Technology and the New Professionalization of Teaching

Topics

by David Williamson Shaffer, Padraig Nash & A. R. Ruis — 2015

Background: *By 2009, 99% of U.S. classrooms had access to computers, with an average ratio of 1.7 students per computer, and 40% of teachers report using computers often in their classrooms. However, while K–12 schools are investing more heavily in digital technologies, only a small fraction of this investment is going to instructional software (7%) and digital content (5%). Education policy leaders have called for increased investment in and use of digital learning technologies in K–12 education, which has significant professional implications for the 40% of teachers who use computers often and, perhaps more importantly, for the 60% who do not.*

Objective: *This article explores for a broad audience the changing landscape of education in the digital age, the changing roles of teachers in a technology-rich education system, and the skills, knowledge, values, and ways of thinking that teachers will need to have to support students' social, emotional, and intellectual development in a digital learning environment.*

Research Design: *This analytic essay reviews and synthesizes research on learning in a digital environment, providing theoretical framework for understanding the changing landscape of learning in technology-rich environments and the consequent changes in teacher preparation that this may entail.*

Conclusion: *We explore the influence of educational technologies on teaching and teacher preparation by looking at three kinds of learning technology: digital workbooks that help students learn basic skills through routine practice; digital texts, such as ebooks, virtual museums, and learning games, that provide students with mediated experiences; and digital internships that simulate real-world practices, helping students learn how to solve problems in the ways that workers, scholars, and artists in the real world do. We examine the extent to which these technologies can assume different aspects of teachers' traditional functions of assessment, tutoring, and explication. We argue that increased use of these and other digital learning technologies could allow teachers to provide more nuanced curricula based on their students' individual needs. In particular, teachers will likely assume a new role, that of a coordinator who provides guidance through and facilitation of the learning process in individual students' social, intellectual, and emotional contexts. We suggest this may require changes to teacher preparation and in-service professional development to help both new and experienced teachers succeed in an ever-changing digital learning environment, as well as new methods of evaluating teacher performance that account for more than student achievement on standardized tests.*

Interesting things happen along borders—transitions—not in the middle where everything is the same.

—Neal Stephenson, *Snow Crash*

The technologies of the digital age are fundamentally transforming economies, societies, and cultures worldwide. In the United States, 60% of jobs now require

competency with information technologies (Lamb, 2005). The number of people using Facebook to share information with friends grew a thousand-fold in a less than a decade, from 1 million in 2004 to over 1 *billion* in 2012 ("Facebook: 10 years of social networking, in numbers," 2014). Information technologies have fundamentally changed retail business, medicine, journalism, and a host of other fields, including education. We have come a long way since the first "Net Day" in 1995, when parents and IT professionals volunteered time to wire the nations' classrooms: Today more than 95% of U.S. public school classrooms have internet access. By 2009, 99% of classrooms had access to computers,

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have internet access. By 2008, 93% of classrooms had access to computers, with an average ratio of 1.7 students per computer, and 40% of teachers report using computers “often” in their classrooms (Gray, Thomas, & Lewis, 2010).[1]

But what are the professional implications of this transition for the 40% of teachers who use computers often and, perhaps more importantly, for the 60% who do not?

In this paper, we examine the changing landscape of education in the digital age, the changing roles of teachers in a technology-rich education system, and the skills, knowledge, values, and ways of thinking that teachers must have to use new technologies to support students’ social, emotional, and intellectual development. Rather than present a detailed, empirical analysis, we aim to synthesize existing research for a broad audience. Our goal is to provide a framework for practitioners and policy-makers, as well as researchers, to understand the changing landscape of learning in technology-rich environments and the consequent changes in teacher preparation that this may entail.

To look forward, though, we must first look back. To understand how modern learning technologies have fundamentally altered classroom teaching, curriculum development, content delivery, communication, assessment, and even discipline, we must understand the historical context of teaching.

THE TEACHING CENTER

The sociologist Erving Goffman described activities in which a group of people are all paying attention to the same thing *focused gatherings* (Goffman, 1966). In this sense, training young people outside of the home has for centuries been a focused activity, with some adult—the master or teacher—at the center. Whether the pedagogy was the hands-on, practice-based training of an apprenticeship, the proverbial “sage on a stage” of the traditional schoolhouse lecture and recitation, or the more modern incarnation of progressive, student-centered instruction, the teacher played a central role in guiding the development of students.

Traditionally, the best K–12 teachers have performed some combination of five primary functions in the developmental trajectories of young people.[2] While these functions are prioritized differently in different contexts and settings, each has been a key part of the student-teacher relationship:

1.

Content delivery: Based on expertise in both pedagogy and subject matter, as well as *pedagogical content knowledge* (Gess-Newsome & Lederman, 1999; Mishra & Koehler, 2006), a discipline-specific understanding of how students learn in different subjects, teachers organize activities—what they themselves do and what the students do—to help students develop particular skills or acquire knowledge about a subject. This is the teacher as *tutor*.

2.

Epistemological guidance: Teachers communicate to students not only the content of a subject but also how to think about particular kinds of problems and how to decide whether actions are “correct” or “acceptable.” That is, teachers set the norms by which decisions and actions are justified, deciding, for example, whether it is sufficient to get the “right” answer to a problem or whether a student also has to explain his or her reasoning.[3] This is the teacher as *explicator*.

3.

Socialization: Teachers establish and maintain a particular social structure within which students operate. They enforce discipline, and as a result, they reinforce particular values and norms of behavior. This is the teacher as *disciplinarian*.

4.

Nurturing: Teachers build constructive interpersonal relationships with

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Nurturing: Teachers build constructive interpersonal relationships with students. These relationships are, in turn, used by good teachers to facilitate students' emotional and social development. This is the teacher as *counselor*.

5.

Assessment: Teachers determine how well students perform in each of these areas. Teachers grade work, write reports, and communicate with families and with other educators about students' progress. This is the teacher as *evaluator*.

The mechanism through which teachers have assumed these various roles in the lives of their students is *feedback*. Feedback involves the formal elements of structured and routine assessment, such as exams and parent–teacher conferences, response to students' comments or questions, and classroom punishments or rewards, but it also includes informal mechanisms, such as body language and casual conversations with students. Teachers exhibit the various (and often simultaneous) roles of tutor, explicator, disciplinarian, counselor, and evaluator through the process of giving feedback—by structuring, guiding, enforcing, and assessing, both formally and informally, students' activities and behavior.

This raises a critical issue that has characterized schooling since the founding of the U.S. public school system in the 19th century. Through the provision of feedback the teacher has traditionally been the *focus* of the *focused gathering* of the classroom: He or she has been at the center of students' experience of tutoring, explication, discipline, and evaluation in the classroom and in many cases, the primary source of counseling as well. The teacher delivered the content, structured the learning experience, assessed student progress, and communicated with students about their learning processes and outcomes. Even when the teacher was not directly involved—for instance, when students read textbooks or completed problem sets outside of class—the work occurred in the context of learning pathways managed by the teacher.

CENTRALITY AND THE PROFESSIONALISM OF TEACHING

The positioning of the teacher as the focus of the classroom creates an inherent tension because the different roles of the teacher conflict with one another (Elbow, 1983; Yusko & Feiman-Nemser, 2008). Thus the "centering" of the teacher has compromised each of the roles that he or she can and should be playing in students' development.

The easiest way to see this conflict is in the realm of assessment. When the teacher is responsible for *tutoring* a student in content and then *assessing* whether a student has understood it, functioning as a "guide" and "coach" to a student is far more challenging; dispassionate evaluation and impassioned advocacy are difficult to balance. Furthermore, when the person doing the *tutoring* in the content of a subject is also *assessing* the results, it is a challenge as an *explicator* to convince students that what constitutes good or bad work is anything other than "what the teacher wants." Similarly, it is hard for the person responsible for enforcing *discipline* to simultaneously serve as a *counselor* for students who are having problems in school. Complicating things even more, as schooling is presently conceived, teachers assume all of these roles in children's lives, but they are only rewarded professionally for one thing: their students' academic performance. This introduces further conflict between teachers' various roles, as well as conflict between the best interests of students and the professional interests of teachers.

Navigating the tension between the developmental and evaluative portions of a teacher's job—between helping individual students grow and assessing their performance—has long been a critical part of the professionalism of teaching. A teacher's decisions have always been simultaneously conditional on what was appropriate in the larger social and intellectual context of schooling and what was best for a particular class or an individual student. Thus teachers have been defined not only by their ability to assume the roles of tutor, explicator, disciplinarian, counselor, and assessor but also by their ability to balance those roles appropriately.

