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CULTURAL SCAFFOLDING AND TECHNOLOGICAL CHANGE

A Preliminary Framework

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TECHNOLOGY HELPS US to do new things or to do old things in new ways. This, at least, is our common understanding and continual hope. Technologies, however, only become useful when guided by human means to human ends, and they therefore do not add to our arsenal of abilities in an unproblematic, straightforward manner. Rather, they must confront a complex and preexisting set of biological traits and cultural practices before their potentialities and consequences are clear. My goal here is to sketch an account of how technologies interact with the innate and socially supported human capacities to learn and develop, using cultural scaffolding as an interpretive tool.

To realize that goal, I should first sketch some key terminology. *Developmental scaffolding* refers to the structures that support growth in developmental systems. It can be fruitfully applied to many types of systems, at scales from the microscopic to the institutional (Caporael, Griesemer, and Wimsatt 2014). *Cultural scaffolding* is a type of developmental scaffolding that describes the self-perpetuating patterns of systematic behavior—what Linnda Caporael (2014) calls repeated assemblies—organized to confer valuable skills or competencies to individuals or groups. I rely here on earlier formulations of the concept by William Wimsatt (2014) and Wimsatt and Griesemer (2007), who point out that cultural scaffolding, as a conceptual tool, can fruitfully describe a diverse array of systems. It can capture phenomena from the caregiver interactions that help children acquire language, to the repetitive training that allows a tennis player to hit a consistent backhand, to the rehearsal schedule that prepares an orchestra to perform a concert as a cohesive unit. This is, by design, a tool for a messy world, wrought broad and flexible to capture a wide variety of cultural practices.

Identifying the limits of what should qualify as technology, and what should not, is a similarly imprecise exercise. Historian of technology Robert Friedel, for example, notes this difficulty while provisionally defining technology as "the knowledge and instruments that humans use to accomplish the purposes of life" (Friedel 2007, 1). This definition would include many cultural-scaffolding processes. Military drilling, so critical to compelling soldiers to function as a cohesive unit, might be easily classified as both a scaffolding process and a technology. Friedel points out that it is easier to say what is *not* technology than to say what is. In that spirit, I exclude organized behavioral interactions among human beings from the technological realm. Some technologies, of course, might lack material form; although many technological ideas result in a material manifestation, like a better mousetrap or an improved transistor design, others, such as software programs, might not. For the purposes of this analysis, though, I will not consider to be technology those ideas that are enacted through human interactions—such as political and institutional organizations, games, and other social practices.

By characterizing these concepts, I do not aim to draw bright lines between them but to map out two realms, which are overlapping and interacting but nevertheless discernable. The location and the substance of their interaction is the subject of the following discussion, which describes the ways in which technological change influences cultural scaffolding and suggests how this understanding can be used to guide technology policy. I propose three ways of describing the interaction between technology and cultural scaffolding. First, technology can displace existing scaffolds. Second, it might combine with existing scaffolds and assume a role in scaffolding practices themselves. Third, it can catalyze the assembly and growth of new scaffolding structures. These effects are not exclusive of one another, but for the sake of clarity, I treat them separately. After outlining these interactions, I present a matter of current policy interest—the use of digital information technology in the K–12 classroom—to demonstrate how the scaffolding perspective offers policy utility.

TECHNOLOGY'S EFFECTS ON CULTURAL SCAFFOLDING

This section describes three primary ways cultural scaffolding can change in the face of technological change: displacement, combination, and catalysis. These are related processes and will often occur simultaneously. As a result, their boundaries are not sharply defined. Which one we perceive to dominate in any specific example will depend upon our frame of reference and interpretive goals.[1]

To offer a simple example, the widespread use of digital technologies, and therefore keyboards, to generate text has led to a reduction in the amount of time young people spend writing by hand, both in school and on their own. Recent research has uncovered evidence that this comes at a cost, not just to handwriting ability but to basic fine motor skills as well (Sülzenbrück et al. 2011). In this sense, digital technology is in the process of displacing scaffolding processes—formal handwriting instruction and the informal practice that accompanies it—that promote basic fine motor skills. The proliferation of computing technologies nevertheless also demands new scaffolding processes to confer new skills, such as touch typing, and also makes itself a part of existing scaffolding processes, for instance, by serving as a delivery mechanism for books and other content used in educational contexts.

