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If We Didn't Have the Schools We Have Today, Would We Create the Schools We Have Today?

Thomas G. Carroll

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We have a unique opportunity in education today. Massive funds are pouring into the technology infrastructure of K-12 schools. It is estimated that $7 billion a year is being spent to equip schools with infrastructure, networking activities, and hardware.

The investment of resources on this scale is comparable to the space program. The process of building this infrastructure is similar to launching a rocket in education. Now that we have launched that rocket, we must learn to fly. That may seem backwards, but it is often the ways things work.

When the Wright brothers were going to make the first flight, there was no flight school to prepare them. There was nobody to teach them to fly. They just launched their plane and figured out how to fly it after they were on it. We are in the early stages of flight with technology in education. Pilots in the early stages of flight crashed a lot of planes, but they also discovered the principles of flight. They came together in learning communities where they could share their experiences and knowledge about what works and what does not work. They developed and evolved principles that make modern flight possible today, including the space program. That kind of learning opportunity is available to us in our schools today.

"If We Didn't Have Today's Schools, Would We Create Today's Schools?"

(Careful, This Is A Trick Question!)

The question in the title of this article *is* a trick question, because I want readers to really think about it. "If we didn't have today's schools, would we create today's schools?" And the trick is, if you wouldn't create today's schools, what are you doing about it? If we continue to prepare teachers as we have always prepared them, we are going to continue to recreate the schools we have always had. We have to start preparing teachers differently. If we are going to continue preparing educators to work as solo, stand-alone teachers in self-contained, isolated classrooms, we are going to perpetuate the schools we have today. If we want schools to be different, we must start today to prepare teachers differently… s*ignificantly differently.*

If a surgeon from the 1800s walked into an operating room today where arthroscopic surgery was being performed, could that surgeon step in and perform the surgery? No way. The surgeon would not even understand what the

procedure was, would not understand what the instruments were, and would be totally lost about what was going on.

But if a teacher from the 1800s walked into a classroom today, could he or she substitute as a teacher? If so, why would that be possible? Perhaps the educators of the 1800s were able to anticipate the needs of the 21st century and designed a system that perfectly fits our educational purposes today. The other possibility is that our industrial era schools have not changed to keep pace with our current understanding of cognition and learning. If this system of factory era schooling does not meet the needs of today's learners and the demands of our information age economy, we have a problem. If we have a system that does not fit our needs anymore, we must begin thinking about how to transform the educational system we have.

Papert (1996) has suggested that another way to think about this question is to ask, "If the changes in education over the last 100 years had been as dramatic as the changes in medicine over that time, what would our schools look like today?"

If we start to push our thinking about what the educational system could become, we begin to get some idea of the opportunities before us and the work required to realize those possibilities.

Can Technology Be Used to Improve Education?

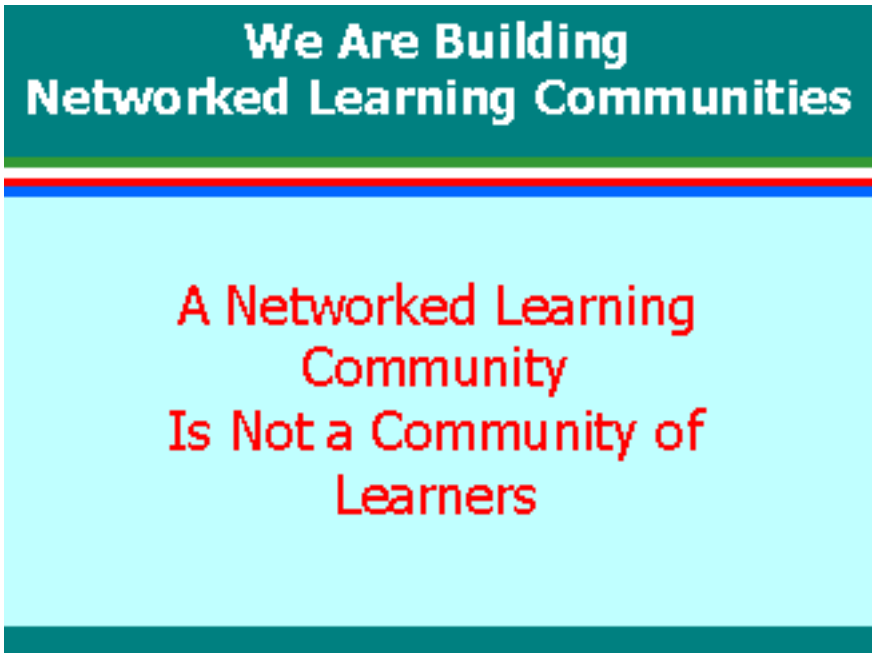
When asked whether technology can be used to improve education, education reformers will answer, "Yes. Computers can be used to improve schools." Most often the reformers are talking about using computers within the context of the schools as they are today ¾ making refinements, tinkering with the schools we have, but not transforming them to meet the needs of 21st century learners and our new knowledge-based economy.

