, and nationhood, is known variously as "postmodernity" (Lyotard 1984), "hyperreality" (Baudrillard 1994), "late capitalism" (Harvey 1989; Jameson 1991), "risk society" (Beck 1992), or "high modernity" (Giddens 1991).

Of particular relevance for learning is increased skepticism and contestation of what constitutes "truth." In the view of many commentators, the collapse of metanarratives (Lyotard 1984) and a heightened awareness of the limitations of language (Derrida 1998; Wittgenstein 2002) have rendered truth as a fluid entity validated primarily by consensus. In the absence of recognized authorities and standards for determining what is considered true, learning is problematic. This postmodern perspective is not universally shared. Many continue to operate in a climate in which facts are fixed entities taken for granted, information is created and circulated relatively slowly, and authority figures are invested

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with the responsibility of determining and sharing what is considered true and good. Even so, it is undeniable that new opportunities for individuals to assert the truth, or their truths, are afforded today; educators will likely grapple with questions about what is true, and what is worth teaching and learning, more and more, both now and in the future.

It seems improbable that the traditional educational model is capable of serving the needs of a transformed culture and a population that is growing up in radically changed milieus. The prospect of how education might change (based on how one could learn) has engendered a dynamic discourse, with scholars and researchers volunteering different sets of prescriptives—skills, curricula, and the like—to better align the educational system with contemporary challenges and opportunities.

Critical Skills for Today and Tomorrow

Many educators have attempted to categorize what, in this changed environment, constitutes necessary skills across a variety of developmental levels: Murnane and Levy (1996) promote "hard skills" (math and reading), "soft skills" (collaborative and social skills), and computer skills as a way to secure middle-class jobs; Gardner (2007) identifies the disciplined, synthesizing, creative, respectful, and ethical minds as "five minds for the future." Many others propose future skill sets: "seven survival skills for teens today" (Wagner 2008); the right brain–themed "six sense" (design, story, symphony, empathy, play, and meaning [Pink 2005]); the "four outcomes" (core subjects and 21st-century themes, learning and innovation skills, information media and technology skills, and life and career skills (Partnership for 21st Century Skills 2007), to name a few.

In these frameworks, the traditional "three R's" remain but are supplemented by a broader focus on metacognitive skills and an acknowledgment that individuals live in a complex world defined in part by existing but fluid frames of meaning (Geertz 1993). Most would agree that a well-educated individual should be able to successfully participate in a global economy where money, culture, ideas, and people circulate rapidly; to synthesize and utilize vast rivers of information obtained through a variety of channels (textual, visual, multimediated); to engage with this information across a variety of disciplines; to be comfortable negotiating a range of social connections, including interacting with diverse populations; and to serve as an engaged and responsible member of one's profession and one's communities.

Digital Cultures

The new digital media (NDM) are implicated in many of the broad changes underway and underscore the importance of the aforementioned new skills. Digital media allow for nearly ubiquitous access to people and to virtually infinite amounts of information, as well as affording new forms of sociality, play, creativity, social activism, networking, and collaboration. It is important to acknowledge that access to digital technologies is inequitable. Despite significant progress in bridging the "digital divide" over the last decade, most of the world's populations are offline; only 5.3% of Africa's population can use the Internet, compared to North America's population, of which 73% are Internet users. In the developed world, the relatively privileged enjoy access to digital media tools and resources. North America boasts the largest rates of Internet penetration, but the statistics do not elaborate on the range of Internet experience for those who have access, from the fully wired, robust, and easily accessible home computer to the censored and shared access offered by the local library or Internet café. Twenty-seven percent of North Americans remain offline either by choice or by circumstance (all statistics from World Internet Uses and Population Stats 2008).