This example illustrates that technologies are apt to have multiple, simultaneous influences on preexisting scaffolding structures. But for the purposes of generating a framework with practical utility, these three types of effects may be fruitfully considered independently. The distinctions drawn here are not designed to carry deep ontological implications but rather to describe features of technology-scaffolding interactions that are self-similar enough to be taken as discrete for the purposes of drawing attention to features of technological change that might otherwise escape our attention.

Displacement

Scaffolding displacement is the process by which new technologies encourage the cessation of capacity-promoting cultural-scaffolding activities. The following criteria describe the conditions under which it can occur:

1. Cultural-scaffolding processes support the acquisition of capabilities and competencies on the part of individuals and organizations.
2. New or improved technologies often replicate capabilities that individuals possess autonomously after benefiting from the existing scaffolding processes.
3. If a technology replicates a capability that is supported by an extant scaffolding process and the technology becomes prevalent, then the cultural activities that compose the scaffolding structure, which confers

autonomous agency, can be halted or altered. In such cases, the technology becomes the predominant way in which the capability is exercised.

4. If 1–3 occur, capabilities that individuals could once exercise without immediate technological assistance become difficult or impossible to accomplish without the aid of the technology that displaced the capability-conferring scaffold. By this mechanism, technologies become increasingly necessary and can thereby become entrenched (Martin 2015a, 5–6).

We often think of technology as expanding our range of capabilities, and it often does. But just as often, it encourages us to do things we were already able to do in new, technologically dependent ways. The history and philosophy of technology offer plentiful examples of technology displacing scaffolding processes. Langdon Winner's classic essay "Do Artifacts Have Politics?" describes the introduction of pneumatic molding machines in the 1880s into Cyrus McCormick II's Chicago plant, where the iconic McCormick reaper was manufactured. The machines were expensive to buy, install, and operate but nevertheless produced an inferior product than did the skilled casters who were deskilled by the machines. So why install them at all?

Citing Robert Ozanne's study of labor-management relations at the same factory (Ozanne 1967), Winner points out that the molding machines *settled an issue;* by replacing the skilled labor of hand molding with unskilled machine operator jobs, McCormick could undermine union action and tilt the balance of factory relations in favor of management (Winner 1986, 24–25). The machines, we can say, displaced a scaffolding process. In labor contexts, workers become skilled through years, sometimes decades, of apprenticeship and experience. The depth of their investment in scaffolding processes gives them social capital in the workplace because their expertise is resource-intensive to replicate, and so they are difficult to replace. The introduction of a machine that does the same work, even if that work is substandard, renders slow and demanding scaffolding processes redundant, with consequences for the social dynamics of the workplace. The consequence, once the scaffolds that supported skilled labor erode, is increased dependence on the new technology and further entrenchment of the technological system of which it is a part. Indeed, the process by which technology replaces skilled labor can be understood as a cultural analog of what Wimsatt (1986) calls *generative entrenchment* in molecular genetics, in which a gene is more resistant to evolutionary perturbation the greater the diversity of its developmental consequences. The mechanization of labor, which integrates machines more richly into the processes of production, causes a manufacturing system, in the absence of the expertise capable of replicating machine work, to become less flexible.

The example above is one instance of a more general phenomenon, one not limited to labor contexts. Scaffolding can also be displaced in the conduct of quotidian affairs, such as the example of the decline of handwriting and the consequences for fine motor skills. Relying on technology to accomplish tasks that we are able to complete independently—perhaps with the commitment of a bit more time and the exertion of a bit more cognitive effort—can inhibit acquisition of the capabilities in question. Scaffolding displacement, in short, occurs when new technologies discourage individuals or groups from partaking in particular kinds of scaffolding processes that would otherwise have allowed them to develop capabilities independent of the new technologies.

