Technology has long been a part of the classroom space. It is incorrect to say that "technology in education" is a new or radical phenomenon; blackboards, books, paper, and pencils are all technologies, to say nothing of written language or mathematics. Sometime in the 1990s, the word technology was co-opted to refer only to digital tools. "Technology in the classroom" or "technology stocks" or "the dangers posed by technology" came to refer only to digital technology rather than to technology as a whole. As such, much of the discussion surrounding those new tools—pro and con—has been far too narrow in scope and consequence. In order to thoughtfully approach digital technology acquisition and use in classrooms, I propose that we look at technology inclusively; that is, view digital technologies as part of the larger "information ecology" of the classroom, which has long housed technologies of many varieties (see the sidebar).

In this article I propose 10 questions, the answers to which will help guide faculty in adapting digital technology for classroom use. These questions especially target those late adopters who have largely refrained from employing digital technology in the classroom.

10 Assessment Questions

The guidelines built around the answers to these 10 questions present what I believe to be a thoughtful approach to digital technology, one that does not assume that teachers should automatically adopt the latest tool for fear of appearing behind the curve. Nor does this approach automatically reject new technology acquisition in a reactionary belief that such tools have no proper place in education. Digital technology will not aid in education—and in fact can have harmful, unintended consequences—if not used wisely. In an educational setting, that wisdom derives from pedagogical concerns and from the teaching practices and philosophies of educators who use the technologies.

1. What impact does the technology have on the ergonomics of the classroom space?

The spatial arrangement of people and technologies is often an explicit statement of pedagogical practice. Think of a traditional classroom space, with rows of desks bolted to the floor facing a lectern at the front. Such a physical arrangement favors a lecture-based pedagogy, one in which a professor "professes" to an audience of students who listen and absorb his information. I prefer a classroom with easily moveable chairs that can be arranged in a circle or distributed around the room, since I practice a pedagogy based on both general class discussion and small-group work. Similarly, the physical arrangement of the technologies in the classroom space should reflect the instructor's pedagogical strategies.

I once visited a digital classroom where computer terminals were placed upon rows of bolted desks, suggesting a continuation of the lecture mode.

"Information ecology," a term coined by sociologists Bonnie Nardi and Vicki O'Day, means "a system of people, practices, values, and technologies in a particular local environment. In information ecologies, the spotlight is not on technology but on human activities that are served by technology."[1] Thus, it is the complex interactions between people, their values and practices, and technology that constitute a classroom space defined as an information ecology. I find this a useful way of thinking about the classroom. Our classrooms are not devoid of technology, a pristine space that digital tools despoil. Rather, digital tools must be viewed as standing side by side with—and in some cases displacing—preexisting technologies.

Information ecologies share similar characteristics with their biological counterparts. Nardi and O'Day observed that information ecologies are systemic, in that the parts and the whole interact in complex ways. Since an information ecology is made up of people and technology along with practices and values, the interactions between these elements cannot help but produce complex, even unpredictable, change. Because ecologies are complex systems, adding a new plant does not yield the same ecology plus the new plant; rather, a new ecology is created. Similarly, if you change one part of an information ecology, the entire system is affected.[2]

Information ecologies are diverse in that a variety of tools and people make up any healthy, thriving system. "Monoculture—a fake, brittle ecology—gives sensational results for a short time, then completely fails."[3]

Nardi and O'Day suggested, for example, that an ATM machine is not a healthy ecology, since one experiences only a small number of technologies in a jTc(, a nsulogii5l,SesuggesdigitaTJT9ol-) 1s1n-that 2uggfad

2. How does the technology expand the dimensions of the classroom space?

Not all instruction occurs within the classroom. Engagement with students also occurs outside the classroom, as during office hours. I have taught at colleges where students think nothing of sitting down next to me during my lunch break or in the quad to ask a question or to have a discussion. Professors ask students to complete homework; lead them on field trips; and require their attendance at concerts, performances, and other out-of-class functions. At the same time, faculty—even faculty who do not employ technology in the classroom—use digital tools to produce syllabi, to write up term paper assignments, and to calculate grades. Each of these activities is an extension of classroom activities.

Digital technologies can often legitimately expand the information ecol-

look at reproductions. Digitized images displayed with PowerPoint or on a Web site are high-resolution images, much higher resolution than transparencies or Xeroxed paper copies. Replacing these lower-resolution methods with a computer and projector is not merely a technological "upgrade" decision but a pedagogical choice.

For example, in teaching a class on "visual thinking," I rely on online images to communicate the concepts. If my classroom has no digital technology, I cannot use the kinds of images I want, having to settle instead for lower-resolution paper handouts. Display technologies like overhead projectors allow me to point to specific areas of the image so that we might analyze it as a class. This substitution of paper for digital images lowers the quality of the experience and makes it harder—although not impossible—to achieve the pedagogical goals of the class.

It is perfectly acceptable not to use a new technology when an old technology works just as well. Face-to-face discussion is an excellent pedagogical technique, especially useful in discerning facial expressions and other non-

Applications exist for self-guided tourism and, clearly, for classroom education.