We acknowledge that attempting to draw any generalizations relating to NDM are problematic, as engagements with NDM vary widely across economic, ethnic, and social cohorts. Assumptions are frequently made about the digitally savvy, especially with respect to age: It is the younger generation who are often accorded such labels as "digital youth," "digital natives" (Palfrey and Gasser 2008; Prensky 2001), "neomillenials" (Dede 2005), and "net generation" or "net gen" students (Oblinger and Oblinger 2005). These labels have been contested by scholars who point to the variation in access and digital skills among youth on the one hand, and the age variation among the digitally savvy on the other (Jenkins 2007; Palfrey and Gasser 2008; Vaidhyanathan 2008). Leslie Johnston, affiliated with the Library of Congress, writes of working with a diverse range of technology users, including technically savvy sixty-something faculty members, middle-aged librarians who both

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reject and embrace new technologies, and "students at…research universities who could not care less about being digital" (Johnston 2007).

That said, we must also acknowledge that many American youth are introduced to digital media at relatively young ages and spend more time engaging with digital media at critical developmental stages than their older counterparts did. While adults as well as youth use NDM to build upon existing social links (Kennedy et al. 2008), the average teen spends approximately 11.5 hours a week of his or her free time creating, exploring, playing games, and communicating online (ConsumerLab 2008); over half of teens age 12–17 use a social networking site; approximately three out of five teens upload some type of creative content online (Lenhart et al. 2007); and virtually all teens engage in some type of video gameplay (Lenhart et al. 2008). The online practices of teens vary dramatically; they may be avid texters and emailers, social networkers, casual surfers, and news browsers, or deeply invested MMORP gamers and social activists.

The meaning of this teen engagement with digital media is widely contested. Critics lament the decline of literacy, divided attention, and the decline of autonomy, among other concerns (Bauerlein 2008; Keen 2007; Turkle 2008; Wolf 2007), while enthusiasts laud the social and intellectual skills cultivated in games, virtual worlds, and online communities (boyd 2007; Gee 2003; Jenkins et al. 2006; Shaffer 2006). The net impact of youth digital engagement remains to be seen. In the subsequent section we describe the ways in which the growing prevalence of digital media in young people's lives—and the powers of these media in and of themselves—may hold the potential to occasion a decisive tipping point with respect to long-standing modes of K-12 learning and education, as well as lifelong education.

New Digital Media Affordances

While technology is often cited as a primary driver of cultural change, we recognize an iterative relationship among individuals, the technologies they use, and their cultural practices, with each informing and shaping the other. We similarly acknowledge that the term "new digital media" does not represent a single unitary entity; rather it encompasses diverse hardware, software, and technologies—a "digiverse" defined primarily by the ease of circulation of digitally based materials and communication.

We align ourselves to an intellectual tradition that sees people, their ideas, and technologies as intertwined in dynamic systems or dialectical relationships (Callon 1986; Latour 1987; Scribner and Cole 1978, 1981; Smith and Marks 1994; Williams 2003; Winner 1977). We do not consider ourselves technological determinists—we acknowledge that technologies (including all forms of media) are created in social contexts and through social relations. Once created, technologies have social impacts, but no technology in and of itself has ineluctable consequences. At this point in their proliferation, much remains unknown concerning the educational and learning impacts of NDM: Will they be large or small, will the outcomes be positive, negative, mixed, or neutral? It is still too early to tell.

That having been said, we believe that a "perfect storm" of NDM affordances, sociocultural changes associated with globalization, and the growing pace and interconnectedness of human life may potentially add up to a formidable tipping point. We operate on the assumption that NDM contain affordances that, if leveraged properly, could create future learning environments and cultures in which the promises of constructivist, social, situated, and informal learning are realized. We recognize that we could be wrong. We also recognize—and will elucidate at critical points—how the integration of NDM practices into a school setting can be challenging, such as the difficulties of implementing more social-based Internet practices in the classroom, or of incorporating youth's extra-curricular, digital pursuits into fruitful classroom instruction, for example.

In the discursive pairs outlined below, we profile the positive and negative NDM affordances as they relate to contemporary learning strategies and the ways in which they can support, or thwart, the cultivation of the new skills we believe to be important today.

Informal Learning as a Complement to School-Based Learning

Traditional learning employs a mechanical model of "one curriculum fits all" under the guise of fairness and efficiency. Critics have argued that such a "uniform system" is arguably unfair to those students with different learning styles or intelligences; while it may be efficient, it is unclear that this approach is particularly effective in the context of universal schooling. In digital environments, different

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options or pathways to understanding—textual, visual, game based—may be readily available in keeping with principles of "universal design for learning" (Rose and Meyer 2002).