I begin with displacement because it is the subtlest aspect of the interface between technology and cultural scaffolding. First-generation users of new technologies typically will have acquired any capability the technology replicates with the benefit of existing scaffolding structures. Their comfort with these structures will sometimes generate resistance to adopting the new technology. But even if they do so, they will retain at least some of the skill they derived from older scaffolding processes, even in the event that their facility decays through disuse. As a result, displacement effects will appear most markedly in the generation that grows up using the new technology, and so lacks the incentive or the opportunity to participate in the scaffolding processes the technology displaced. This is a crucial policy consideration, which I will discuss in more detail below, but first let us consider the other ways in which technology and cultural scaffolding interact.[2]

Combination

Technologies are often themselves components in scaffolding processes. We require scaffolding to learn how to use existing technologies effectively, and technologies can help us attain capabilities that we can then exercise more or less independently, without immediate external aid. When new technologies appear, they can therefore change, supplement, or replace parts of existing scaffolding processes so that the relevant skill is scaffolded by different means. That is, new technologies encounter existing cultural practices with which they interact, and that interaction can result in their incorporation into those practices. The examples below describe three ways in which technological developments can combine with existing scaffolding practices.

Technological change has had a marked effect on the way sports are played. In ice hockey, for instance, skate construction has changed radically over the past fifty years. Hockey skates from the 1970s and earlier were predominantly of soft leather construction, much like leather boots, with little ankle support. They demanded considerable ankle strength on the part of the skater, favored long strides, and were not conducive to tight turns or quick stops and starts, which required tremendous strength and coordination from skaters attempting to keep their weight centered over the blade. Newer skates are much stiffer and more like ski boots, making it easier for skaters to center their weight. This does not make strong skating any less essential to success in the game, but it has changed what it means to be a strong skater. In a game played with hard-shell skates, quick stops and starts and hard, tight turns are more essential than long, graceful strides. The way young players are taught to skate has changed correspondingly, responding to new expectations created by the shift in skate construction. It would be problematic, though, to claim that modern skaters are any more or less proficient than their earlier counterparts. The technology, in this example, has produced a *qualitative change,* without enabling novel new possibilities.

In a different context, we see a raft of changes introduced by digital indexing and cataloging services in libraries. The library catalog is as old as the library itself, and it scaffolds the effective use of library resources—not merely helping researchers find materials but helping them think about how those materials relate to one another. The advent of computing technologies made it natural to migrate older physical systems, such as card catalogs, to digital format. Simple iterations of digital catalogs offer little beyond standard browsing and searching functions that were previously available with physical resources. The functions available through digital databases, though, have expanded substantially in recent decades, and in this case replacing one scaffold with another has opened up new possibilities. These capabilities are exerting subtle but substantial forces on the way scholars approach the research process (Martin 2015b). It is now possible to juxtapose a wide array of sources, which might be physically housed in geographically disparate locations, in a very short span of time, allowing researchers to make comparisons that would have been theoretically possible but practically infeasible using older analog catalogs. In this instance, the technological changes in existing scaffolding offer *novel capabilities.*

Combination, however, can also have a deleterious effect on how skills are scaffolded, especially when the technology in question offers advantages in other areas. Take audio recordings, which are now frequently used, usually in the form of software programs, to help language learners develop vocabulary and correct pronunciation and that combine with existing scaffolds for language instruction. Before recording technologies became widespread, language learners would need access to a native speaker to develop any reasonable grasp of pronunciation. With the advent of recordings, examples of correct pronunciation could be more widely distributed and easily accessed. This is a technological change that has little influence over the *way* the skill is scaffolded. It might, however, have consequences for how *effectively* it is scaffolded, considering that interactions with recordings are one-directional and so are less flexible than interactions with a native speaker, which would allow the learner to ask, for example, for additional examples or for immediate feedback. Although they can be distributed widely and thus may generate more occasions to hear a native speaker, recordings do not permit the learner to interact directly with a native speaker, who can take questions, provide context, and identify errors that might not be obvious to an untrained ear.

The case of language instruction shows how combination, in addition to generating qualitative differences in the way skills are exercised and enabling new capabilities, can also produce *interference* with skill conferral. Research on the efficacy of language instruction software has indeed indicated that, although software offers the learner greater convenience and autonomy, more resource-intensive teaching practices are better at conferring competency (Nielson 2011). This case of combination interfering with a scaffolding process is similar to scaffolding displacement, as outlined above. It differs from displacement, however, because the technology aims to scaffold the same skill as the preexisting cultural practice—that is, the end goal of the process is to enable the learner to speak on his or her own, rather than to make the technology the principle means by which people communicate in a second language (such as in the case of speech-to-speech translation apps). In the case of combination producing a reduction in scaffolding efficacy, we instead see the technology sacrifice some features of the learning process, in this case flexibility and adaptability, in favor of others, such as convenience and accessibility.