Put another way, a critical feature of the professional work of teaching has been the centralization in one individual of most aspects of the educational process

the centralization in one individual of most aspects of the educational process. Despite the edicts of school boards and superintendents, teachers set the rules for their own classrooms and manage the content delivery, epistemological guidance, socialization, nurturing, and assessment in accordance with their own understandings of what was best for their students. In this way, although public school teachers have been characterized since at least the 1960s as a unionized labor force (Retsinas, 1983), their interactions with students are guided by the exercise of discretion and judgment that characterize professional work (Goodwin, 1994; Schön, 1983; Shaffer, 2007).

THE CENTRIPETAL FORCE OF TECHNOLOGY

The traditional role of the teacher as the center of schooling is thus an important context for understanding recent developments in learning and the role of new technologies in education. In particular, one critical effect of new technologies has been what Suzanne Damarin, among others, refers to as the *decentralization* of teachers in the learning environment (Damarin, 1998).

State education standards and standardized testing began the process through which teachers were shifted from the center of the learning environment. Standards set external goals for content delivery, and standardized tests did the same for assessment. Instead of teachers being the primary source for and gatekeeper of student learning, both teachers and students became engaged in a mutual endeavor to satisfy the objectives defined by the standards, which by definition lay outside the classroom and even the school itself. Put another way, modern assessment technologies have shifted teachers from the central position in terms of *assessment*; what counts as acceptable work is no longer up to the teacher alone but is determined by test developers (Herman & Golan, 1990; Stake, 1991).

This creates a new tension, of course. In this case, the struggle is not between teachers' own conflicting roles of *tutor* and *assessor*, but between the role of external assessment tools and teachers' other traditional functions. Teachers are forced to teach to the test—or at least to teach with the test in mind—thus potentially compromising their decisions about content, explication, and even nurturing in the presence of an external standard (Volante, 2004). We see this tension when a teacher worries that he or she is rushing through material to "cover content" for the test, when too little class time is available for "off topic" discussions that are important for children's development, or when teachers feel forced to cover material that may not be developmentally appropriate for some of their students.

In other words, standardized assessments may conflict with the professional judgment of teachers. This is not true in all cases, of course, but it is true often enough. Teachers are held accountable to external standards in preference to their own understandings of best practices, a departure from the American tradition of local control of schooling.

As standards and standardized tests have *decentralized* teaching, they have increasingly *centralized* the control of education. However, the role of instructional technologies in the centralization or decentralization of teaching has been less clear, in part because the types of instructional technology used in schools are more varied. To understand why, we need to look at how modern digital tools change learning in the first place.

Traditional schooling was built around reading, writing, and arithmetic. Those were the basic skills that a person needed to be part of a literate culture, and they were the foundational skills that young people needed to be successful in an industrial society. However, writing and mathematics are fundamentally *static* representation systems. The symbols do not change on their own. Written work remains the same until someone erases, alters, recombines, or otherwise reconfigures it. Modern, literate culture is a partnership in which the mind evaluates and transforms the information stored in books and other records to make decisions (Donald, 1991).

In a literate culture, people do not have to rely on memorization to keep track of information because they can write things down. But they still must know a lot because while books and paper are powerful tools for storing symbolic information, words on a printed page are inert. Someone has to be there to read them, to interpret them, and to use them.

them, to interpret them, and to use them.

What makes computers transformative is that they allow people to *process* information externally. Writing outsources memory: it allows us to record, organize, and share knowledge in great detail. But what computers do is *outsource thinking itself*. Consider the following example:

As I write this page, there is a little red squiggly line under the word "outsources" in the last paragraph. Ironically, it seems, Microsoft Word doesn't recognize "outsources" as a correctly spelled English word. It is not in the dictionary that Microsoft's spell-checker refers to. So the computer is telling me that the word is misspelled and asking if I want to correct the mistake. Many common mistakes it doesn't even ask me about. In that last sentence, for example, I forgot to type the "e" in "mistakes." The program automatically replaced what I typed, "mistaks," with the correctly spelled word, "mistakes" (Shaffer, 2007).

While this is a simple example, a computer can perform any task for which we can write a set of explicit rules. Computers are tools that take a particular form of thinking (understanding that can be expressed in the form of a finite-state algorithm) and allow it to be performed independent of any person. In fact,

computers are called "computers" because before we had electronic machines to perform calculations, people had to do that work.

Human computers actually played a critical role in developing the electronic machines that have now replaced them. Because so many American men had been drafted during World War II, it was mostly women computers who performed the calculations necessary for the construction of artillery tables, the analysis of encrypted materials, and the mathematical operations that described nuclear fission, among others. The people who programmed the ENIAC (the first general-purpose, electronic, digital computer) came from this group of human computers, so the first computer programmers were human computers (Rojas & Hashagen, 2002).

That, in turn, explains why instructional technologies are potentially de-centering for teachers. In a traditional classroom, a teacher was simultaneously a tutor, explicator, disciplinarian, counselor, and evaluator because the teacher was the only person in the room who was trained to manipulate and evaluate symbols. There was only one source of feedback in the system, only one functioning computer in the room: the teacher. The students were not yet trained.[4]

The question of how teaching will change in the era of digital technologies is thus quite profound: What is the role of the teacher in a classroom where he or she is no longer the only trained computer—where every student can have his or her own computer, or even more than one? What happens when the learning environment is no longer just a classroom but an online ecosystem? Or, to put it in global economic terms: Which of the traditional roles of the teacher will be outsourced to smart machines?[5]

THREE HYPOTHESES ABOUT INSTRUCTIONAL TECHNOLOGIES

Before we leap to a dystopian vision of an education system in which computers overthrow the teacher and begin systematically programming our children, let us begin by recognizing that—for reasons we will discuss in more detail below—computers are unlikely to be anyone's first choice for the roles of disciplinarian or counselor. The social and emotional lives of children are far too complex—and far too rooted in their relationships with adults—to be managed by machines anytime in the near future.

Of course numerous technologies, from the humble blackboard to social media, have already had a tremendous impact on teaching and learning (Cuban, 1986; Poore, 2012). Social media, for example, have changed the way that teachers and students communicate, increased access to resources, fostered new learning (and teaching) communities, and opened the classroom beyond the boundaries of geography. In these settings, peers have more opportunities to

provide feedback on academic, social, and emotional issues. Yet studies (Ahn, Bivona, & DiScala, 2011; Greenhow, Robelia, & Hughes, 2009; O'Keeffe & Clarke-Pearson, 2011) of social media in school settings suggest that the result is often a recreation of the best—and worst—of peer school culture, as stories of online bullying vividly demonstrate. In other words, social media have changed and vastly expanded the learning environment but not the function of the teacher in that environment. Similarly, MOOCs (massive, open, online courses) may expand access to education, but most simply deliver traditional pedagogy in digital form. Like social media, both the content and the discussion are embedded in the tool, but the result is typically a learning experience that mirrors the brick-and-mortar classroom, with the teacher remaining the central focus and retaining the same professional roles, even if he or she now sits in a remote location.

There are, however, a number of learning technologies that are fundamentally changing the centrality of teachers or their professional roles. In what follows, we look at three existing forms of instructional technology, each of which has different implications for the centralization and professionalization of teachers. These technologies—which provide illustrative examples rather than a complete taxonomy—serve various pedagogical functions in the 21st-century classroom. In the near future, teachers will likely employ all three, even in a single class, according to the needs of individual students and the learning goals of different units. Although we discuss each separately, it is perhaps most helpful to think of these not as discrete categories but as reference points on a continuum of present and future instructional technologies (Dede & Richards, 2012).

DIGITAL WORKBOOKS

The first type of instructional technology is perhaps the easiest to imagine: an automated workbook. Just as teachers give students worksheets to practice skills in almost every subject, those same worksheets have been adapted into computer-based workbook systems (Auzende, Giroire, & Le Calvez, 2009; Roschelle, Pea, Hoadley, Gordin, & Means, 2000). Consider, for example, the computer game *Math Blaster*, which remains a popular educational title. In the game, students fly through a fictional universe, gaining points and power for their spaceship by solving problems like "Find the sum of 30 + 10." There is nothing particularly unique about *Math Blaster*. There are games that teach spelling or typing, and some even help children remember to take their medications (Beale, Kato, Marin-Bowling, Guthrie, & Cole, 2007; Ito, 2008; Kato, 2010; Kebritchi & Hirumi, 2008; Rice, 2007). What all these games have in common is that they help children to internalize basic facts, skills, and habits. They recreate traditional classroom worksheets in digital form.