While the ubiquity of digital media resources allows for more customized learning within a formal learning context, its primary value lies in the acknowledgment of the legitimacy and value of learning that take place beyond formal schooling. While the concept of informal learning has been acknowledged for decades (Tough 1979), its definition varies across contexts including the home, the playground, the afterschool setting, and even the school setting as well as through various mediated sources of information. In a review of the literature on informal learning with technology outside of schools, Sefton-Green defines the difference between informal and formal learning as based on "the intentions and structure of the learning experience" (Sefton-Green 2006, p. 6). One could argue that a strictly formal learning experience is characterized by classroom-based instruction featuring an explicit curriculum and traditional pedagogical goals, and scaffolding implemented by a single educator; a pure informal learning experience lacks all of these characteristics. While these extremes help to define the argument, multiple hybridic forms of pedagogical practice located on a continuum between formal and informal, which combine elements from both approaches, are more the norm.

In a postmodern, globally interconnected, digital world, individuals will likely be required to master new technologies and related behaviors throughout a lifetime to successfully learn, synthesize, and adjust to rapidly shifting requirements of the workplace and the culture. "[A] capacity for independent learning," suggests Brown, "is essential to [students'] future well-being, since they are likely to have multiple careers and will need to continually learn new skills they were not taught in college" (Brown 2006, p. 18). Others argue that informal learning can harness learners' passion related to the activities they voluntarily engage in, and capitalizes upon the collective power of group, rather than individual, endeavors (Ito 2008; Jenkins et al. 2006), with the Internet providing opportunities for self-study and self-directed learning for all, while schools increasingly do not—indeed cannot—handle the burgeoning educational requirements of a growing, ever more diverse population.

Informal NDM activities commonly undertaken by youth include independent investigations of topics of interest (sports, news items), participation in online communities, writing a personal or topical blog, content creation (video, music, art), and gaming. The learning potential within games may be viewed by some with skepticism (Bauerlein 2008), but video game researchers credit games with invoking and nurturing key competences (Gee 2003; Shaffer 2006). Valuable metacognitive skills, or "new media literacies," can also be nurtured through online engagements (Jenkins et al. 2006). As evidence grows concerning the competences gained through these activities, traditional notions of school as the ideal locus of the full range of learning may be disrupted.

Whether the potential of such informal learning experiences can be achieved either to complement or augment formal learning remains unclear. A core pedagogical challenge for informal learning is the learner's ability to apply lessons learned in one context to related (and even unrelated) contexts; this is the classical educational issue of transfer. For informal learning to augment, or even in certain instances replace, formal learning, measures of its quality and its (real or potential) transference to other contexts will need to be more firmly established. One strategy might involve formal education playing a role in informal learning spaces (perhaps on the analogy of teaching hospitals), and learners' out-of-school passions finding a validating place in formal educational arenas. However, students may resist the cooptation of their free play by teachers bent on measuring its impact; teachers may similarly resist the introduction of unorthodox materials into the classroom. Should strategies be crafted for assessing the quality of learning in informal environments, helpful criteria might be found among the features of constructivist learning.

Constructivist Approaches Replace Didactic Learning

In the traditional classroom, a teacher distributes text-based materials and augments them with oral information; lessons are reinforced through notetaking, homework, and textbook guides. Knowledge is possessed by the educator and imparted to his or her students in a top-down, unidirectional transfer, and a student's classroom success or failure is assessed by said educator (or by an externally mandated examination). Constructivist epistemologies redefine existing pedagogical roles, eliciting more engagement and

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investment on the part of the learner, and less overt control and knowledge dissemination on the part of the educator.

NDM's vast resources, including the provision of many activities in which the user assumes a formative role, can complement constructivist approaches to education. As noted above, a motivated learner can investigate a wide variety of personal interests on his or her own. Or potentially, he or she can learn sophisticated analytic and social skills by playing complex games or participating in a social network or online forum, entirely independent of formal educational experiences or designated instructors.