Our greatest hopes for new technology often turn on combination, assuming that we will be able to exercise or acquire existing skills in new, better ways. As these examples show, that can indeed be one effect of integrating new technologies into scaffolding processes. Offering new affordances is just one of the ways combination can have an effect on existing scaffolding, however. It might, as in the case of changes in hockey skates, enact a qualitative difference without offering anything strictly new; novice skaters still learn to skate but with an emphasis on a different style and differential emphasis on various fundamental skills. Combination might also, as in the case of language instruction software, reduce the efficacy of skill conferral or performance in favor of emphasizing some other value, such as convenience or access.

How technology combines with scaffolds depends as much on its implementation as its function. Language software is capable of supplementing language instruction by providing additional practice and consistent repetition, but if it is used to the exclusion of scaffolded interactions with experienced speakers, then its rigidity limits its utility. Here, we begin to see how this framework can be useful in a policy context. If the goal of new technologies is to confer existing competencies in a better way and to promote the generation of new capabilities, then policy-making around new technology should attend to how it combines with existing scaffolding structures in order to ensure that it does not compromise the elements of those structures that make them effective.

Catalysis

Scaffolding catalysis occurs when new technologies require the assembly of new scaffolds. Consider the following poem, "First Snowfall in St. Paul," by Katrina Vandenberg:

This morning in the untouched lots
of Target, St. Agnes, and Lake
Phalen, girls all over the city
in the first snowfall
of their sixteenth year are being asked
by brothers, fathers—my cousin
Warren—to drive too fast then lock
their brakes, to teach them how to right
themselves. The whine of the wheels, the jerk
when they catch—from Sears to Como Park
to Harding High, the smoke

that bellows from their lungs,
the silver sets of jagged
keys, the spray of snow,
the driver's seat, the encouraging Go

Vandenberg describes a ritual that will be familiar to anyone who came of age in the snowbelt of the United States, where the subtle skill of winter driving is essential. It is one example of the many informal scaffolding processes that have grown up around the automobile. New technologies, even while they displace and combine with existing scaffolding structures, can also prompt the growth of new ones. Rarely are the full potentials of a new technology, or the best practices for using it, self-evident. As a result, they require new and sometimes elaborate scaffolding to prepare new users.

The automobile necessitated both informal scaffolding processes, such as those described in the poem above, and formalized scaffolding practices, such as drivers' education programs, certification exams, and road tests. The car is part of a large technological system—entrenched by the highway and roadway infrastructure, urban planning decisions that assume its presence, and cultural traditions and expectations—with which it is all but essential for full participation in modern American society. Vandenberg's poem channels the idea that technology's success also depends on constructive interaction with local cultural practices—such as those that develop in response to local environmental constraints.

A notable feature of catalysis is that the scaffolding necessary to navigate new technological landscapes does not appear spontaneously for all groups who might benefit from it. Uncertainty about when and how that scaffolding matures can be a source of considerable friction as new technologies proliferate. Keeping, for the nonce, with the autovehicular theme, consider the number of traffic fatalities per year since 1900. Figure 11.1 shows how motor vehicle fatalities rose dramatically beginning in the 1910s, as automobiles became widespread. Many of these deaths would have been due to structural challenges: cars had to operate alongside horse-drawn carriages, streetcars and trollies, and pedestrians unaccustomed to heeding fast-moving vehicles. But it is also critical to note that the know-how needed to operate a