Critics—cybercynics—say, "We don't need computers in schools. Learning is best done through face-to-face interaction without these technologies (especially in early grades), and we don't need computers to improve education in our schools today."

The cyberprophets say that, with networked computers, we do not need schools. I am not prepared to say that we do not need schools. Anyone who thinks we do not need schools does not have children. I have children. They are grown now. But when they were younger, and I was at work, they were in school. Children have to be supervised in a safe place that is structured to support learning. I believe that in the near future the places where children will learn are not going to look anything like the schools we have today.

Networked Learning Communities

For now, I am calling these new places



Networked Learning Communities. Institutions similar to schools may serve as organizational nodes in these learning communities (along with libraries and community centers, museums and colleges, and homes and workplaces, among others). But most schools and classrooms will no longer be the central learning hubs they are today. Today's model of schooling is to bring the learner to the knowledge—tomorrow we will bring the knowledge to the learners. We must recognize that schools and classrooms are becoming nodes in networked learning communities. We must begin to think about how to organize learning in networked communities and not limit learning within the boundaries of classrooms and school buildings—which would be to limit our thinking to what has been possible in the past in a single school or node.

A Networked Learning Community is constructed as its members collaborate to achieve common goals, learning together as they develop solutions for problems they are addressing in common. As the learning community grows, the members of the community develop new knowledge and skills through their participation and contributions. Everyone becomes a learner in a Networked Learning Community, and the distinctions between students and teachers fade away.

A networked learning community has three dimensions, and our schools have traditionally focused on only the first of these dimensions.

Transmission and conservation. The first dimension is knowledge "transmission" and conservation. In this learning mode, the community focuses its resources on ensuring that the young learn from the old. Traditions are passed from generation to generation along with valuable skills and knowledge, the community's history, its language arts (including reading), the expressive arts, and its solutions to simple and complex problems (mathematics, sciences etc). These bodies of knowledge are passed on as valued cultural wealth. In the knowledge transmission mode, the young learn from the old, stability is valued, and *Change is Bad*. Knowledge transmission is the mode dominating our schools

today. However, two other dimensions of learning communities exist. Until recently, our educational system has suffered by largely ignoring these other dimensions.

Knowledge adaptation. The second dimension of a learning community is knowledge "adaptation." In this mode, traditions and existing knowledge are modified to accommodate new developments. The old often learn from the young (as they do when older generations in immigrant families learn from their children, who adapt quickly to new cultural traditions). Old knowledge blends with new. The community values progress and accepts that *Change is Necessary*. The community is often focused on applied learning, in which existing knowledge and understandings are revised through experience. Traditional schools built around knowledge transmission through a fixed curriculum focused on an immutable body of facts have not been hospitable to this mode of learning.

Invention and knowledge generation. The third dimension of a learning community is "invention" and knowledge generation. In this mode, young and old learn to collaboratively construct new knowledge. Through this collaborative learning, young and old join forces to create the future. The community values innovation, and *Change is Good*. Our traditional K-12 schools have rarely made room for adults and young people to collaboratively contribute to each other's learning, or to the development of new knowledge on a sustained basis. But our information age economy demands this intergenerational, collaborative construction of knowledge, and our schools will fail to develop young people who can be productive citizens in this economy if they do not support this mode of learning.