Various research groups are currently developing user-driven applications such as the semantic web, affective computing, and other such variants that will react to user input in real time and be able to assess the developmental or cognitive levels of the user (Chen 2008). Our research has shown that students today may have the resources to be more informed about global events such as the Darfur genocide or the plight of Romanian orphans—interests prompted by school content or peers, and by the availability of information online—than they have been in the past.

Most schools have already invested in the necessary infrastructure upgrades to allow some level of Internet access, and are able to take advantage of these pedagogical opportunities. However, there are serious challenges associated with implementing an NDM-based pedagogy. NDM may be seen as sources of entertainment and escape, not learning; additionally, the determination of the proper level of scaffolding can be difficult.

The Internet's potential for learning may be curtailed if youth lack key skills for navigating it, if they consistently engage with Internet resources in a shallow fashion, and/or if they limit their explorations to a narrow band of things they believe are worth knowing. Left to their own devices and without sufficient scaffolding, student investigations may turn out to be thoughtful and meaningful—or frustrating and fruitless. A successful informal learning practice depends upon an independent, constructivistically oriented learner who can identify, locate, process, and synthesize the information he or she is lacking. More specifically, a variety of cognitive limitations, along with features of current search engines, problematize the identification, depth, and assessment of online searches for the typical student (Guinee 2007):

Identification: The number of information sources available can be overwhelming and potentially paralyzing to information seekers, a problem identified by Schwartz (2003) as "the paradox of choice." Depending on the developmental and intellectual sophistication of the learner, such a virtually unlimited range of choices may be liberating, confusing, or frustrating.

Depth: Current research suggests that when young learners do dive deeper for information online, their search skills are typically lacking. They are prone to drift off-task as they become distracted by tangential material and fail to return to their original search thread (Palfrey and Gasser 2008). What is known about the browsing habits of youth and adults suggests that "searchlight" techniques—browsing for surface information to get a general feel for a subject—are more typical than focused "laser beam" searches (Palfrey & Gasser 2008; Rowlands and Fieldhouse 2007). In an information-saturated environment, skimming is a critical skill; however, learners drawn to superficial content may be less able to sustain a directed focus, assess findings, and reflect upon the meaning and significance of rapidly encountered information.

Assessment: Students trained in traditional media literacy curricula (i.e., those based on books, advertising, television, film) may or may not apply these skills to online sources (Metzger et al. 2003). As one educator whom we interviewed noted, "Kids are taught media literacy skills, but then they go online and they are dazzled." Youth interviews we conducted demonstrate that a link listed as Google's top result is all too often interpreted as a credible marker for information sources. The growing presence of commercial interests behind or alongside content is particularly problematic in this regard.

The Internet may assist in narrowing perspectives if an individual chooses to engage with a single line of reasoning or point of view with limited, superficial exposure to contrasting information (Bishop 2008; Sunstein 2007). Defined by some as the problem of "balkanization" online, unscaffolded

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Internet engagement may allow users to self-select information that further refines, or shrinks, one's worldview.

Educators tend to frame NDM as either entertainment devices or as tools to simplify administrative tasks such as locating images or reading papers (Developing Minds and Digital Media Project 2008). The sustained popularity in the classroom of "skill and drill" software packages that mimic repetitive offline practices suggests that the tools, actors, and culture of the typical classroom are not yet aligned to support the more constructive pedagogical approaches facilitated by NDM. At this point in time, deeply constructivist classrooms remain few and far between despite evidence that hands-on, problem-solving approaches in the classroom result in higher levels of student engagement, conceptual thinking, knowledge transfer, and retention (Scardamalia, Bereiter, and Lamon 1994; Bransford et al. 1999; Hmelo-Silver 2004; Meier 1995; Project Zero and Reggio Children 2001; Sizer 1984). But in an environment of "No Child Left Behind" and standardized tests linked to federal funding, the implementation of constructivist principles in the classroom can be considered a risky enterprise for public schools.

Opportunities for Contextualized Learning

Before the advent of classroom education, most learning was contextualized by default; the apprentice learned metalsmithing from the journeyman in his workshop, the daughter learned weaving from her mother in or near the home. The classroom model of a shared room equipped with books that held the keys to learning was a radical departure from the apprentice model of one-to-one learning and onsite knowledge transfer.