Digital workbooks have several important advantages over paper. First, they are easier to search, collect, catalog, and retrieve. Teachers potentially have access to a vast library of automated workbooks that students can use to develop and practice their mastery of facts and skills. Second, digital workbooks are dynamic and non-linear. They can include "just in time" information, so students can ask for help or see worked examples if they have trouble with a particular problem or class of problem. Digital workbooks can skip problems that will be too easy for students based on prior work or direct students to supplementary activities. Third, once digital workbooks are collected online, they can be used to track students' performance over time. Each student can have a Digital Education Record (an analog, perhaps, of a Digital Medical Record) that tracks their progress over time on a range of skills and knowledge across the curriculum.

What makes all of this possible, of course, is the fact that a digital workbook can do something that paper cannot: A digital workbook can evaluate—and thus provide feedback on—students' work. Paper workbooks can only record what students write. Digital workbooks can both record and manipulate information, enabling them to track progress and to offer new or different material in response to student performance. In other words, the digital workbook can assume a teacher's traditional function of evaluator. It can then use assessment to play the role of tutor, providing instructional resources and selecting appropriate topics for further (or remedial) study. As a result, the epistemology of the digital workbook is analogous to the pre-digital classroom only now, the measure of a correct answer is what the computer (rather than the teacher) indicates.

In this sense, a dystopian view of the digital workbook is that it will continue the process of decentralizing and deprofessionalizing teaching begun by the adoption of standards and standardized tests. The curriculum would be stored, accessed, assessed, and monitored online through a student's Digital Education Record. The teacher would retain the roles of disciplinarian and counselor, but the roles of tutor, explicator, and evaluator would be assumed by a centralized system. Of course, the more likely scenario is that teachers would still provide tutelage and explication, but in the context of the digital workbook, which would frame and perhaps even guide this process.

DIGITAL TEXTS

A second type of instructional technology is the digital equivalent of books, film, artwork, and many other media. We choose the term "digital texts" with some care.[6] We include in this category not only digital recreations of print media, such as e-books or online encyclopedias, but also audio and visual libraries (including video), various interactive hypermedia, such as virtual museums, and computer games and simulations of many kinds.[7]

In a literate society, things such as books and movies provide *mediated experiences*: settings where we experience the events and emotions not directly but through a particular medium (Jenkins, 2006). When reading a novel about war, for example, a student does not experience the combat itself. From very early in life, children learn to make sense of narratives of events (Nelson, 1996). That is, they incorporate the meaning of indirect experiences told to them by others into their own understanding. Critically, though, it is rare in the context of schooling that students are left to read books (or watch videos) on their own. The indirect or mediated experience is meant to serve as a starting point for discussion, debate, and reflection.

Some advocates of digital technologies for learning suggest that games and other digital environments will function differently, in the sense that students will be able to play with (i.e., use) digital tools and develop their own understandings of these simulated experiences. In this view, students are "noble savages" growing up in a digital wilderness untainted by the prejudices and strictures of adults (Bennett, Maton, & Kervin, 2008; Ito, 2010a, 2010b; Resnick, 1994). Other researchers argue that the most plausible use of games and simulations —as well as digital versions of books and other media—will be similar to the use of books in the traditional classroom. Students will use the mediated experiences of games and other media to make sense of events and concepts. But, this argument goes, students' understanding of those experiences will be shaped by conversations with peers and with the teacher through additional learning activities set around the games and media themselves (Gee, 2007; Squire, 2005).

Consider, for example, a computer game like *Civilization*, which has been studied in some depth as an educational tool (Shaffer, Squire, Halverson, & Gee, 2005; Squire, 2004). *Civilization* is a strategy game that lets players build an empire. Beginning with a Stone Age settlement, they make technological, economic, political, religious, and military decisions to help their civilization grow. As a result, they have an opportunity to see how geographical location, trade, and available raw materials shape historical development. In the context of school, they do so not just by playing the game but by playing the game and then discussing it in class.

In this sense, the digital text *reverses* the process of decentralizing and deprofessionalizing teaching seen with digital workbooks. As with digital workbooks, the curriculum is stored and accessed partly online through a library of digital tools and their associated curricula. Indeed, digital texts—including games and simulations—can be far richer than the texts of the past. But unlike the digital workbook, the digital text assumes that the teacher will continue to play the role of tutor and explicator, helping students make sense of their mediated experiences, selecting additional experiences, and weaving together a coherent curriculum from an increasingly large array of choices. For example, a student cannot accomplish significant goals in *Civilization* without first understanding the historical principles that underlie the game (Squire, 2004). The teacher would also retain the roles of disciplinarian and counselor. The role of evaluator would remain centralized, either through standardized tests similar to those we have today or, as many scholars advocate, through assessment

to those we have today or, as many scholars advocate, through assessment tools integrated into the digital text itself, what Valerie Shute terms *stealth assessment* (Gee & Shaffer, 2010; Ifenthaler, Eseryel, & Ge, 2012; Phillips & Popović, 2012; Shaffer & Gee, 2012; Shaffer, 2009; Shute, 2011; Shute & Ventura, 2013; Williamson et al., 2004).

DIGITAL INTERNSHIPS

A third type of educational technology is the digital simulation of an internship, apprenticeship, or practicum, a virtual environment in which students can engage in practice-based or work-based learning (Barab et al., 2009; Chesler, Arastoopour, D'Angelo, & Shaffer, 2011; Hickey, Ingram-Goble, & Jameson, 2009; Sadler, Romine, Stuart, & Merle-Johnson, 2013; Scardamalia, 2004; Shaffer, 2006, 2007; Slotta & Linn, 2009). Just as digital workbooks and digital texts are computer-enhanced versions of their analog cousins, digital internships are computer simulations in which students assume the role of interns in a real-world avocation or occupation. We can imagine digital internships where students work in a simulation as doctors, or engineers, or accountants, or playwrights, or advertising executives, or music producers, or auto mechanics, or artists, or in a host of other roles.

Digital internships have already been developed in which students work as engineers who are designing filtration membranes, robotic legs, or wireframe models of animated characters (Chesler, Arastoopour, D'Angelo, Bagley, & Shaffer, 2013; Svarovsky & Shaffer, 2006); as urban planners who must rezone a city (Bagley & Shaffer, 2009; Beckett & Shaffer, 2005); as biologists, chemists, and other professionals who must evaluate causal relationships in pond and forest ecosystems (Dede, 2012; Metcalf, Kamarainen, Tutwiler, Grotzer, & Dede, 2011); or as science journalists who report on the impact of new discoveries on local communities (Hatfield & Shaffer, 2006). Systems like *epistemic games* (Shaffer, 2007), WISE (Linn et al., 2014; Slotta & Linn, 2009) and Knowledge Forum (Scardamalia, 2004) support creation of a wide range of problem-solving scenarios. Collectively, these simulations enable students to frame, investigate, and solve complex problems based on real-world issues and practices. In the digital internships we have developed, for example, students take on a *role* (intern) and interact with other people during the internship: other students in the simulation (i.e., other *players*), but also computer-generated *non-player characters* (NPCs), such as their internship supervisor. During the digital internship, students receive directions, feedback, and guidance from these NPCs, whose actions are controlled in part by programming and in part by a human facilitator. Through this combination, NPCs answer students' questions, offer suggestions, guide reflective conversations, facilitate collaboration, and provide support. Because all action and communication is virtual, digital internships can be run remotely by trained facilitators, who control the actions of the supervisor, advisor, and other NPCs in the simulation. Using customized scripts and artificial intelligence supports, facilitators can work with multiple groups of students. Interactions that students have within the simulation are analyzed in real time, and they help the facilitator guide students through the simulation's content in a way similar to a digital workbook.

What research on digital internships shows is that in these environments, students do not just learn important academic skills and content knowledge; they also learn to think about and solve complex problems *in the way* scholars, artists, and workers in the real world do (Bagley & Shaffer, 2011; Chesler et al., 2013; Hewitt, 2004; Nash & Shaffer, 2011; Shaffer, 2007; Slotta & Linn, 2009). Sam Wineburg has argued, for example, that the history taught in high school classrooms often bears little relationship to history as practiced by historians. The "dates and greats" approach that characterizes most standard texts, which are replete with passive language, vague or diffuse causation, and depersonalized events, reduces the rich complexity of historical scholarship to only the most basic and uncontroversial facts. For the students whom Wineburg studied, history is an objective account of events—indeed, *the* account of events—recorded in textbooks. Professional historians, in contrast, regard historical inquiry as an epistemological system in which various kinds of evidence are interpreted, analyzed, and combined to construct arguments about the events and people of the past. Accordingly, history teachers should emphasize not memorization of basic facts but teaching students to think about history like historians do: to evaluate facts, interrogate sources, and construct historical narratives from fragmentary and often contradictory evidence (Wineburg, 1991).

