

Beyond Technology Integration: The Case for Technology Transformation

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When a new technology is introduced in any field of practice, it is typically used to support the prevailing methods in that field. Gradually over time people recognize that it can be used to create methods that were previously not feasible. And after considerable investment of time and resources to develop and refine those methods, the new methods frequently result in quantum improvements in performance (Kuhn, 1996).

To date, technology has had minimal impact on K-12 education in the United States (Hannafin, Hannafin, Hooper, Rieber, & Kini, 1996). For this reason, there has recently been a strong push by the U. S. Department of Education and technology leaders to integrate technology with teaching in the schools (Riley, 2000). This "technology integration" movement generally focuses implicitly on how to use technology to support the way teaching is currently done in the schools. But perhaps there would be greater leverage if we invest in finding ways that technology can *transform* the way we teach, ways that technology can allow us to teach that weren't feasible before.

This article explores whether technology might allow us to transform our teaching methods in ways that could result in a quantum improvement in learning, and if so, what some of the new methods might be like. It begins with a look at how broader changes in society might influence the issue of technology integration versus technology transformation. Then it explores the sorts of transformations that may be needed and the roles technology might play in enabling those transformations.

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Of Paradigms Lost and Gained

Many social scientists have observed great differences between the industrial age and the emerging information age (Banathy, 1991; Bell, 1973; Naisbitt & Aburdene, 1985; Toffler, 1980). A synthesis of those key markers was done by Reigeluth (1992) and is elaborated in Table 1. Our current educational system reflects most of the industrial-age key markers.

Table 1. Key markers that distinguish industrial-age and information-age systems.

Industrial Age	Information Age
Standardization	Customization
Compliance	Initiative
Conformity	Diversity
Compartmentalization	Holism
Parts-oriented	Process-oriented
Bureaucratic organization	Team-based organization
Centralized control	Autonomy with accountability
Adversarial relationships	Cooperative relationships
Autocratic decision-making	Shared decision-making
One-way communications	Networking
Planned obsolescence	Total quality
Boss as "king"	Customer as "king"

To take standardization as an example, in our current educational system we typically divide students into large groups by age and teach them the same content in the same amount of time. Why? Because this allows valid comparisons of students with each other, which met an important need of the industrial age: **sorting students**, separating the laborers from the managers. After all, we couldn't afford to—and didn't want to—educate the common laborers too much, or they wouldn't be content to do boring, repetitive tasks and would do what they were told to do without question. When you really think about it, our current paradigm of education is not designed for learning; it is designed for sorting (Reigeluth, 1992). But those assembly-line jobs have largely disappeared, and employers, even in the manufacturing sector, are now looking for people who can solve problems, take initiative, and offer diverse perspectives as part of teams.

To meet these new educational needs, our educational system must switch its focus from sorting to learning—from the Darwinian notion of "advancement

of the fittest" to the more spiritually and humanistically defensible one of "advancement of all." Since we know that different children learn at different rates and have different learning needs, we can no longer afford to hold time constant and allow achievement to vary. We should hold achievement constant at a mastery level, by allowing children as much time as they need to reach those standards. This would mean allowing children to progress at different rates and therefore to pursue different goals at the same time. It would also mean a shift in focus from presenting material to making sure that learners' needs are met. In brief, it would require a learning-focused educational system that offers customization rather than standardization.

In a similar manner, we could analyze the remaining key markers in Table 1 to get some sense for the ways in which our K-12 educational systems might change to better meet our needs in the information age. For example, our teaching methods might not only shift from passive to active learning, but also help develop initiative and responsibility in learners for their own learning. Our teaching methods might shift from decontextualized learning to authentic tasks and might utilize a wide diversity of methods for different learners and at different times. Table 2 summarizes some principles that might characterize this new paradigm of education. And, in fact, our educational systems show signs of moving toward such a learning-focused paradigm.

Table 2. Principles for a learning-focused paradigm of education.

- **Mastery learning.** Each student should continue to work on a skill or topic until it is mastered.
- **Continuous progress.** Each student should move on to another skill or topic as soon as one is mastered.
- **Personal learning plan.** Each student should have his or her own plan that specifies what to learn, in what order, and through what methods.
- **Authenticity.** Each student should learn tasks or topics that are relevant to his or her life and should learn them in as authentic a context as possible.
- **Performance-based assessment.** Each student should be assessed through means that are as typical of real-world requirements as possible.
- **Peer-assisted learning.** Each student should have ample opportunities to learn collaboratively with peers.
- **Self-directed learning.** Each student should be given gradually increasing responsibility for managing his or her own learning, as the ability to do so is developed.
- **Teacher as coach.** Each teacher should coach students to become better self-directed learners while helping them to acquire domain-specific skills and topics.
- **Meaningful content.** Each student should focus his or her learning on skills and topics that will be most useful personally, including higher-order thinking skills and meaning-making.