Recently, renewed attention has been paid to situated or contextualized learning—the contention that learning cannot and should not be separated from relevant physical and social contexts (Lave 1985; Lave and Wenger 1991). In contrast to mainstream classroom approaches, immersive technologies such as virtual worlds, augmented reality games, massive multiplayer games, social networking tools, and knowledge and fan communities offer highly active, situated, and social learning experiences. Engaging recreations of complex historical and present-day events may engender more enduring or nuanced understandings and, when framed as games, perhaps deeper investments in learning. For example, *Quest Atlantis* and *River City* and serious games such as *Darfur Is Dying* engage participants in quests in which learning about science, the environment, and global political issues are integral to the game (*Darfur Is Dying* 2008; *Quest Atlantis* 2008; *River City* 2004). Traditional teaching approaches to such topics are more abstract and less engaging; these approaches may have worked well for some learners, but not for others.

Virtual learning environments offer diverse pathways to understanding, thereby accommodating individual intelligences and learning styles (Dede 2005; Gee 2003; Jenkins et al. 2006; Rose and Meyer 2002; Shaffer 2006). Games and software tools such as *LittleBigPlanet*, *Gamestar Mechanic, Stagecast Creator*, and *Scratch*, which invite and scaffold youth in the design of their own games, take these affordances even further (*Gamestar Mechanic* 2008; *LittleBigPlanet* 2008; *Scratch* 2008; *Stagecast Creator* 2008). *Second Life*, the massive multiplayer environment, offers a buildable environment for online interactions that straddles gameplay and virtual reality; *GoogleEarth* allows users a bird's eye view of the world (*GoogleEarth* 2008; *Second Life* 2008). A Montana State University professor has incorporated these tools in his architecture courses, where his students can now manipulate simple 3D shapes and import digital models into dynamic models of the world (Kieran 2007).

Mobile tools such as handheld computers or similar portable, sophisticated appliances have the potential to free students from the classroom context and immerse them in rich, meaningful learning experiences while maintaining access to text- and graphics-based learning supports. These types of mobile media, or "augmented reality," provide unique educational affordances, including portability across multiple sites, social interactivity, context-specific engagements, connectivity that can capitalize upon the resources of a network, and a unique experience for each individual learner (Klopfer et al. 2002). The teams of students who play *Environmental Detectives*, for instance, investigate a virtual chemical spill in the real world by collecting data and interviewing experts, witnesses, and suspects via a handheld device. In Waag Society's *Frequency 1550* game, students are transported back to a historical Amsterdam to search for a lost relic—all courtesy of their mobile phones (*Frequency 1550* 2005).

A major concern for augmented contextualized learning is the question of impact, particularly with respect to computer-generated environments. To what extent is a screen-based simulation, which

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limits tactile input to two of the five senses, a legitimate substitute for a real world version? Would we fly with a pilot or have surgery by a physician who has learned only on a simulator? In other words, what might be lost if simulations entirely replace real, high stakes learning by doing (Gardner 2006)?

There is also the challenge of trying to focus the attentions of a group of children of various maturity levels and temperaments within novel physical or virtual environments. To what extent might a contextualized setting function as a distraction or a hindrance to learning? What are the merits of traditional classrooms in this regard? Familiarity and comfort with the environment of the usually age-graded classroom may allow a student to focus on the less familiar and often challenging tasks at hand. The school is usually the first place in which a student is expected to heed the directions of an adult not in his or her family, to sit still and to behave in a socially appropriate way, and to learn about important matters that are not within the current frame of reference—all skills that are still valued in an adult as he or she progresses through life.

And, finally, situated learning with NDM suffers from the same difficulties associated with formal assessments as do many NDM learning initiatives. In order for NDM to help students move out of the classrooms and into the world, educators need to carefully consider how to establish baselines for assessing progress in unorthodox settings with little or no precedents, and how to grade students on the basis of their activities in these types of settings.