Our schools may become marginalized as learning places if they continue to focus only on knowledge transmission, while our workplaces, communities, and homes begin to take full advantage of modern communications and information technologies for knowledge adaptation and generation. With these technologies, our youth will have access to powerful learning tools that will enable them to exploit the full potential of all three dimensions of a learning community, whether we are ready to join them or not. Margaret Mead wrote extensively about these three modes of learning, and her thoughts are best captured in *Culture and Commitment* (Mead, 1978).

Roles in a Networked Learning Community

Everyone has an opportunity to be an active learner in a networked learning community, that supports intergenerational knowledge adaptation and generation. Each member has a role as a community learning resource.

- If you are an experienced learner in the community—practiced at solving problems—you have a role to play helping others to learn. You may bring past knowledge and experience, and you will learn more as you help them learn.
- If you are a young person or a novice at learning in a particular field, you still have a role to play as you construct your own knowledge and understanding, and through that process contribute new insights,

experiences, and creations that enhance the learning of others in the community.

Everyone plays an active role in a networked learning community, contributing to the community's construction of knowledge as its members collaborate to address problems (whether the goal is learning to read or learning to fly a rocket to the moon). In the networked learning communities of the future, *expert learners* (we call them teachers, educators, scientists, and researchers today) are going to be recognized for their ability to learn and help others learn, as they continue to construct new knowledge and develop their own expertise. Their job will not be to teach – but to help others learn, as they model learning through collaboration to solve problems and achieve goals they have in common. (A significant part of the expert learner's role will be organizing and managing the collaborative learning community.)

In a networked learning community, we will have "schools" that are nodes in a larger learning environment, and in those schools there will be no teachers and no students–*just learners*.

The *novice learners* in the community will grow to become *mature learners*. We all begin as novice learners from birth (perhaps earlier). Through various stages of experience in our lives, our learning matures. We may remain novice learners in one field of knowledge while becoming mature learners, or even expert learners, in another. As we collaboratively work together in a learning community, we can complement each other's knowledge and skills. In a networked learning community, we can greatly accelerate and augment the learning of all members by linking them with other learners in collaborative efforts organized by expert learners.

In a networked learning community, modern communication and information technologies can enable us to construct knowledge and skills at a faster rate and at a higher level, because we can be connected with more learners, more resources and experiences, and more experiments and learning opportunities than ever before. The power of networked learning communities is already being used to great advantage in scientific research. Biologists located in laboratories around the world are collaborating on research to accelerate understanding of the human genome. Now we must find ways to use modern technologies to extend the concept and power of networked learning communities to education at all levels.

These are some of the ideas that lead me to believe that the schools we have today are about to undergo a dramatic transformation.

Learning as a Community

As we begin this transformation, it is important to note that a networked learning community is not a community of learners. A learning community learns as a community—unlike a community of learners in which each individual is engaged in his or her own learning.

In our schools today for example, we have communities of learners who are individually and separately going about their own individual

learning—occasionally calling on each other's knowledge and experience—but otherwise focused on their own individual learning tasks in isolation from each other. Individual inquiry and learning, of course, will continue in the future, and we are finding new ways to support that learning with modern communication and information technologies. The new and more powerful opportunity available to educators today is to use these technologies to help individuals collaboratively construct networked learning communities that will accelerate and augment the community's learning, as well as each individual's learning.

If we return to the three dimensions of a learning community for example, the factory-era teaching and learning model still prevalent in most of our schools today primarily supports an information transmission mode in which information flows one way from the teacher to individual students, who are expected to learn independently from each other.

Figure 1 illustrates a teacher making a full frontal assault on a student, with the teacher engaged in a one-way broadcast of facts to individuals who are not in a position to collaborate with each other or with the teacher. The teacher is broadcasting information to the students, but is not learning from the students in this model. The transmission of information from one person to many, as I am doing with you through this document, still dominates most of what we are doing in education, even when we attempt to integrate powerful communication and information technologies into our efforts. The readers of this document, and listeners during a one-way information broadcast, are learning in isolation from each other, with no opportunity to collaborate on what they are learning (drawing on each other's expertise and constructing new knowledge in the process) and little or no opportunity for the author or presenter to learn from the readers and listeners. This can only be an effective mode of education when the content is assumed to consist of static or immutable facts, and when our expectation is that all learners need to acquire the same facts at the same time. This is the transmission and knowledge conservation learning mode.