To better understand the nature of this paradigm shift, consider the school "report card." Currently, we list the names of courses and provide a grade that compares how well one student performed compared to others in each course. In this norm-based assessment system, receiving a B- in U.S. history tells us nothing about what that student *knows*. An alternative assessment paradigm would be to have an inventory of attainments, each of which reflects certain standards, and to check off each attainment (or standard) when it is mastered. This standards-based, criterion-referenced assessment system epitomizes a very different mental model for teaching and education that characterizes the learning-focused paradigm.

The industrial age ushered in new transportation needs—to ship large quantities of raw materials and finished goods to and from factories. But it also introduced new manufacturing technologies that made it possible not just to produce buggies and covered wagons more efficiently, but to create an entirely new paradigm of transportation—the railroad—which afforded a quantum improvement in our ability to meet those new transportation needs. In a similar way, the information age has brought in new educational needs—to prepare all learners to problem-solve, take initiative, use metacognitive skills, work well in teams, and so forth. But it also provides new information technologies that make it possible not just to support the ways in which we have traditionally taught, but to create an entirely new paradigm of education—the learning-focused paradigm—which can provide a quantum improvement in our ability to meet those new educational needs.

How to Transform?

This shift from a time-based to an attainment-based system would represent a fundamental transformation of our educational systems. But there are many obstacles to designing and implementing such a fundamental transformation of our schools. So how might we bring about such a transformation? How can a teacher help 30 children to all learn different things at different rates and in different ways utilizing authentic tasks? How can a teacher even keep track of what each of those children has learned and should learn next? These are monumental challenges that can only be made manageable and affordable with technology. It is not an exaggeration to say that technology is indispensable for allowing us to transform teaching and learning to better meet our children's needs in the information age.

Clearly, this fundamental shift requires fundamentally different roles for both people and technology. For policy-makers and educators to work towards this technology transformation, it is important to understand what those new roles ought to be. For different students to be able to learn different things at the same time, the

teacher has to be more of a "guide on the side" rather than a "sage on the stage." So, if the teacher is a facilitator rather than the agent of most of the learning, what other agents can the teacher and learners utilize? Technology is important, but it would be a mistake to look only to technology.

Fellow learners can be powerful agents of learning. It is often said that the best way to learn something is to teach it. Peer-assisted learning (Topping, 2000) and collaborative learning (Nelson, 1999) can take many forms, but they all facilitate the social construction of knowledge (Vygotsky, 1978). Additional agents include parents and other community people (e.g., tradespeople and artists), organizations (e.g., businesses and social service agencies), and natural resources (rivers and woods). Still others include remote information resources (through the Internet) and well-designed instructional resources, which is where educational technology can play a particularly large role.

The answer to the question "How to Transform?" lies within the teacher and student relationship (Elmore, 1996). Using technology and the agents of learning described above to build upon the existing teacher-student relationship only prevents us from finding new methods of learning and instruction. We must look to various technologies and methods for not only the purpose of enhancing the teacher-student relationship, but more importantly for the purpose of transforming this relationship.

Diverse Technologies and Methods

Given the diversity of agents for learning and roles for technology in the learning-focused paradigm of education, many different types of technology are needed in K-12 education, and different types of methods are needed for each type of technology. The differences in agents, technologies, and methods are all likely to be influenced by differences in the learning requirements for the different types of learning. For example, learning to perform a procedural task, such as solving a quadratic equation, can often be best facilitated through use of a computer-based tutorial or an electronic performance support system (EPSS). But learning to perform a complex cognitive task, such as identifying the most cost-effective ways to create a cleaner environment in one's local community, can often be best facilitated through use of a computer-based simulation. And developing deep understandings, such as the ways in which people's values and mindsets influence their perceptions and thinking, can often be best fostered through dialogue (Bohm, 1996).