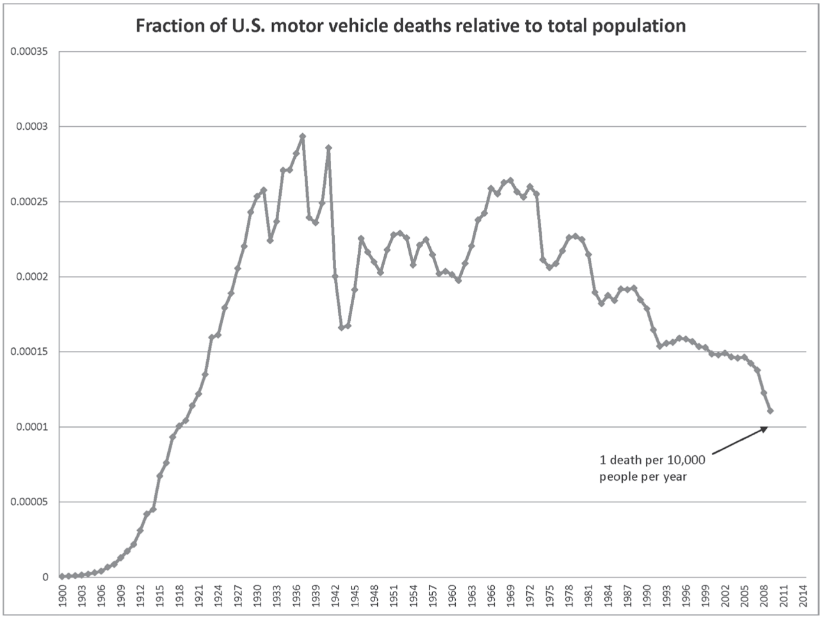

Figure 11.1. Fatalities caused by motor vehicles in the United States, 1900–2010. The x-axis is the year; the y-axis measures deaths as a proportion of the total population. Data from the National Highway Traffic Safety Administration and the Federal Highway Administration; courtesy of Wikimedia Commons.

motor vehicle, and operate it safely, took some time to penetrate the population. The scaffolding necessary to support safe motor vehicle operation took some time to catalyze.

It was not until 1932 that Amos Neyhart, an engineer associated with the Pennsylvania State College, instituted the first high school driver's education program in the United States. Neyhart's program, along with parallel industry initiative and government investigations to raise awareness of traffic safety, responded to a rash of traffic deaths beginning to be understood as an urgent public health threat (Damon 1958).

Driver education programs proliferated through the mid-1930s. Many of them attempted to teach driver safety as an element of good citizenship (Packer 2008). In his introduction to *Man and the Motor Car,* the widely adopted driver safety manual first published in 1936, Albert W. Whitney lamented: "We have shown little fighting spirit in the face of the hazard that the automobile has created,—perhaps because we have not been willing to discipline ourselves, perhaps because we have felt the pleasure and convenience that it has brought us was something that we could not have except at a price" (Whitney 1938, xi). The recipe for lowering that price, according to Whitney, was safer drivers, who would be made so by education programs in America's high schools.

The rise of driver's education programs in the mid- to late 1930s corresponds neatly with the leveling off in the rate of traffic fatalities in the same period, as seen in Figure 11.1. That is not, of course, the only factor to consider. Infrastructure was improving on the strength of New Deal programs, cars themselves were getting safer, and the population was becoming more aware of the dangers automobiles posed. The outbreak of World War II introduced additional complications. Gasoline rationing, the cessation of civilian automobile production, and other changes would have suppressed traffic mortality. Similarly, the introduction of a national speed limit in 1974 likely played some role in the reduction at that time. It is therefore difficult to disentangle the effect of education programs from other factors conspiring to suppress traffic mortality throughout the mid-twentieth century. Nevertheless, the realization that many drivers were ill-prepared to operate cars safely, and the concerted efforts to build the scaffolding structures that would allow them to do so, are an illustrative case of scaffolding catalysis. Contemporaries perceived poor driver preparation to be a contributing factor to high mortality rates, and they responded by developing formal systems of scaffolding to address the problem.

Catalysis shows us that the challenges posed by technology sometimes require more than technological solutions (see also Weinberg 1966). The automobile did not come prepackaged with the scaffolding necessary for people to use it safely and effectively, and the local, informal scaffolding procedures that would allow more experienced operators to confer their expertise to novices proved insufficient to stem the traffic fatalities that had become an epidemic by the early 1930s. The more rapidly new technologies are adopted, the more likely the scaffolding required to use them safely or effectively will lag behind. As of this writing, automobile safety is again a matter of widespread public and policy interest, this time focusing on the issue of self-driving cars. Should they come to fruition, autonomous vehicles would indeed offer a technological response to the problem of traffic fatalities and would displace the elaborate scaffolding that now prepares drivers to operate motor vehicles safely—perhaps even to the satisfaction of all but the most committed gearheads. But this solution, if it comes at all, will not be feasible until well over a century after the problem first arose. The intervening years required the catalysis of scaffolding structures, both formal and informal, to ease the integration of one of the most ubiquitous pieces of modern technology into American life.