Figure 1

Although we are trying to use modern learning technologies to move away from this one-way, broadcast mode of instruction, we often find technology still being used in schools to reinforce one-way communication and passive modes of learning. We want to encourage more two-way learning (not just two-way communication, but two-way learning in which the teacher also learns more and constructs new knowledge as the students learn and construct their knowledge)—to move at least to a "Knowledge Adaptation" model.

Generation WHY. A strong model of such two-way interactive learning (in which the traditional teacher and student roles begin to fade) is the *Generation WHY* initiative in Olympia, Washington [http://genwhy.wednet.edu/]. Several years ago, in a middle school in Olympia, they found that they had teachers who knew science, but who did not know how to use technology to improve learning. And they had students who did not know science, but they did know how to use

technology. So they created collaborative learning teams of teachers and students, who combined their respective knowledge and expertise to construct new multimedia and web-based learning activities. The teachers learned to use the technology from the students, and in the process, the students learned science. As they did, some of the distinctions between the roles of the teacher and the student began to fade. *They were learning from each other as learners with different levels and areas of expertise* in a learning community, and the question of who was teaching whom became irrelevant. Working together, the teachers and students all continued to learn more about how to use the technology, and they all continued to learn more science. In fact, the teachers, especially, began to learn more science than they had before. They were connecting to expert learners in science and to vast sources of information. This connectivity began to accelerate their learning (and the learning of their students) in ways that were never possible when they were teaching solo in isolated classrooms with only their own knowledge, a dated textbook and a static curriculum to work with. Now, Generation WHY has evolved into a web-based initiative where Generation WHY teachers and students are helping other teachers and students in over a thousand schools across the country to engage in networked collaborative learning activities.

The Virtual High School. The Virtual High School organized by the Concord Consortium [http://vhs.concord.org] is becoming another well-known example. Teachers (as expert learners) located in different high schools around the country are using network connectivity to collaborate, with the help of experienced facilitators, to design and offer new Internet netcourses. Each VHS school provides a part-time coordinator, who acts as liaison between students and the VHS teachers. The Concord Consortium provides professional development, netcourse expertise, and curriculum development support to the collaborating teachers, who are offering over 200 courses in over 350 schools in 30 states and 6 foreign countries. Student participation is expected to reach 4,000 this year.

These emerging networked learning communities stand in sharp contrast to our current linear, fragmented teacher preparation model. Our traditional knowledge transmission model for teacher preparation is depicted in Figure 2.

Figure 2

The "F" in the diagram depicts a faculty member at a university, who is engaged in one-way transmission of knowledge to a student teacher ("S/T"). The assumption is that the faculty member will transmit knowledge to the student teacher, and at the end of four years a transition will occur, through which that student teacher will become a classroom teacher engaged in yet another one-way transmission to K-12 students ("S"). Those K-12 students, in turn, leave the teacher's classroom and use that knowledge in ways that are not known to the faculty, the next cohort of student teachers, or to the

teacher in the classroom. There is no way for the faculty or teachers to collaboratively learn and construct new knowledge in this system—no way for them to know whether the knowledge that might have been acquired by the student teacher is actually the knowledge the student teacher then conveys as a teacher to the K-12 students. Few, if any, of the educators know anything about what the K-12 students might be doing with any of the knowledge they may have acquired after they leave the K-12 classroom. This is a linear, fragmented teaching approach—the epitome of the factory-era assembly line approach to teaching and learning—which defeats any opportunity for collaborative learning or feedback across the various levels of teaching and teacher preparation.

Two-Way Interactive Communication

With modern learning technologies, we can move toward two-way interactive communication that enable learners at many levels to collaboratively construct knowledge. We are observing the early stages of development of this new learning environment in some of the "Preparing Tomorrow's Teachers to Use Technology" (PT3) grants awarded by the U.S. Department of Education [http://www.pt3.org/]. Some of the grantees have begun changing the roles of people we call student teachers. What do we call a student teacher who is teaching faculty members about how to use new technologies to improve learning on the campus? Are they still students, or have they become mentors or teachers—and have the faculty become students? And many of these student teachers are now mentoring K-12 teachers in the schools on the use of new technologies, as they themselves learn effective strategies from master teachers for helping K-12 students develop new math or science knowledge.