Digital internships based on this principle have a different effect on teaching than the other two kinds of learning technology. Digital workbooks continue the decentralization and deprofessionalization of teaching, and digital texts reverse that process, recentralizing and reprofessionalizing teaching. Digital internships, in contrast, do something quite different. They simultaneously *DE*-centralize and *RE*-professionalize teachers.

Digital internships accomplish this repositioning of the teacher by offloading to the digital tool the roles of tutor, explicator, and evaluator. In this sense, digital internships are more like digital workbooks than digital texts. But unlike digital workbooks—where the machine is always right—each digital internship is built around different characters, different problems, and different real-world practices. The computer plays multiple roles, and because different internships simulate different kinds of problem solving, they may even have different "best" solutions to the same problem. Thus, the teacher plays a higher level role of explicator: not deciding which answer is right, but helping students understand when one kind of thinking is more useful than another to solve real problems. Balancing those discussions, in the context of the role of disciplinarian and counselor, is a task that requires the kind of professional judgment that has long characterized teaching, only now that judgment is exercised independent of the teacher's traditional functions of tutor and evaluator. The teacher assumes a meta-role that is focused on helping students integrate various internship experiences into their understanding of themselves and their world.

Although the concept of an internship is something we typically associate with teenagers and young adults, this approach can work just as well with younger children. At the most basic level, digital internships situate learning in the context of doing. That is, they help people learn facts, skills, and ways of thinking not in the abstract but in the context of (simulated) real-world activities or problems. Those activities and problems may be complex, in the case of older learners, or simpler for younger learners.

THREE PHILOSOPHIES OF INSTRUCTIONAL TECHNOLOGY

These three categories of instructional technology—digital workbooks, digital texts, and digital internships—reflect different hypotheses about the nature of learning in the digital age, hypotheses grounded in different educational philosophies. Digital workbooks are based on the idea that what students need to learn in school are basic knowledge and skills, the kind that can be developed through workbook practice. Digital texts (including many kinds of computer game) are based on the idea that students should learn from mediated experiences, which can then be interpreted and understood in conversation with peers and adults. Digital internships are based on the belief that students require enculturation: learning the skills, values, and ways of thinking of groups that play important roles in society.

These are not mutually exclusive functions, of course. For example, some games attempt to be a hybrid of digital text and digital internship, such as the *SimCity* game currently being adapted by GlassLab to embed assessments

("EA and Glasslab collaborate to inspire next generation through SimCityEdu," 2013). The apprenticeship model may not be extensive, but the roles and real-world applications that students take on can still be robust. Based on the discussion above, however, each of these approaches does have different implications for teaching in the digital age. Each use of digital technology for instructional purposes requires a different configuration of roles and responsibilities for teachers (see Figure 1 for a summary).

Fully realized digital workbooks have the potential to reduce the teacher's roles, as such tools could assume from them much of the subject-matter expertise and the tasks of content delivery and assessment. Embedding the roles of tutor, explicator, and evaluator in the digital workbook could thus leave teachers less freedom to exercise professional judgment regarding content. Digital texts can assume the task of assessment, enabling teachers to focus more on instructing and guiding students and on structuring the learning environment. However, this still requires teachers to perform many of their traditional duties, and teachers remain centered in students' learning experiences. Where digital workbooks fundamentally alter the teacher's role, digital texts change it only slightly. Digital internships fall somewhere in between. The digital internship assumes the role

of tutor and evaluator, as with digital workbooks, but teachers retain the role of explicator, not by determining which answer is right, but by helping students understand when and why to apply different kinds of thinking. In engineering, for example, digital internships would evaluate and provide feedback on students' work. The same thing would be true for digital internships in urban planning. But now imagine a student who participated in a digital internship in engineering *and* one in urban planning, both studying water quality issues in a city. The discussion with the teacher would no longer be about whether the work the student did in one internship or the other was correct, but about the advantages and disadvantages of the different perspectives, and the contributions of each approach to finding solutions to complex problems. In other words, in digital internships the teacher retains a critical epistemological function of *explicator* in helping students understand the nuances of decision making when there is no one "right answer" to issues and problems.

Figure 1. Roles of the teacher using three kinds of digital learning technology.

			Digital Workbook	Digital Text	Digital Internship
Pedagogical Roles	Social	Disciplinarian	Teacher	Teacher	Teacher
		Counselor	Teacher	Teacher	Teacher
	Academic	Tutor		Teacher	
		Explicator		Teacher	Teacher
		Evaluator			
Focus and Professionalism		Central Focus		Teacher	
		Professional Judgment		Teacher	Teacher

Regardless of any single person's—or single group's—philosophy of what is best for students, it seems likely that in the near future, *all* of these digital tools will be used routinely in schools, each serving a different educational purpose. The implications for teaching, then, are complex. As has always been the case, teachers will need to use different tools in different ways. Across these pedagogical tools, however, there are two consistent themes that will mark teaching in the coming years. First, the guidance—and particularly the social support—that teachers provide to students will not disappear, and in fact will become even more integral. Second, the role of the teacher will move from its traditional position of centrality in the academic life of a student to a decentralized position in a distributed network of mentoring.

DISTRIBUTED MENTORING

Feedback is the central mechanism through which teachers have guided students' development, but teachers are no longer the sole source of feedback in a technology-rich environment. Students using digital workbooks, digital texts, and digital internships receive feedback directly from the technologies themselves in a learning environment structured as much by the digital tools as by the teacher or classroom. Digital workbooks and digital internships in particular assume from teachers the role of delivering content. Teachers using such tools, then, can focus on nurturing students and structuring their learning experiences. They function, as Damarin puts it, more as "guides than as repositories of knowledge" (Damarin, 1998).

Children have highly individualized needs that depend on their particular contexts. When able to concentrate on certain roles, teachers, who have intimate knowledge of their students and their students' communities, can be

more effective advocates and coaches for the children in their classrooms.

Students were once defined largely by their grade in school, and teachers had little choice but to teach primarily to classes rather than individuals. Digital tools make it possible for teachers to engage in a more nuanced and complex relationship with students . Removed from the center of the focused activity of the classroom, teachers no longer have to address students as an undifferentiated mass at the periphery of instruction. Both teachers and students are now part of a technological network that connects them to people and resources beyond the classroom. The learning environment is larger, with more resources and with more space for individualized teaching and learning. The role of the teacher in such an environment shifts toward one-on-one support and guidance. The process looks more like *mentoring* than the instruction and evaluation of the traditional classroom.

But the mentoring role of the teacher does not take place in isolation. Rather it takes place as part of a larger system that could more properly be called *distributed mentoring* (Nash & Shaffer, 2011, 2012, 2013).

Psychologists have argued that learning is a fundamentally social activity. Children learn by engaging in purposeful activities within a social context, and the learning that results comes from the interaction of a student with different people and things in the surrounding environment: peers, elders, and teachers, as well as books, tools, and other technologies (Brown, Collins, & Newman, 1989; Hutchins, 1995; Lave & Wenger, 1991; Rogoff, Baker-Sennett, Lacasa, & Goldsmith, 1995; Vygotsky, 1978). This is a view of learning that is sometimes referred to as *distributed cognition* because the feedback learners receive comes from different people and tools in a social setting (Hollan, Hutchins, & Kirsh, 2000; Salomon, 1997).

Distributed mentoring, in turn, is a theory of development with a similar underlying framework. This theory suggests that young people learn, grow, and

change through interactions not just with an individual mentor but with a *mentoring system* (Freedman, 1999). Young people learn from a network of concerned adults: a community formed of parents and other relatives, coaches, teachers, neighbors, employers, and others. Too often, however, we think of a child's mentor as a kind of super figure—like Mr. Miyagi in the *Karate Kid* movies, who is surrogate father, teacher, trainer, and life-coach to a young boy. This view of mentoring attributes to good mentors a nearly infinite capacity to reach young people and guide them into adulthood.