CULTURAL SCAFFOLDING FOR EDUCATION POLICY

The framework outlined above can provide a practical guide for describing several key features of the interface between scaffolding and technology, especially for thinking about the policy challenges new technologies pose. Considering how to implement new technologies often emphasizes their potential—that is, how they will allow us do things better, faster, or more easily. But responsible implementation requires understanding technological change at a higher resolution, and that finer-grained perspective is something scaffolding language can offer. Managing technological change requires taking into account displacement effects and catalysis requirements, for example, alongside the potential efficiencies and new affordances combination can sometimes provide. This section illustrates how a lack of attention to the full extent of these factors has, in one case, undercut the stated policy goals for the implementation of a new technology.

When examining the consequences of technological change and evaluating policy responses, the considerations sketched above should be taken in conjunction: What scaffolding does the technology displace, how does it combine with existing scaffolding, and what new scaffolding might it require? Using the example of classroom-based digital information technology, it is possible to sketch how such an assessment can anticipate the challenges posed when deploying new technology in order to enact education policy goals. Bringing technology into the classroom has been the subject of a number of initiatives in the United States recently, both on the local and state levels. This section considers how one of those efforts has fared with respect to its stated aims and suggests how the framework developed in this paper can be used to assess it.

Recent efforts in the state of Maine to populate K–12 classrooms with laptops are notable for their scope. The Maine Learning Technology Initiative (MLTI), which began in 1999, was formed to implement a $50 million endowment. The MLTI aimed "to ensure a basic level of access to technology, the Internet and training and learning opportunities for all Maine public schools, students and teachers" (State of Maine 2001, 39). The rhetoric around the MLTI gave special emphasis to vocational skills. Maine's governor, Paul

LePage, praised the program by saying, “It is important that our students are using technology that they will see and use in the workplace” (quoted in Woodard 2013). MLTI rhetoric also developed the argument that giving every student a laptop would empower students to find the information they want. The task force reported: “Students learn largely by working on projects that connect with their own interests—their own visions of a place where they want to be, a thing they want to make or a subject they want to explore” (State of Maine 2001, 8). The MLTI, then, focused first on giving all students a baseline proficiency with digital technologies—a proficiency that potential employers expect—and, second, on allowing students to more easily manipulate digital technologies in a self-directed way and thereby to access information faster and more efficiently.

Close attention to the manner in which the MLTI was implemented, however, shows that the program fell short of these goals in some important respects. Karen Kusiak, in a doctoral dissertation based on extensive in-classroom observations at schools implementing the MLTI program, concluded that laptops were frequently introduced to Maine classrooms with little consideration to how they would integrate with the existing curriculum: “Students might unintentionally be directed to engage in classroom activities that do little to promote their skills and competencies. . . . Laptop use provides tremendous support for students to engage with high school curriculum and to benefit from instruction, however the underlying goals of the curriculum must be examined to be sure the use of laptops is for laudable purposes” (Kusiak 2011, 13, 254). Kusiak’s observations showed that although having laptops in the classroom did help students acquire and maintain basic computer skills, their role in supporting the traditional curriculum had not always been thought out, and their presence therefore sometimes distracted from curricular goals and disrupted the learning environment. The introduction of laptops did proceed more smoothly in some cases because those individual teachers and school administrators took it upon themselves to ensure that the devices worked within the existing curriculum.