What does it mean to be a "student teacher" when you are teaching the faculty, mentoring other teachers and learning to construct knowledge with your students at the same time? We should stop calling these individuals "teachers" and "students" and start calling them "learners" instead. More than just a change of names, it is a change to a fundamentally different role. It is very different to be a "learner" than to be a "student" or a "teacher."

In New Mexico and Kansas and dozens of PT3 projects around the country, the student teacher is now in the early stages of becoming an expert learner. As expert learners, they are mentoring the faculty on the use of technology that will improve the faculty members' ability to construct knowledge with their students. Some of the faculty members are uncomfortable with that change of role. They do not like the idea that a student is mentoring them, but they are, in fact, learning a lot from their students. The student teachers are also collaborating with their faculty and with the K-12 teachers in local schools. They are mentoring some of the in-service teachers, but they are also developing new knowledge and skills by working with some of the in-service master teachers. Many of the people in the country who know the most about how to use this technology effectively in K-12 schools are the master teachers—whom I would call expert learners—in the K-12 schools, and we have a lot to learn from them.

New learning teams are emerging, which consist of college faculty, the teacher candidates, and the in-service teachers. The high school students themselves are

sometimes members of these teams, developing new applications of technology. They are becoming learning communities, "communities of practice," as some would call it. And in these learning communities, the distinctions between "teacher" and "student" no longer serve us well. That is why I believe education is rapidly moving toward new learning environments that will have no teachers or students—just learners with different levels and areas of expertise collaboratively constructing new knowledge.

To move toward this new learning environment some have tried to replace the linear teaching model with the model of the teacher as a "guide on the side," replacing the teacher as a "sage on the stage." Figure 3 is an image representing a teacher on the side constructing a learning environment for the students. The S's in the diagram represent the students. The students are learning from each other as they focus on a problem (represented by the "P") established by the teachers, and we have collaborative learning among students. The students are engaged in authentic learning activities.

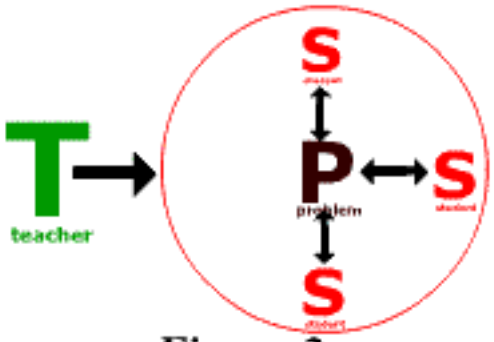


Figure 3

I am not comfortable with this perspective anymore. I do not like the teacher as the sage on the stage, but I do not like the teacher as a guide on the side either, because it places the teacher outside the learning process. The learning is going on inside the circle, but the teacher is standing outside like a soccer coach on the sideline, waving at everybody while the game is going on. We need to change that. We need to get the teacher into the game. The teacher needs to get in there and be part of the learning process, actively engaged in solving the problem with the students and learning with the students—not teaching but modeling learning with the students by functioning as an expert learner solving problems and constructing new knowledge with the students.

Modeling the Learning Process

Once we move the teacher—as an expert learner—into the learning activity we begin modeling the learning process with the students. They are all learning together. And as I have said, once we reach this point, it's not useful to distinguish between students and teachers, because they are all learning. Who is teaching and who is learning? They are all learning. Figure 4 helps us start

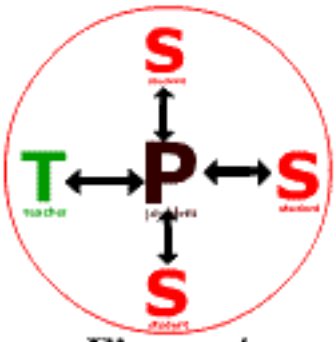


Figure 4

thinking about everyone in this dynamic field as a learner. I represent each individual with an "L" to indicate that they are learners, and that the role of each individual in this activity is learning.