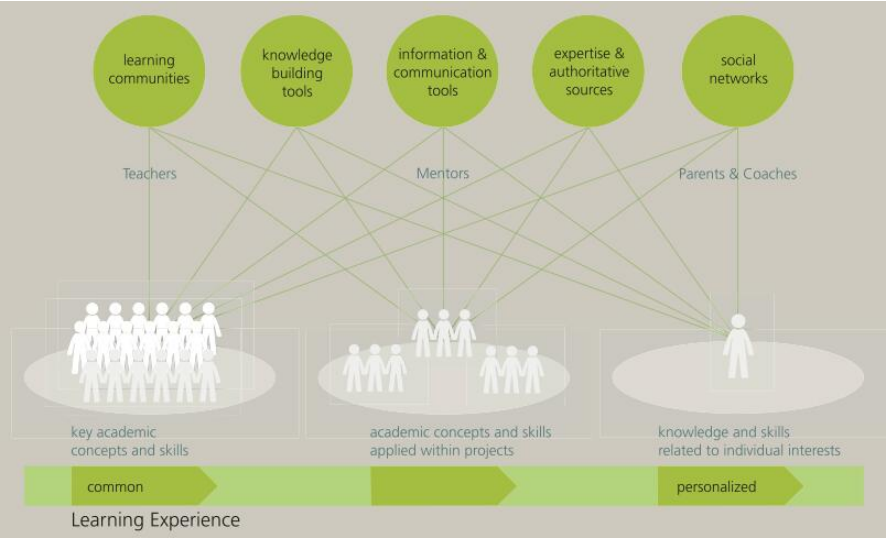
However, research on mentoring suggests that effective relationships between children and their adult mentors occur most often in youth organizations (such as the Boys and Girls Club or YMCA/YWCA), sports programs, after-school clubs, community arts initiatives, and other formal, organized activities. These activities provide a structured environment in which young people experience what Reed Larson calls a "rare combination of intrinsic motivation" and "deep attention" (Larson, 2000). In such contexts, participants' involvement is contingent upon acceptance of the constraints, rules, and goals of the activity.

Thus, no one mentor is key; rather, it is the environment that facilitates mentoring. Mentors provide supervision and guidance, set and enforce rules, establish goals, and evaluate achievement and progress. Development in these environments is partly about a one-to-one relationship between mentor and mentee, but it also involves all of the interactions that a child has with his or her surroundings, the tools that are available, and the people who are there. Thus, mentorship in a learning context is distributed across people, places, and things.

A NEW PROFESSIONALIZATION OF TEACHING

There is increasing recognition in the educational technology policy literature that new learning tools must be leveraged to personalize education and engage students (Atkins et al., 2010; Blomeyer, 2002; Ringstaff & Kelley, 2002; Watson, Murin, Vashaw, Gemin, & Rapp, 2011). This literature acknowledges the importance of network models of education and the need to rethink the place of teachers. However, it often continues to construe the *role* of the teacher as distinct from mentorship (see Figure 2).

Figure 2. Model of learning proposed by the U.S. Department of Education's 2010 report, *Transforming American Education: Learning Powered by Technology* (Atkins et al., 2010).



In arguing that teachers become mentors in a technology-rich classroom, we do not suggest that they should be a kind of super figure. Rather, we argue that they are likely to take on a new role in schooling—the *coordinator*, who orchestrates students' interactions within a system of distributed mentoring—a role more like that of a senior practitioner in an apprenticeship or internship than the role of a traditional classroom teacher. In a learning environment characterized by a complex network of digital workbooks, digital texts, and digital internships, as well as social networks that transcend time and geography, teachers will no longer be the sole source of feedback for students. Instead, they become the coordinators, orchestrators, and interpreters of feedback coming to students through a variety of learning resources.

This, in turn, will require a new kind of professionalism. In the digital classroom, teachers will need to cultivate deeper, more personalized relationships with students. They will have to provide structure and facilitate work on an individualized basis. In this way, they will be able to maximize the learning experience for every student. This new digital pedagogy is based on the distribution of knowledge across people and technologies, the importance of mentoring, and the recognition that there are multiple ways of knowing.[8]

If classrooms become hubs for digital workbooks and nothing else, then surely there is a risk that teachers will be charged primarily with maintaining social order and discipline, and the suggestion will soon follow that students are better off learning on their own at home.

But this would be a set of tragic misunderstandings: Of the importance of teachers as mentors for young people. Of children's need to develop more than just basic skills and knowledge. And of the range of educational tools and experiences that new technologies can provide.

An educational system that takes advantage of digital tools to prepare students for the world that new technologies have created will require *differently trained* teachers than before. Learning technologies offload or outsource those elements of teaching that can be programmed in advance: in digital workbooks with basic instruction and assessment; in digital texts with new forms of mediated experience; and in digital internships with the ability to join communities of innovative and creative problem solvers.

In many ways, these tools will perform their tasks with more accuracy and efficiency than a human could. But rather than making a teacher redundant, this will likely provide teachers with more time to take on the role that computers cannot: the *coordinator* who provides guidance through and facilitation of the learning process in individual students' social, intellectual, and emotional

learning process in individual students' social, intellectual, and emotional contexts, integrating learning, growth, and development across the many tools of instruction.

GETTING THERE

Of course, the transition will not be seamless. Effective use of any digital tool will require changes in pedagogy and teacher training, as, of course, will teachers' new role as *coordinator*. Although it could still be some time before education is based largely on digital workbooks, digital texts, digital internships, and other computer-based learning technologies, the educational system is on the verge of dramatic change, and innovations will continue to appear. Developing new pedagogical strategies and rethinking the functions and training of teachers will be critical to the success of schools in the 21st century.

In what follows, we present a framework that outlines the roles teachers are likely to have as we move into an era of digital pedagogy, and we discuss how teacher preparation programs and educational institutions and policies can facilitate this transition. These are not based on empirical study—although many of the works cited include empirical studies of new technologies and their impact on teaching and learning. Rather, we hope this framework will suggest avenues for further empirical research and provide a useful platform for discussing policy changes that will enhance the evolution of digital pedagogy.

THE ROLES OF THE TEACHER IN A DIGITAL CLASSROOM

The teacher's roles in a digital classroom (and the larger digital ecosystem in which it is situated) are simultaneously less central and more important than ever. As with the traditional roles outlined above, we suggest that the teacher of the future will likely have five primary and overlapping roles, which include many new elements but also incorporate and extend some aspects of traditional teaching. Of course, there are a number of ways in which teachers' roles may evolve in the increasingly digital learning environment. The following framework is one possible path, but it is one in which teachers are de-centered but maintain their professional judgment.

1.

Coordinator. Students in a digital classroom will likely be engaged in a wide variety of activities mediated by instructional technologies. Teachers will increasingly guide each student to the technologies and resources most appropriate for his or her individual needs, facilitating intellectual, social, and emotional development on an individual basis, rather than teaching primarily to class or grade level. For teachers to form this critical bridge between individual students and the variety of instructional tools available, they will need the ability to allocate classroom resources judiciously and facilitate reflective conversations with and among students. The teacher's role will thus be one of *synthesis*. Teachers will help students make sense of a variety of experiences, allowing those students to see the connections between their experiences. They will also help students develop the critical 21st-century skill of *code-switching*, or operating in different contexts according to appropriate but changing norms (Auer, 2013; Heller, 1988).

2.

Mentor. Children have individual needs that depend heavily on their particular contexts. Good teachers already know their students and their students' communities. To develop more individualized learning agendas for their students, teachers will need to be familiar with their students' lives. This requires cultivating a deeper understanding of their students' homes and communities, learning about the other adults in their students' lives, knowing the activities in which their students are engaged, and being familiar with the interests their students have. Teachers will thus need to be able to navigate complex social environments. When not solely responsible for content delivery and assessment, teachers can focus on enhancing their existing relationships with individual students and the community. This greater participation in their students' lives will allow them to be more informed advocates for their students.

3.

Translator. Students heavily immersed in digital learning environments will receive frequent feedback from numerous sources. Teachers will need to help students translate the feedback they receive (from both instructional technologies and their networks of resources) into manageable learning goals and commensurate learning strategies. In doing this, the teacher will also help

students learn to deal with feedback effectively, encouraging them to develop skills such as perseverance in the face of obstacles (Shechtman, DeBarger, Dornsife, Rosier, & Yarnall, 2013). Importantly, translation is not about evaluating students but about helping them acknowledge, interpret, and use the feedback they receive to further their learning and development.

4.

Learner. Teachers in digital classrooms will need to be comfortable with new technologies and new methods for measuring student performance. They will not be able to wait until the proverbial "tech guy" shows up to solve every problem with the machines that are so central in students' work, especially in the context of BYOD programs.[9] The rate at which technology changes will require that teachers keep up with advancements in technology and continually develop their own facility with new tools. This may not be the challenge it once was, however, as there are a number of existing models that successfully combine pedagogical and technological training (Koehler, Mishra, Kereluik, Shin, & Graham, 2014; Mishra & Koehler, 2006; Sandholtz & Reilly, 2004).