Ambivalence about information technology’s role in developing the skills necessary to manipulate information is mirrored elsewhere in the media studies literature. Sonia Livingstone’s research on how children use the Internet challenges the preconception that those who grow up in an environment rich with digital technologies—“digital natives,” in Marc Prensky’s (2001) terms—are naturally facile with them: “Watching children click links quickly or juggle multiple windows does not, necessarily, confirm that they are engaging with online resources wisely or, even, as they themselves may have hoped" (Livingstone 2009b, 5). Similar conclusions emerged from the Ethnographic Research in Illinois Academic Libraries (ERIAL) project, which observed student research habits at a number of Illinois universities. Andrew Asher and Lynda Duke (2012) concluded from observing student researchers at Illinois Wesleyan University that when considered in terms of their abilities to locate relevant resources using library catalogs and databases, "the seeming simplicity of tools like Google belies a complex and iterative process that requires the integration of numerous analytical and technical steps as well as knowledge and experience on the part of the user" (71). The consequences, Asher and Duke noted, were that students were less adept at understanding how information is organized, at evaluating sources successfully, and at figuring out how to access library resources.

These examples suggest that early efforts to exploit the potential of digital information technology to confer both new proficiency with computing technology and old research capabilities to students have been overly sanguine. Understanding these programs within the framework developed in this chapter can clarify why. The principle aim of the MLTI was catalysis. Maine's students, the initiative presupposed, were not exposed to enough computing technology in their existing educational and home environments to ensure that they graduated into college or the workforce with a baseline level of computer skills. This goal was laudable. The problem of differential access to the scaffolding necessary to successfully use new technologies is the source of considerable social justice challenges. The rise of digital information technologies, like the rise of the automobile, requires a new set of structures and processes to scaffold their effective use. Access to informal scaffolds supporting computer skills can differ according to geography, race, gender, and socioeconomic status, and formalizing previously informal scaffolds within the context of the public school system is one way to address this inequality.[3]

What the scaffolding perspective makes clear in this case, however, is that mere access to a new technology is not enough to catalyze the scaffolding required for its most effective use. Just like access to automobiles was insufficient for the skills necessary to operate them safely to penetrate a population, putting laptops in K–12 classrooms is insufficient to support competency with the variety of skills they support. This is doubly true in the absence of careful consideration of the way laptops influence the scaffolding processes already in place within the classroom. Kusiak's observations showed that the MLTI did not, in its inception, account for the variety of ways in which technologies interact with cultural scaffolding. Efforts to introduce laptops into Maine classrooms often equated access with catalysis and paid little heed to how the new technology would combine with the existing formal scaffolding of the school curriculum. In these cases, laptops combined with existing curricular scaffolding in a way that sometimes interfered with the goals of that existing scaffolding, rather than aiding them.

Kusiak's comparison of two Maine high schools that adopted laptops for English class instruction shows that their success depended principally on how well the curriculum was structured, rather than on the presence or absence of the technology itself. When care was not taken to ensure that writing tasks integrated with discussions of source material, laptops, although perhaps helping students gain experience with computing technology, led students to incorporate into their assignments commercial messaging and content that was orthogonal, if not counterproductive, to course goals (Kusiak 2011, 230–32). By focusing on catalyzing skill with computing technology, the MLTI sometimes failed to heed combination effects that could interfere with other curricular goals.

Displacement is also an evident consequence of the ubiquity of information technology. The ERIAL study's observation that, although they are proficient at manipulating digital interfaces, digital natives often lack basic skills associated with manipulating the information those interfaces organize, suggests that student are not participating in the types of activities that might have conferred those skills. The same technology that helps students access *content* about a new subject can also discourage developing familiarity with the *process* that supports competency finding, assessing, and organizing information about that same subject. ERIAL research suggested that the sense of ease conferred by digital tools could prevent students from engaging in behaviors that might have helped them learn: "Although the majority of . . . students struggled with finding the correct database to use, their search terms, locating a known item, and/or technical problems, not one student sought assistance from a librarian during an observed search" (Asher and Duke 2012, 83). These observations support the rationale that underwrites the decision to restrict calculator use in early math classes. Understanding the mechanics of arithmetic is critical for developing mathematical proficiency, even when a calculator might allow one to do sums more quickly.

From a policy standpoint, then, responsible implementation of digital information technology in K–12 classrooms requires attention to displacement, combination, and catalysis. Such attention suggests asking some straightforward but often neglected questions: What practices does the technology discourage that are worth preserving? How do existing practices need to shift to accommodate the new technology? What new practices need to be encouraged to ensure that the new technology is being used effectively?