Also, I want to get past the boundary, (the red circle in the diagram), which is a boundary around this learning environment, (the classroom or the school). We need to get rid of the circle and enable them to be learners in an open learning environment (see Figure 5). One of the large "L's" in the diagram is the expert learner, the more senior, experienced learner, the person we pay to continue to structure these learning activities, but the person who is also constantly learning more and modeling the learning process, as opposed to the teaching process.

Figure 5

Once we have defined these individuals as learners, and once we have taken those boundaries away, we can actually add more learners to the equation. They do not have to be in the school anymore. We can connect to them anytime, anywhere. That other large L could be in universities. It could be a university researcher, who is bringing knowledge and expertise to this community. These other L's could be older learners, high school students, working with elementary school students, or those folks could be community members, parents, librarians, and people at work across all sectors of the economy—learners at all levels of maturity and expertise, connected in a networked learning community.

A Learning Community in Tanaskee, Washington

A few recent examples of networked learning communities are described the January 2000 issue of *Converge* magazine, which focuses on using technology in a learning community. One of the exciting projects described in that issue is in Tanaskee, Washington. Tanaskee is a small, rural community—an apple orchard, farming community. They had a problem there. The students would attend school, graduate, and leave the community. The students were learning little in their schools that would engage them in the work and life of their community. The school system sought ways to get students more engaged in authentic learning that would reconnect them to their community.

They had an acre of land on the grounds of the elementary school, and they decided to establish an orchard. This is a familiar kind of project, using hands-on,

project-based authentic learning. The students, the teachers, and the administration of the school system had to do the research and find out what was involved in establishing an orchard. How many trees can be planted on an acre to have good productivity? What kind of soil conditions exist? How should they market this and how should promote it and write about it so others can learn from what they are doing? How should they do the research? They created a real-life learning environment that began to extend beyond the boundaries of the school into the community.

They went even further. The principal of that elementary school created an advisory group of orchard growers from the community to collaborate with the school on the development of its orchard. Some of the those growers were the parents of children in the school. Even those growers who were not parents were impressed by the fact that the school system was taking their business seriously, and that it was reaching out and investing resources to ensure that the community's young people would have an opportunity to become engaged in the valley's central enterprise. These orchard growers who were formerly just the farmers down the road were now expert learners collaborating with the teachers and students in the school to construct knowledge about what makes an orchard thrive. They were all developing their knowledge of soil chemistry, mathematics, biology, communications and marketing. Those orchard growers became some of the people represented by the L's in the diagram. They are now part of the networked collaborative learning environment surrounding that school. They are in an active exchange with the school on a regular basis. More students are learning more about the orchard industry, and a few may stay in the community to take up careers in the industry. If the school of agriculture at a research university becomes involved, one of those large L's might represent university researchers, and some of those students might find themselves on a pathway to college and a future in biology, agricultural science, or marketing.