5.

Expert. In the digital classroom, some of the subject matter expertise and pedagogical content knowledge is built into the digital tools—depending, of course, on the specific digital tool being used. In the digital learning environment, teachers will still need this expertise, but they will apply it in concert with digital tools, such that students will have multiple, dynamic experts —both human and electronic—that can guide them. Because digital instructional technologies allow learning to be decoupled from location, teachers' expertise is no longer limited to any one class. School districts in the near future could hire teachers for a variety of functions, many of which may not be limited to a classroom or a class period. Of course, teachers will still need to understand the learning goals and standards set by the educational system—and how students' mastery of those standards will be assessed.

Teachers would also retain their traditional roles of disciplinarian and counselor. To assume these new roles, teachers will need to manage diverse projects and levels of student performance, which can be facilitated by the digital tools themselves. Unobtrusive assessments and other applications that update the teacher on student progress and struggle are already the focus of much development, and they will be essential in helping teachers take on these new roles.

We thus present this framework as a kind of best-case scenario, in which teachers and technologies each perform the tasks for which they are best suited. While this scenario is still in the future, we argue that now is the time to begin preparing for it, as schools are already taking important steps in this direction.

PREPARING TEACHERS FOR THE DIGITAL CLASSROOM

What such preparation might look like is, of course, a significant question in its own right. But we can at least speculate as to some of the steps that might support teachers and schools in making the transition to the new role of the re-professionalized and de-centered teacher.

First, novice teachers may need help preparing for a changing educational landscape, and experienced teachers may need additional professional development opportunities to adapt to changing conditions in schools (Lawless & Pellegrino, 2007). For example, it would help teachers prioritize coordination and mentoring and use digital tools for basic instruction if teacher preparation

involved more extensive training in individuation of instruction, counseling, and mentorship more generally. Given current educational disparities for certain groups of students, this preparation should also include training in *culturally*

responsive pedagogy (Gay, 2010) and the use of digital tools to address opportunity gaps.

Second, teachers have traditionally been intimately involved in the creation and deployment of lesson plans, activities, and assignments, and they may need to develop this connection to digital learning media. Teacher preparation programs could help teachers learn how to design, evaluate, and use various digital tools. However, this will require more sophisticated computer and media training than is offered in many such programs (Sung & Lesgold, 2007).

Third, part of teacher training (both pre-service and in-service) may involve teachers learning from the same technologies that their students will use in the classroom, including digital workbooks, digital texts, and digital internships. In this, they could be guided by their own mentors, who can model the digital pedagogies teachers will use in their classrooms and provide feedback to novice teachers on their progress (Yusko & Feiman-Nemser, 2008).

Lastly, the skill-set of teachers in a digital classroom will likely evolve in concert with the digital tools. Teachers could benefit from membership in a robust professional network with which they can share experiences, advice, and strategies. Being a teacher is intensely challenging in even the best of contexts. In a digital teaching and learning landscape, teachers will likely need continuous professional development opportunities, both online and off, and schools and communities could support this ongoing process (Mouza, 2009).

SUPPORTING TEACHERS IN THE DIGITAL CLASSROOM

To make this change successfully, schools could provide space for teachers to continue their training and pursue their interests. Simply put, we cannot overload teachers as we so often do. Teachers inspire students by getting involved in new endeavors, by following their passions and interests, and by sharing them in the classroom. But teachers cannot do this—much less keep pace with rapidly evolving educational technologies—if they are burdened with excessive teaching loads or if they are unable to access important resources.

Digital technologies will restructure not only learning but also school itself—indeed, they have already done so (Ahn, 2011; Zucker & Kozma, 2003). The online environment in which many learning activities take place requires neither the traditional, discipline-based grouping of courses and teachers nor the centrality of the classroom in students' learning environment. Just as digital technologies provide students access to instruction and feedback beyond their classrooms, they also allow teachers to exercise their skills outside the space of any given classroom and beyond the time constraints of any given period.

For example, the teacher who at one point in time may be interacting with students in the new role of coordinator at another time could be developing a new digital text, or be facilitating a digital internship for students across the district. Thus a given school (perhaps even a district) could utilize the abilities of its teachers more effectively because no teacher would be bound exclusively to one class or subject. While this could further the trend in which teachers are expected to assume more and more responsibilities, it could also enable them to be more innovative, or reduce burn-out by providing more variety.

The new professionalization of teaching, in sum, may require renewed investment in teaching, in teachers, and in teacher preparation. Digital technologies are not likely to replace adults as important guides and role models in students' development. What digital tools could do, if well designed, well

chosen, and well deployed, is make teachers more effective in both traditional and new roles, especially in their new role as coordinator.

To accomplish this, we can no longer afford to evaluate teachers on a single metric: the performance of their students on standardized tests. Teachers contribute to the education and development of children in numerous ways, and our educational institutions must devise systems that acknowledge and reward the full range of professional services that teachers perform. In particular, systems for evaluating teacher performance should take into account teachers' shift from the center of the pedagogical exercise to the coordinator of a range of learning and mentoring resources. This will require that teachers receive consistent support as they learn how to shift from the focus of a student's

consistent support as they learn how to shift from the focus of a student's academic life to someone who helps students coordinate the digital experiences they need to grow intellectually, socially, and culturally.

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Notes

1. Of course, aggregate statistics can obscure tremendous local variation, and there is a difference between "Internet access" and "reliable, high-speed Internet access," but the trend is clear nonetheless.

2. Furthermore, internet access is only one indicator of technological change, and other indicators provide a slightly different picture. For example, although digital technology purchases by K–12 schools increased 20% from 2009 to 2010, almost half of the money was spent on interactive white boards; instructional software (7%) and digital content (5%) accounted for only a small percentage of spending on digital technologies in 2010. This suggests that K–12 schools are investing in classroom technologies, but they are not investing heavily in innovative, personalized technologies designed primarily to improve student learning (Education Market Research, 2012).

3. These functions—and the relationships between them—have shifted over the time since modern schools were founded in the mid-19th century. While it is beyond the scope of this paper to chart that interesting and important history, the idea that new social and economic conditions bring changes in classrooms and in the role of teachers is hardly new. For an overview of this, see Shaffer (2007).

4. Of course, studies of American education show that classroom exchanges are often characterized by what researchers have called an *IRE* (initiate, respond, evaluate) dynamic, in which the teacher asks for the answer, a student offers it, and the teacher responds with "right" or "wrong" and then moves on (see, for example, Edwards & Mercer, 1987). Whether teachers engage in more complex discussions with students or not, they are still setting the terms by which knowledge is deemed "correct" or "appropriate", and this epistemological function is a critical part of student learning. In fact, some would argue that it is the most important component of intellectual training students receive (see, for example, Shaffer, 2007).

In making this claim, we do not suggest that children are empty vessels whom teachers fill with knowledge, values, and so forth. Rather, we suggest that historically, children entered school with little or no training in reading, writing,

and other skills that involve the manipulation of symbols, and the teacher was the only source of such training in the classroom.

5. We ask these questions not from a position of technological determinism but simply to understand how the availability of digital technologies is changing teaching and learning. We acknowledge that the relationship between education and technology is influenced by a number of non-technical factors, including changes in social, cultural, and political priorities. These changes are, of course, also partly shaped by those same technologies. In this paper, we focus largely on the technological dimensions of what is a complex and dynamic issue.

6. As one of our colleagues pointed out, this is somewhat like referring to cars as "horseless carriages," but this is precisely our point. Although new media expand the range of things that students can *experience*, the processes of *reflection* and *interpretation* remain the same. There are many ways in which expanding the range of experience is potentially transformative, but a teacher using a digital text is in a similar position relative to the student that a teacher using a traditional print text is.

7. As we have indicated above, these categories are not mutually exclusive. Thus, an interactive digital text can also have some properties of a digital

Thus, an interactive digital text can also have some properties of a digital workbook: For example, students could look up an answer or get additional explanations without having to ask a teacher. But, as we argue below, students' understandings of these experiences will be similar in the sense that they still need to be interpreted outside the text itself.

8. Part of this individualization of education will require that teachers be cognizant of the cultural, social, and economic factors that affect learning, which raises issues of social justice and children's rights. While a detailed analysis of these issues is beyond the scope of this discussion, they will be important as researchers and policy leaders develop systems to support the expansion of digital pedagogy.