Thinking with scaffolding also suggests a route to some preliminary answers. Observing that digital tools can disincentivize students from participating in the processes that allow them to think clearly and flexibly about locating resources indicates that we cannot assume that digital natives are natively proficient with digital research tools and that we should teach them accordingly. The scaffolding that can help students manipulate digital tools effectively needs to be catalyzed. Furthermore, the ways in which digital sources can be marshaled in support of a research project share much in common with the ways in which analog sources can be assembled for the same purpose. For students to learn how to conduct research, digital tools need to combine constructively with foundational training in identifying sources and assessing the reliability of evidence. In a similar vein, if and when we introduce laptops into classrooms, we should think about the balance between combination and catalysis: To what extent is our goal to development proficiency with new tools and to what extent are we using those tools to address existing curricular goals?

Scaffolding provides a vocabulary for describing the complex array of ways technology influences the capabilities we value and want to encourage. In so doing, it offers a potent and necessary antidote to the rhetoric of innovation and progress that often accompanies the introduction of new technologies (Russell and Vinsel 2016), rhetoric that focuses attention disproportionately on the novel capabilities new technologies allow, without attending to the possibility of displacement or recognizing the hard work of combination and catalysis they will require.

TECHNOLOGY AND cultural scaffolding interact in complex and multifaceted ways, a fact that should be no surprise given the diversity that exists within each. I nevertheless contend that we can characterize their interaction with enough clarity and resolution to ground reasoned and effective policy planning. I have outlined three modes of interaction between technology and cultural scaffolding and have argued that a lack of attention to one or more of these is likely to be the culprit when new technologies produce unanticipated effects or fail to meet the high expectations we often set for them.

Because discussions of technology often focus on what it allows us to do, we might pay less attention to the things it stops us from doing. Attending to these things highlights the ways in which technology can displace cultural scaffolds. When a new technology becomes an important part of navigating the world, the practices that technology causes us to cease might be critical components of scaffolding processes and worth the upkeep for their own sake. New technologies therefore present the challenge of identifying the capacities they might threaten by displacing scaffolds and concocting ways to preserve them, either by maintaining those scaffolds or by scaffolding the relevant capacities in different ways.

Ensuring that new technologies combine with existing scaffolds in a way that serves our desired ends demands a great deal of spadework that, as seen in the case of the MLTI, is easily neglected amid an enthusiastic, wide-scope embrace of new technology. When new technologies are called upon to accomplish existing tasks, it will not always be obvious how they can best be used to do so. The MLTI shows that conscious attention to how laptops in the classroom could be used to complement and supplement established curricular tasks is necessary to ensure a successful rollout that realizes the potential of the technology while guarding against its pitfalls.

One reason we might neglect combination—a reason, for example, we might give short shrift to questions about how we need to think through K–12 curricula to accommodate the changes to classroom practice that come with laptops—is that it is often easier to recognize that new technologies require the catalysis of new scaffolding to support competency with new technologies. Catalysis cannot be assumed to be spontaneous. It is not implied by the logic of the technology itself, and effective management of the systems that will support competency with new technologies alongside their safe and effective implementation is essential to responsible technology policy.

The assumption that new technologies will make their own way in the world and present to us their own optimal modes of use is seductive. If, however, we are committed to the idea that technologies can only be useful to the extent to which they modify, enhance, or expand human capabilities, then we must be sensitive to the processes that allow them to do so. I have offered one account of those processes with the hope that making them explicit is the first step to developing useful conceptual tools for navigating a world defined in many ways by technological change.

NOTES

Discussions with the participants at “Beyond the Meme: Articulating Dynamic Structures in Cultural Evolution” at the University of Minnesota helped bring this piece into focus. I am further indebted to Alan Love and Bill Wimsatt for their incisive comments and careful editorial work.

1. Note also that these all describe one-way effects, from technology to cultural scaffolding. This is not to imply that reciprocal effects are not possible, or even uncommon; the shapes new technologies take depend integrally on how people already participate in scaffolding processes, and they might shift and adapt in response to feedback from scaffolding processes. I limit my focus to the effects of technology on cultural scaffolding with the goal of establishing a clear, preliminary framework for discussing this interaction.

2. Displacement, it is worth noting, need not always be complete. In instances where scaffolding is partially displaced, it might be more appropriate to refer to it as *suppression*.

3. I thank Malik Horton for bringing this point to my attention.

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