The Internet provides a powerful tool for accessing information and instruction. But finding the best resources can be a daunting task. And there is frequently a need to "repurpose" the resources that are

available. Knowledge objects, learning objects, and metatags show great promise for providing methods to find, repurpose, and combine existing resources in powerful ways. A knowledge object is a precise method of describing content in its most basic form, to be used for instructional purposes (Merrill, 2000). A learning object is "any digital resource that can be reused to support learning" (Wiley, 2001). MetaTags are user-defined keywords that are used by search engines to index Web pages, and are used by learners to find appropriate content.

The concept of on-the-job training can be easily extended to provide a powerful form of community-based education for K-12 students, as well as professional development for teachers. EPSSs show great promise here, particularly as ubiquitous computing and wireless palm-size computers become more powerful, less expensive, and more prevalent. Self-directed learning will certainly be an important method to combine with these technologies to maximize their effectiveness.

For creating well-designed instruction, some powerful tools are being developed. Merrill (1999) is developing transaction shells and learning objects that generate sound instruction using proven methods for different types of learning. Ultimately, we may see computer systems that allow a learner not only to select what skills or topics to learn next (subject to such constraints as human development stages and learning prerequisites), but also to select from several sound approaches for learning those skills or topics. Each of those approaches might be adjusted in real time to particular learning styles or preferences about which the computer has learned from previous learning sessions. That computer system could also provide periodic advice to foster the learner's self-directed learning skills and other metacognitive skills.

The Primacy of Methods

In all these cases, we should not focus our decisions on technology but on methods that will best facilitate learning (which we refer to as methods of instruction in the broad sense of the term "instruction" as anything that is intended to foster human learning or development). But we must think beyond the methods that we have traditionally used, and work on inventing methods that are consistent with the key markers of the learning-focused paradigm, keeping in mind the new capabilities that technology offers. We have already explored the key markers of the learning-focused paradigm, so let's now take a look at the new capabilities that technology offers.

What we usually think of as "hard" technology affords portability (such as palm-size computers) connectivity (such as wireless communications and the Internet), and greatly increased processing power and storage capacities. But there are also soft technologies

that afford such capabilities as simulations, virtual reality, expert systems, artificial intelligence, electronic performance support systems, voice and optical character recognition, among others. Peer-to-Peer communications systems have begun to move us away from a centralized form of computing that we are accustomed to via Internet servers, toward a decentralized method of data exchange between individual computers (Lewis, 2000). For example, it was a Peer-to-Peer communications system that was the backbone of Napster's (the music exchange company) success. Peer-to-Peer systems may offer some promise in a learning-focused system.

By looking carefully at these kinds of capabilities and the key markers of a learning-focused educational system, we can work on developing methods that should eventually result in a quantum improvement in meeting our children's educational needs. These needs include not just intellectual development, but also social and emotional development, which we are just recently coming to recognize as every bit as important as intellect (Goleman, 1995; 1998; Stone-McCown & McCormick, 1999).

Methods that show considerable promise for the new paradigm include problem-based learning, project-based learning, simulations, customized tutorials, peer-assisted learning, and self-regulated learning. Reigeluth edited a book (1999) that has assembled a broad sampling of work that is being done on this new paradigm of methods. While several of those methods utilize powerful capabilities of technology (see e.g., Hannafin, Land, & Oliver, 1999; Merrill, 1999; Pogrow, 1999; Schank, Berman, & Macpherson, 1999; Schwartz, Lin, Brophy, & Bransford, 1999), much work remains to be done to develop these and other methods to their full potential.

Conclusion

Society is undergoing massive changes that are creating new educational needs and new educational tools that both require and enable a new, learning-focused paradigm of education that holds promise for a quantum improvement in meeting the new needs of learners for the information age. These changes highlight the need for us to go beyond technology integration with teaching to technology transformation of teaching and learning.

But such transformation will not be an easy task. Policy-makers must invest more resources to support innovative research and development on methods of instruction that utilize emerging technologies to transform the current paradigm of teaching and learning. Researchers must invest their time and energies in developing and improving those methods, which requires more developmental or formative research (Reigeluth & Frick, 1999), such as that done

by Lewis, Watson, and Schaps (1999), Stone-McCown and McCormick (1999), and Pogrow (1999). And educators must recognize that using technology to support what they are already doing is not a productive course of action when compared to using technology to transform their teaching to a paradigm that is attainment-based rather than time-based.

It is only through transformation to this learning-focused paradigm that we will be able to produce quantum improvements in our educational systems. We encourage policy-makers and researchers to work with school districts and communities to help them engage in transforming their systems to learning-focused educational systems that will better meet all our needs in the information age. □

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