9. Schools with bring your own device (BYOD)—sometimes referred to as bring your own technology (BYOT)—programs encourage students to use their own computers, tablets, mobile phones, and other devices in the classroom to access digital learning tools. Thus, teachers may need to facilitate student activities on a range of devices with various hardware and software capabilities.

References

Ahn, J. (2011). Policy, technology, and practice in cyber charter schools: Framing the issues. *Teachers College Record*, *113*(1), 1–26.

Ahn, J., Bivona, L. K., & DiScala, J. (2011). Social media access in K-12 schools: Intractable policy controversies in an evolving world. *Proceedings of the American Society for Information Science and Technology*, *48*(1), 1–10.

Auer, P. (2013). *Code-switching in conversation: Language, interaction and identity*. London, UK: Routledge.

Auzende, O., Giroire, H., & Le Calvez, F. (2009). Innovative technologies in education: Creating dynamic and interactive tests. In S. C. Kong, H. Ogata, H. C. Arnseth, C. K. K. Chan, & T. Hirashima (Eds.), *Proceedings of the 17th International Conference on Computers in Education*. Hong Kong, China: ICCE.

Atkins, D. E., Bennett, J., Brown, J. S., Chopra, A., Dede, C., Fishman, B., . . . Williams, B. (2010). *Transforming American education: Learning powered by technology*. Washington, DC: U.S. Department of Education.

Bagley, E. A., & Shaffer, D. W. (2009). When people get in the way: Promoting civic thinking through epistemic game play. *International Journal of Gaming and Computer-Mediated Simulations*, *1*(1), 36–52.

Bagley, E. A., & Shaffer, D. W. (2011). Promoting civic thinking through epistemic game play. In R. Ferdig (Ed.), *Discoveries in gaming and computer-mediated simulations: New interdisciplinary applications* (pp. 111–127). Hershey, PA: IGI Global.

Barab, S. A., Scott, B., Siyahhan, S., Goldstone, R., Ingram-Goble, A., Zuiker, S., & Warrant, S. (2009). Transformational play as a curricular scaffold: Using videogames to support science education. *Journal of Science Education and Technology*, *18*(3), 305–320.

Beale, I. L., Kato, P. M., Marin-Bowling, V. M., Guthrie, N., & Cole, S. W. (2007). Improvement in cancer-related knowledge following use of a psychoeducational video game for adolescents and young adults with cancer. *Journal of Adolescent Health*, *41*(3), 263–270.

Beckett, K. L., & Shaffer, D. W. (2005). Augmented by reality: The pedagogical praxis of urban planning as a pathway to ecological thinking. *Journal of Educational Computing Research*, *33*(1), 31–52.

Bennett, S., Maton, K., & Kervin, L. (2008). The "digital natives" debate: A critical review of the evidence. *British Journal of Educational Technology*, *39*(5), 775–786.

Blomeyer, R. (2002). *Virtual schools and e-learning in K-12 environments: Emerging policy and practice*. Naperville, IL: North Central Regional Educational Laboratory.

Brown, J. S., Collins, A., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 453–494). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Chesler, N. C., Arastoopour, G., D'Angelo, C. M., Bagley, E. A., & Shaffer, D. W. (2013). Design of professional practice simulator for educating and motivating first-year enginnering students. *Advances in Engineering Education*, *3*(3), 1–29.

Chesler, N. C., Arastoopour, G., D'Angelo, C. M., & Shaffer, D. W. (2011). Use of a professional practice simulation in a first year introduction to engineering course. *American Society for Engineering Education Annual Conference*. Vancouver, BC.

Cuban, L. (1986). *Teachers and machines: The classroom use of technology since 1920*. New York, NY: Teachers College Press.

Damarin, S. K. (1998). Technology and multicultural education: The question of convergence. *Theory into Practice*, *37*(1), 11–19.

Dede, C. (2012). Interweaving assessments into immersive authentic simulations: Design strategies for diagnostic and instructional insights. In *Invitational Research Symposium on Technology Enhanced Assessments*. Washington, DC: K-12 Center at ETS.

Dede, C., & Richards, J. (2012). *Digital teaching platforms: Customizing classroom learning for each student*. New York, NY: Teachers College Press.

Donald, M. (1991). *Origins of the modern mind: Three stages in the evolution of culture and cognition*. Cambridge, MA: Harvard University Press.

EA and Glasslab collaborate to inspire next generation through SimCityEdu. (2013). Retrieved from http://www.simcity.com/en_US/simcityedu

Education Market Research. (2012). *The complete K-12 report: Market facts & segment analyses*. Rockaway Park, NY: Education Market Research.

Edwards, D., & Mercer, N. (1987). *Common knowledge: The development of understanding in the classroom*. London, UK: Methuen.

Elbow, P. (1983). Embracing contraries in the teaching process. *College English*, *45*(4), 327–339.

Sedghi, A. (2014). Facebook: 10 years of social networking, in numbers. *The Guardian*. Retrieved from http://www.theguardian.com/news/datablog/2014/feb/04/facebook-in-numbers-statistics

Freedman, M. (1999). *The kindness of strangers: Adult mentors, urban youth, and the new voluntarism*. Cambridge, UK: Cambridge University Press.

Gay, G. (2010). *Culturally responsive teaching: Theory, research, and practice*. New York, NY: Teachers College Press.

Gee, J. P. (2007). *What video games have to teach us about learning and literacy*. New York, NY: Palgrave/Macmillan.

Gee, J. P., & Shaffer, D. W. (2010). Looking where the light is bad: Video games and the future of assessment. *Phi Delta Kappa International EDge*, *6*(1), 3–19.

Gess-Newsome, J., & Lederman, N. G. (1999). *Examining pedagogical content knowledge*. New York, NY: Kluwer Academic Publishers.

Goffman, E. (1966). *Behavior in public places: Notes on the social organization of gatherings*. New York, NY: The Free Press.

Goodwin, C. (1994). Professional vision. *American Anthropologist*, *96*(3), 606–633.

Gray, L., Thomas, N., & Lewis, L. (2010). *Teachers' use of educational technology in US public schools: 2009. National Center for Education Statistics*

technology in US public schools: 2009. National Center for Education Statistics. Washington, DC: U.S. Department of Education.

Greenhow, C., Robelia, B., & Hughes, J. E. (2009). Learning, teaching, and scholarship in a digital age: Web 2.0 and classroom research: What path should we take now? *Educational Researcher*, *38*(4), 246–259.

Hatfield, D. L., & Shaffer, D. W. (2006). Press play: Designing an epistemic game engine for journalism. In *International Conference of Learning Sciences*. Bloomington, IN.

Heller, M. (1988). *Codeswitching: Anthropological and sociolinguistic perspectives (Vol. 48)*. Berlin, Germany: Walter de Gruyter.

Herman, J. L., & Golan, S. (1990). *Effects of standardized testing on teachers and learning—another look*. Los Angeles, CA: UCLA Center for Research on Evaluation, Standards, and Student Testing.

Hewitt, J. (2004). An exploration of community in a knowledge forum classroom. In S. A. Barab, R. Kling, & J. H. Gray (Eds.), *Designing for virtual communities in the service of learning* (pp. 210–238). Cambridge, UK: Cambridge University Press.

Hickey, D., Ingram-Goble, A., & Jameson, E. (2009). Designing assessment and assessing design in virtual educational environments. *Journal of Science Education and Technology*, *18*(2), 187–209.

Hollan, J., Hutchins, E., & Kirsh, D. (2000). Distributed cognition: Toward a new foundation for human-computer interaction research. *ACM Transactions on Computer-Human Interaction*, *7*(2), 174–196.

Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA: MIT Press.

Ifenthaler, D., Eseryel, D., & Ge, X. (Eds.). (2012). *Assessment in game-based learning: Foundations, innovations, and perspectives*. New York, NY: Springer.

Ito, M. (2008). Education vs. entertainment: A cultural history of children's software. In K. Salen (Ed.), *The ecology of games: Connecting youth, games, and learning* (pp. 89–116). Cambridge, MA: MIT Press.

Ito, M. (2010a). *Hanging out, messing around, and geeking out: Kids living and learning with new media*. Cambridge, MA: MIT Press.

Ito, M. (2010b). Mobilizing the imagination in everyday play: The case of Japanese media mixes. In S. Sonvilla-Weiss (Ed.), *Mashup cultures* (pp. 79–97). Vienna: Springer.

Jenkins, H. (2006). *Convergence culture: Where old and new media collide*. New York, NY: NYU Press.