Supports for Social Learning

In a traditional classroom, each student is regarded as an independent and separate entity with his or her own desk, books, assignments, motivations, assessment, and grades; progress is evaluated in light of the student's record of individual achievements or failures. Students who engage in group work as part of their training are likely to be better prepared for the networked, globalized marketplace than those who do not (Brown and Duguid 2002; McConachie et al. 2006; Murnane and Levy 1996; Wenger 1998). In recent decades group work has become increasingly prevalent in schools as well; well-organized classroom group work can both engage students and assist the teacher in classroom management (Cohen 1994; Johnson and Johnson 1975; Slavin 1983).

Digital technologies offer new ways for students to engage in social learning. Enthusiasts point to the virtues of fully wired learning spaces that enable ongoing dialogue (back-chat) during lectures, polling of students, instantaneous sharing of ideas and work in progress, and immediate access to the Internet's knowledge communities (Vogt and Mazur 2005). The potential also exists to extend this model through long-distance collaborations, distributed cognition projects, and collective intelligence work. A web-based project at MIT, for instance, paired French language students with peers in France learning to speak English, and provided students an authentic opportunity to practice their language skills, learn online communication skills, and negotiate the implicit guidelines of a different culture (*Cultura* 2007).

In the current era, communities in which knowledge is forged by consensus—the "wisdom of crowds" (Surowiecki 2004)—are growing in number, facilitated by digital media's collaborative, networked capacities. As Shirky most recently notes, the new tools of "social media" create unprecedented opportunities "to share, to cooperate with one another, and to take collective action, all outside of the framework of traditional institutions and organizations" (Shirky 2008, p. 21).

These affordances also carry discernable risks. Voices of dissent may not be heard or, perhaps worse, shouted down by the majority. "[T]he power of the majority…[is] not only preponderant, but irresistible," cautioned Alexis de Tocqueville in his classic treatise *Democracy in America*. "The moral authority of the majority is partly based upon the notion that there is more intelligence and wisdom in a number of men united than in a single individual" (de Tocqueville, 1899). However, history teaches us that too often the majority opinion is driven by factors other than rational discourse and honest debate; we note that the concept of the mob is being reframed as a smart or wise agent of change (Rheingold 2003; Surowiecki 2004) in contrast to the traditional definition, "a riotous or disorderly crowd" (Oxford English Dictionary 2000). NDM social learning activities need to be actively monitored to ensure that everyone has an equal chance to participate, and that colleagues treat one another with mutual respect.

Collaborations can also be difficult to maintain; common pitfalls include conflicts over intellectual property (IP) rights, competition trumping collaboration, unclear directives, and trust and personality

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issues (Leslie 2006). Online collaborations in which the participants are otherwise unknown additionally struggle with temporal delays, which can lead to misunderstanding and a tendency to blame some remote "other" for difficulties. Walther and Bazarova (2007) found that the most successful online collaborative groups were longer-term projects in which participants had shared expectations concerning response time, and were physically located in the same regional geographical area.

A group's structure and its form of participation—elective or mandatory—will also influence its functioning, endurance, and value for individual participants. With voluntary associations, the ease with which an individual can join or leave a group depends largely upon the strength of ties within the community itself as well as his or her level of investment in it. Although the leader of a raiding party in *World of Warcraft* can, technically, stop playing at any time, many players would be adversely impacted by the leader's departure; conversely, community participants of a DIY site such as *Instructables* may collaborate offline, but a community member's departure would not significantly impact the site experience itself (*Instructables* 2008; *World of Warcraft* 2008).

The social dynamics of a group, and demographic characteristics of members, may affect its potential as a learning collective. Research suggests that students enjoy engaging in group tasks because it enables them to socialize more with their peers; it can be a challenge to keep adolescents in particular—developmentally highly social and self-conscious—focused on tasks when they would prefer to just hang out with friends. The gender of digital participants has also been found to affect collaborative learning practices: As they mature, girls may not want to publicly demonstrate technological fluency for fear of appearing "weird" or violating gender roles. Girls and boys employ different strategies as they pursue investigations, with boys more likely to assemble data and girls more likely to conduct interviews (Klopfer and Squire 2008, p. 218).