Resistance to Change

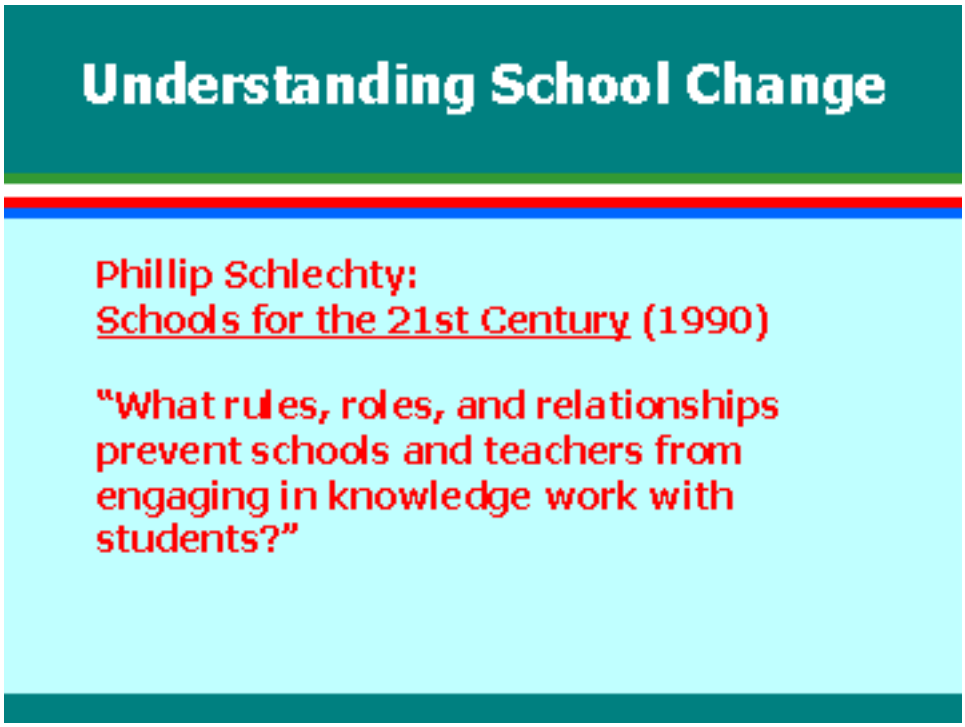
With the modern learning technologies available today and with recent research on cognition and learning we now have the tools to change our learning environment dramatically. But schools will resist this change. I want to tell you from my own background as a cultural anthropologist, schools resist change, because they are designed to resist change. They are cultural organizations, and cultural organizations are not supposed to change. Cultures are designed to preserve existing solutions to problems—considerable social and economic capital goes into developing culturally valued solutions to problems and change is risky. Stability reduces risk—"change is bad"—and our schools have been designed to focus on the *knowledge transmission* mode of learning.

We have all had many encounters with school systems that resist change. An example of this resistance to change is the response to open space schools. A lot of people feel like open space schools were a fad that has failed. About a year ago, an article in the *Washington Post* focused on open space schools. Northern Virginia communities experienced a tremendous population growth in during the 1970s expansion of the government and businesses around Washington, DC. A lot of new schools were built in northern Virginia right at the height of the open

school movement. A *Washington Post* reporter went out and interviewed teachers and principals in those open space schools. In most of those schools, she heard complaints from the principals and from the teachers that the open space model did not work. Teachers who were interviewed in the article said things like, "When I am trying to lecture to my students, I can't keep control of the class, because they are distracted by lectures and noise from the other teachers and their students. My students listen in on what the other teachers are saying or doing with their students, and they have a lot of ways to send messages to the other students. It doesn't work. I just can't teach my class in an open space."

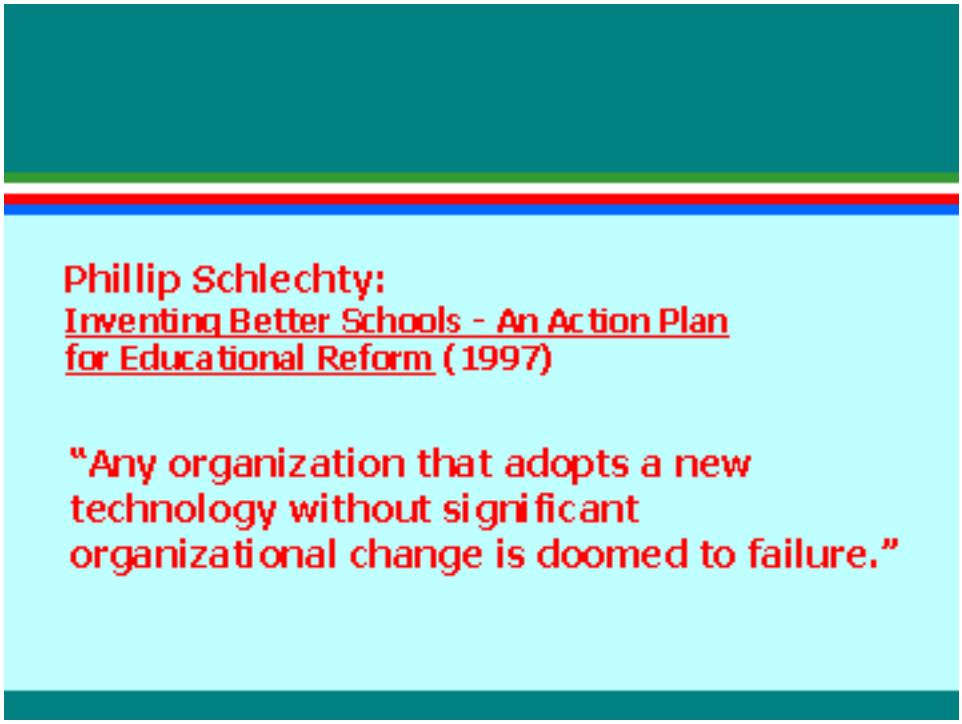
However, at one school, the principal said, "This is great. It works really well for us. Our teachers have organized themselves into teams. We have cross-age classes and we have team projects across our subjects. Our teachers and students can move around and reconfigure themselves any time they want to work on a new task together. We have some older students tutoring younger students. This is a great school, and we are very happy with it."