Kato, P. M. (2010). Video games in health care: Closing the gap. *Review of General Psychology*, *14*(2), 113–121.

Kebritchi, M., & Hirumi, A. (2008). Examining the pedagogical foundations of modern educational computer games. *Computers & Education*, *51*(4), 1729–1743.

Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2014). The technological pedagogical content knowledge framework. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), *Handbook of research on educational communications and technology* (4th ed., pp. 101–111). New York, NY: Springer.

Lamb, P. (2005). Technology and the new class divide. *CNET*. Retrieved from http://www.cnet.com/news/technology-and-the-new-class-divide/

Larson, R. W. (2000). Toward a psychology of positive youth development. *American Psychologist*, *55*(1), 170–183.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, MA: Cambridge University Press.

Lawless, K. A., & Pellegrino, J. W. (2007). Professional development in integrating technology into teaching and learning: Knowns, unknowns, and ways to pursue better questions and answers. *Review of Educational Research*, *77*(4), 575–614.

Linn, M. C., Gerard, L., Ryoo, K., McElhaney, K., Liu, O. L., & Rafferty, A. N. (2014). Computer-guided inquiry to improve science learning. *Science*, *344*(6180), 155–156.

Metcalf, S., Kamarainen, A., Tutwiler, M. S., Grotzer, T., & Dede, C. (2011). Ecosystem science learning via multi-user virtual environments. *International Journal of Gaming and Computer-Mediated Simulations*, *3*(1), 86.

Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017–1054.

Mouza, C. (2009). Does research-based professional development make a difference? A longitudinal investigation of teacher learning in technology integration. *Teachers College Record*, *111*(5), 1195–1241.

Nash, P., & Shaffer, D. W. (2011). Mentor modeling: The internalization of modeled professional thinking in an epistemic game. *Journal of Computer Assisted Learning*, *27*(2), 173–189.

Nash, P., & Shaffer, D. W. (2012). Epistemic youth development: Educational games as youth development activities. *American Educational Research Association Annual Conference*. Vancouver, BC.

Nash, P., & Shaffer, D. W. (2013). Epistemic trajectories: Mentoring in a game design practicum. *Instructional Science*, *41*(4), 745–771.

Nelson, K. (1996). *Language in cognitive development: Emergence of the mediated mind*. Cambridge, UK: Cambridge University Press.

O'Keeffe, G. S., & Clarke-Pearson, K. (2011). The impact of social media on children, adolescents, and families. *Pediatrics*, *127*(4), 800–804.

Phillips, V., & Popović, Z. (2012). More than child's play: Games have potential learning and assessment tools. *Phi Delta Kappan*, *94*(2), 26–30.

Poore, M. (2012). *Using social media in the classroom: A best practice guide* . Los Angeles, CA: Sage Publications.

Resnick, M. (1994). *Turtles, termites, and traffic jams: Explorations in massively parallel microworlds*. Cambridge, MA: MIT Press.

Retsinas, J. (1983). Teachers and professional autonomy. *Educational Forum*, *47*(1), 25–36.

Rhodes, J. E. (2005). A model of youth mentoring. In D. L. DuBois & M. J. Karcher (Eds.), *Handbook of youth mentoring* (pp. 30–43). Thousand Oaks, CA: Sage Publications.

Rice, J. (2007). Assessing higher order thinking in video games. *Journal of Technology and Teacher Education*, *15*(1), 87–100.

Ringstaff, C., & Kelley, L. (2002). *The learning return on our educational technology investment*. San Francisco, CA: WestED.

Rogoff, B., Baker-Sennett, J., Lacasa, P., & Goldsmith, D. (1995). Development through participation in sociocultural activity. *New Directions for Child and Adolescent Development*, *1995*(67), 45–65.

Rojas, R., & Hashagen, U. (2002). *The first computers: History and architectures*. Cambridge, MA: MIT Press.

Roschelle, J. M., Pea, R. D., Hoadley, C. M., Gordin, D. N., & Means, B. M. (2000). Changing how and what children learn in school with computer-based technologies. *Future of Children*, *10*(2), 76–101.

Sadler, T. D., Romine, W. L., Stuart, P. E., & Merle-Johnson, D. (2013). Game-based curricula in biology classes: Differential effects among varying academic levels. *Journal of Research in Science Teaching*, *50*(4), 479–499.

Salomon, G. (1997). *Distributed cognitions: Psychological and educational considerations*. Cambridge, UK: Cambridge University Press.

Sandholtz, J. H., & Reilly, B. (2004). Teachers, not technicians: Rethinking technical expectations for teachers. *Teachers College Record*, *106*(3), 487–512.

Scardamalia, M. (2004). CSILE/Knowledge Forum. In A. Kovalchick & K. Dawson (Eds.), *Education and technology: An encyclopedia* (pp. 183–192). Santa Barbara, CA: ABC-CLIO.

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

Shaffer, D. W. (2006). Epistemic frames for epistemic games. *Computers and Education*, *46*, 223–234.

Shaffer, D. W. (2007). *How computer games help children learn*. New York, NY: Palgrave Macmillan.

Shaffer, D. W. (2009). Wag the kennel: Games, frames and the problem of assessment. In R. Fertig (Ed.), *Handbook of research on effective electronic gaming in education* (Vol. II, pp. 577–592). Hershey, PA: IGI Global.

Shaffer, D. W., & Gee, J. P. (2012). The right kind of GATE: Computer games and the future of assessment. In M. C. Mayrath, J. Clarke-Midura, D. H. Robinson, & G. Schraw (Eds.), *Technology-based assessments for 21st century skills: Theoretical and practical implications from modern research* (pp. 211–228). Charlotte, NC: Information Age Publications.

Shaffer, D. W., Squire, K. D., Halverson, R., & Gee, J. P. (2005). Video games and the future of learning. *Phi Delta Kappan*, *87*(2), 104–111.

Shechtman, N., DeBarger, A., Dornsife, C., Rosier, S., & Yarnall, L. (2013). *Promoting grit, tenacity, and perseverance: Critical factors for success in the 21st century*. Washington, DC: U.S. Department of Education.

Shute, V. J. (2011). Stealth assessment in computer-based games to support learning. *Computer Games and Instruction*, *55*(2), 503–524.

Shute, V., & Ventura, M. (2013). *Stealth assessment: Measuring and supporting learning in video games*. Cambridge, MA: MIT Press.

Slotta, J. D., & Linn, M. C. (2009). *WISE science: Web-based inquiry in the classroom*. New York, NY: Teachers College Press.

Squire, K. D. (2004). *Replaying history: Learning world history through playing Civilization III*. Bloomington, IN: Indiana University.

Squire, K. D. (2005). Changing the game: What happens when video games enter the classroom. *Innovate: Journal of Online Education*, *1*(6), NP.

Stake, R. E. (1991). The teacher, standardized testing, and prospects of revolution. *Phi Delta Kappan*, *73*(3), 243–247.

Sung, Y.-T., & Lesgold, A. (2007). Software infrastructure for teachers: A missing link in integrating technology with instruction. *Teachers College Record*, *109*(11), 2541–2575.

Svarovsky, G. N., & Shaffer, D. W. (2006). Engineering girls gone wild: Developing an engineering identity in Digital Zoo. *International Conference of the Learning Sciences*. Bloomington, IN.

Volante, L. (2004). Teaching to the test: What every educator and policy-maker should know. *Canadian Journal of Educational Administration and Policy*, *35*. Retrieved from https://www.umanitoba.ca/publications/cjeap/articles/volante.html

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes* (14th ed.). Cambridge, MA: Harvard University Press.

Watson, J., Murin, A., Vashaw, L., Gemin, B., & Rapp, C. (2011). *Keeping pace with K-12 online learning: An annual review of policy and practice, 2011*. Durango, CO: Evergreen Education Group.

Williamson, D. M., Bauer, M., Steinberg, L. S., Mislevy, R. J., Behrens, J. T., & DeMark, S. F. (2004). Design rationale for a complex performance assessment. *International Journal of Testing*, *4*(4), 303–332.

Wineburg, S. S. (1991). Historical problem solving: A study of the cognitive processes used in the evaluation of documentary and pictorial evidence. *Journal of Educational Psychology*, *83*(1), 73–87.

Yusko, B., & Feiman-Nemser, S. (2008). Embracing contraries: Combining assistance and assessment in new teacher induction. *Teachers College Record*, *110*(5), 923–953.

Zucker, A. A., & Kozma, R. (2003). *The virtual high school: Teaching generation V*. New York, NY: Teachers College Press.