In a broader cognitive sense, there may be risks associated with learners and learning distributed across real and virtual spaces conducting the vast majority of their learning through devices. The current extent of multitasking and the phenomenon of continuous partial attention associated with 24/7 engagement with digital devices needs to be acknowledged (Stone 2008). Turkle suggests that the fact that we can be, and increasingly are, always connected to one another through digital devices has somewhat unsettling implications for how we think, feel, and understand ourselves and others. "Adolescents naturally want to check out ideas and attitudes with peers. But when technology brings us to the point where we're used to sharing thoughts and feelings instantaneously, it can lead to a new dependence…and what of adolescence as a time of self-reflection? [Texting and instant messages] are not intended to open a dialogue about complexity of feeling" (Turkle 2007). A student's persistent connection to others may undercut opportunities for reflection, synthesis, and integration of knowledge as we increasingly rely on each other for what we need to know. If not used judiciously, digital media may over time undermine personal autonomy rather than enhance it.

Conclusions: Implications for Education as We Know It

In this article, we have argued that the contours of learning—what is deemed important to learn, and where, when, and how—evolve over time, albeit at times very slowly. Remarkably few significant changes in teaching and learning have occurred since the onset of the modern era, despite broad and deep changes that arguably amount to the rise of a postmodern, globally interconnected, and digital world. We have highlighted the new digital media as a powerful facet of these changes; these media carry affordances that could foment further shifts (for both good and bad), particularly in relation to learning.

The new digital media provide new ways of engaging with each other, with information, and with the world; we have pointed to both promising and problematic implications of these affordances. Ultimately, we believe that digital media could be leveraged in ways that bring about a tipping point when learning becomes more decidedly individualized, constructivist, situated, and social. Again, the paradoxical confluence of opportunities for individualized *and* intensely social learning experiences is a noteworthy facet of digital media. It is far from clear who understands, takes seriously, and—importantly—is poised to act upon these potentials. While talk of reform is everywhere, far too much of the discussion centers on test scores in traditional subjects, secured in traditional ways.

The question of whether learning should take place in radically different ways—in terms of content,

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pedagogy, and assessment—is likely to become urgent in the very near future, in part because young learners themselves may be different from prior generations in their learning orientations; if so, these differences are arguably related to their increasingly digital lives. The question of the role of schools and teachers vis-à-vis digital cultures is particularly urgent. Schools cannot afford to ignore, nor simply attempt to curtail, students' uses of digital media for several compelling reasons.

First, youth are engaging with digital media at ever-younger ages (Rideout et al. 2003). Students walk into classrooms (even toddle into preschools) armed with new competences, learning preferences, and expectations that call into question existing curricula. Indeed, there is mounting evidence that the learning preferences and styles of youth are affected by their digital engagement. Dede argues that "people's daily use of new devices is shifting their lifestyles toward frequent mediated immersion, which in turn is shaping their learning styles" (Dede 2005, 15.12) toward "neomillenial" characteristics. These new learners are described as "more active based on real and simulated experience," visually oriented, self-reflective, social, fluent in multiple media, adept at navigating diverse information sources, and appreciative of co-designed learning experiences that are personalized to individual needs and preferences (Dede 2005, 15.15). Others describe "net gen" students as adept multitaskers, who are "social and team-oriented," and geared toward "a hands-on, 'let's build it' approach—all encouraged by the IT resources at their disposal" (Brown 2005, 12.2; Oblinger and Oblinger 2005).

These observations suggest that many students today are using digital media in ways that might lead them to question approaches that are more teacher-centric, uniform, and passive for students. Again, these labels ignore both the "digital divide" (unequal access to technologies among youth) and the "participation gap" (unequal access to the opportunities, experiences, skills, and knowledge that will prepare youth for full participation in the world of tomorrow [Jenkins et al. 2006]). Not all youth exhibit the "neomillienial" traits described above. However, the trends being observed among some students are worth paying attention to, especially as larger efforts are undertaken to narrow the divides and gaps among youth. The world as a whole is increasingly wired, and we are charged with preparing our youth to face the challenges of the future. Success in that endeavor will remain elusive until we teach them to weather the challenges of the present.