Hybrid classes (those that combine classroom and online experiences) or traditional physical classroom spaces augmented with digital technology should reflect a balance among the physical world of people, the natural environment, and the virtual world of rich digital information. In a healthy classroom space, the virtual complements the real.

7. Will professors use the technology to aid students in the acquisition of knowledge, not just information?

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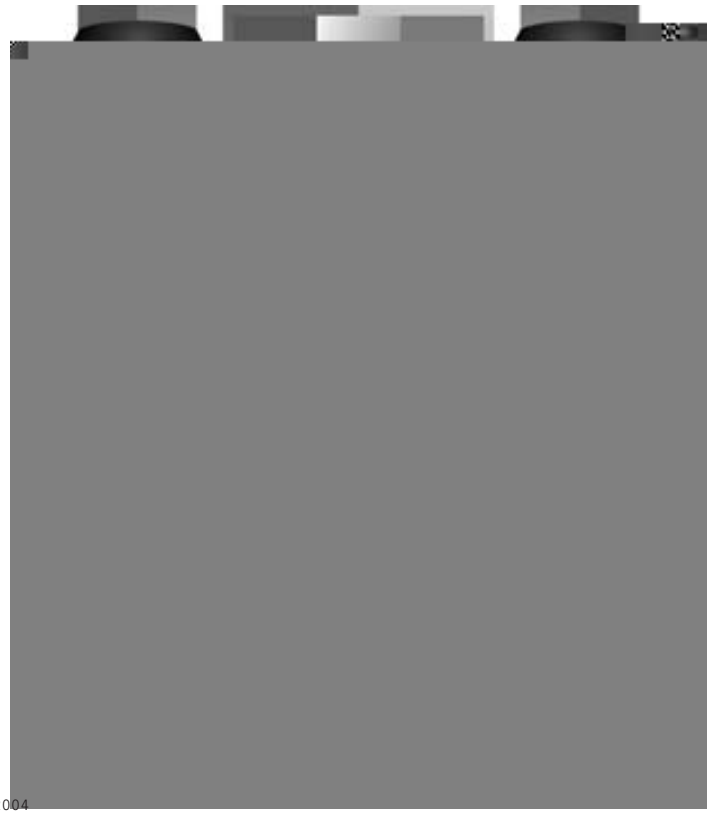

performance: a written essay or test. Effective educational technologies enable all students to produce visual, kinetic, and logical-mathematic performances. In addition to submitting written essays, for example, students

and education conferences where the same question arises: "Is it any good?" That is, how do we know that the results of a student's use of technology are any good? I cannot provide a single rule of thumb that governs the assessment of student uses of technology; I can only point to the specific requirements of each discipline.

Students do not use technology in a vacuum: except in some limited circumstances, simply demonstrating technical proficiency with a technology is rarely sufficient. For example, some of my students have submitted written papers with clip art additions that were irrelevant (and distracting) and never integrated into the written text. Other students (using the same techniques) have written papers on the history of art, adding scanned images that were analyzed in the body of the text. The latter use of the technology was much better than the first; better, at least, in the context of the discipline of history.

Each discipline establishes its own criteria for authentic performance. Technology use in education is context specific as well: each discipline establishes its own assessment criteria. This is what Nardi and O'Day meant when they described healthy information ecologies in terms of their "locality"—each discipline defines how "good" a student's use of technology is.

Does this mean that students should only use the tools to the extent that they replicate traditional forms of performance? Take my history example: what if a student wanted to use technology and software that would produce something other than a written paper (the standard performance for historians)? I had one student who used technology to produce a Web-based oral history and another who used PowerPoint to produce a museum-like display of images, analyzed with richly worded captions. Both were legitimate disciplinary performances but also outside the traditional assignment typically available to history students. In fact, these students were creating something authentic that they might not have been able to do were the technology not available. A "good" use of technology derives from a disciplinary context, not from technical proficiency. If teachers find it difficult to have students use technology to produce "good" work, then the technology should not be adopted.

Technology and the Pedagogical Infrastructure

Digital technologies serve a variety of infrastructural functions in the modern university, from administration to communications to recreation. That digital technology is part of the space of the university cannot be denied. Nonetheless, universities do not attract students because of the presence of digital technology. In today's environment, digital tools have become as indispensable and as invisible as indoor plumbing or electricity. Digital technology cannot be viewed as a value-added product in and of itself, but its absence—like the absence of electricity—could well discourage prospective students. Given the rise of ubiquitous computing, how and when should such technologies be placed within the physical and conceptual space of the classroom? What are the best strategies for making digital technology a part of a university's pedagogical infrastructure?

As the assessment criteria in the 10 questions stress, education is a relationship between teacher and student. Technologies used effectively in education mediate this relationship. Any assessment of technology in the classroom must consider how these tools enhance, extend, and enable that core relationship between teacher and student. *e*

Endnotes

1. D. Levin and S. Arafeh, "The Digital Disconnect: The Widening Gap Between Internet-Savvy Students and Their Schools," Pew Internet and American Life Project, Aug. 14, 2002, pp. 11–12, <http://www.pewinternet