Second, as exciting as these new facets of learning are for supporters of constructivist, situated, and group learning, the mixed potentials described in the "Looking Forward" section of this article must be acknowledged. Educational institutions are important stakeholders for cultivating the promises but also helping to counter the risks associated with these trends. For example, while young people may be comfortable with, and even enjoy, navigating the volume of information yielded from a typical Google search, their assessments of what is reliable and trustworthy may be weak (Guinee 2007; Palfrey and Gasser 2008). Formal schools have both a stake in—and are well poised to scaffold—good assessments and syntheses of information (Gardner 2007). Understanding informal learning should arguably be on the agenda for schools, too. Should informal learning spaces continue to grow in importance, it seems that a role for schools and teachers may be warranted—perhaps if only to provide their students with scaffolding so that they can properly acknowledge, assess, and (ideally) transfer learning to other contexts.

The advent of digital media and their affordances—particularly those related to the emergence of potentially new learning styles and the explosion of informal learning communities online—constitutes clear pressures on educational institutions to acknowledge them in some fashion. If schools do not take seriously the positive and negative potentials of digital media for learning, they risk becoming increasingly irrelevant to the lives students lead outside of school and to the futures for which they are being prepared. In thinking about the future, Perkins (2008) argues that our attention should be directed to the growing "relevance gap" in education today—the failure to teach things that have a good chance of being relevant in the uncertain future. As we've noted, successful and fulfilled individuals, workers, and local and global citizens in the future will need new kinds of competences ranging from information synthesis to social skills to the cultivation of an ethical mind. Of special importance is the capacity to draw on various disciplinary skills in order to tackle problems that by their nature entail multiple disciplinary perspectives. Schools themselves have little experience in doing this, at least before the years of higher education; it is difficult to see how they can meet this challenge without judicious use of the new digital media (Gardner 2007).

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Very few schools have risen to the challenge of remaining relevant; most have hardly progressed beyond the models in place a century ago. What might it take for slow-to-change schools to embrace the potentials, and deftly manage the risks, associated with digital media and cultivate broader competences for the future? With respect to digital affordances in particular, perhaps surprisingly to some, access to technology per se is not the panacea. As Christensen (2008) documents, the over $60 billion that schools have invested in technology over the past twenty years has had little discernible effect on pedagogies or learning outcomes. He argues that only disruptive innovation—adopting digital learning wholesale—will change education. This disruption is most likely to emerge in places where traditional ways of teaching are outright failing; over time, Christensen says, educators and the general public will come to see the potential of powerful, individualized, and connected forms of media. Other studies of school change suggest that for systemic change to be widely adopted and successfully implemented, innovations must be at least somewhat familiar to stakeholders, and presented as a coherent system (Ellsworth 2004). Informed and skilled leadership is obviously essential as well (Fullan 2007).

Part of the answer to change surely lies beyond the walls of schools themselves. Parents, government, the professions, even the marketplace, are all important stakeholders in the state of learning. Alignment among these diverse constituencies may be hard to achieve; here political leadership of the highest order is essential. In the last few decades, the phrases "learning communities," "lifelong learning," and "the learning society" have virtually become clichés. Yet like many clichés in education, and elsewhere, the terms themselves are more familiar than actual instances of the phenomena they describe. In our view, no society is likely to thrive in the future unless it actually is dedicated to lifelong learning; and this, in turn, will require both a society that values learning, and communities that continue to learn. As educators, we hope that this learning will continue to take place in educational institutions. But unless the schools are equal to the task of absorbing the new digital media, and making acute use of their potentials while guarding against their abuses, schools are likely to become as anachronistic as almshouses, teachers as anachronistic as barber-surgeons. Any culture that wishes to survive will ensure that learning takes place, but the forms and formats remain wide open.

Acknowledgments

We are thankful to David Buckingham, Tara McPherson, and Katie Salen for their helpful comments on earlier drafts of this paper. We are grateful to the John D. and Catherine T. MacArthur Foundation and to Judy Dimon for their generous support of our work in the area of digital learning.

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