What was happening? In the majority of the schools where the teachers and principals were complaining about the distractions and the disruptions, the teachers were beginning to pull in bookcases and blackboards on wheels to make these little impromptu walls around their space. They were intent upon continuing to be solo teachers, teaching in isolation from the rest of their colleagues and the other students in the school. The school boards in those communities had decided to pass bond issues to raise funds to build walls in the schools, so that they could get back to the isolated classroom with the teachers teaching as solo practitioners.



Did the open space concept fail, or did we fail to prepare teachers who could teach in an open space model? We changed the physical space in those buildings, but because we continued to prepare most teachers as if the only way to teach is

using the solo, stand alone, self-contained, isolated classroom model—the open space concept could not work. That was how those young and mid-career teachers were prepared to teach. They believed they were doing what was expected of them as teachers and that open space thwarted their teaching efforts. They were not prepared to do anything different. That's our responsibility—and we will get the same result if we introduce modern learning technologies in our schools but do not prepare teachers to work in this new learning environment. If we want to take advantage of these new technologies and the billions we are investing in equipment for our schools, we have to prepare teachers very differently than we have in the past. We have to change our own model of teaching and instruction in higher education. (See Schlechty, 1990.)



We do not know whether the open space design of those schools failed, but we do know that we failed to make the changes in the roles, rules, and relationships that would be necessary for it to succeed. Any organization that adopts a new technology without significant organizational change is doomed to failure. You have to change the organization. You cannot just add the technology. You have to actively work on changing the roles of the teachers, the roles of the students, the roles of the parents, and the roles of the administrators, and start to work toward building new relationships and new structures, or you will be disappointed with the results.

Disruptive Technologies

Trying to introduce new technologies into schools without these changes would be similar to efforts in the sailing industry during the 1800s, when steam engines were installed in wooden sailing ships.

Steam engines were disruptive technologies. Disruptive technologies change our

thinking about possibilities. They become transformational tools. The sailing industry in the 1800s had reached its zenith. They had perfected the art of sailing. They had some really remarkable crossing times when you consider that they were sailing by wind power only. They had designed a very efficient system of transportation, and then along came steam engines.

Steam engines were a new power source, a completely different power source than had ever been available before. Steam engines were a disruptive technology. They changed people's thinking about the possibilities. Before, if you wanted to cross the ocean, you had to have wind power to do it. Now, you had the possibility of powering that ship with a steam engine. The first steps in using that technology as a transformational tool led to adaptive hybrids. They put steam engines in wooden sailing ships. They were essentially the same ships, with masts and sails, except with steam engines in them.

There was a debate about that in the sailing industry, with some folks saying, "This is a terrible idea. It will never work." And others were saying, "No. It's a great idea. When there is no wind, we still will be able to sail." The people arguing against it said, "This is just not a technology suited to a sailing ship. This is a wooden sailing ship. Steam engines are big and heavy—taking up a lot of cargo space for the coal to fuel the engine—and they have fires in them—not a good thing in a wooden sailing ship." The opponents had a lot of arguments on their side—some ships did burn down.

But the people who tried steam engines also made a lot of gains. They started to make faster crossings, because they could sail against the wind and sail when there was no wind. Their biggest problem, though, had to do with the sailors. The sailors only knew how to sail ships, and they would say, "We are good sailors and we know how to navigate well without this machine. And besides, manning a sailing ship is demanding work—we don't have time to learn how to use this steam engine, because we have to be up there in the masts tending the sails. Don't bother us with this new technology, we are good sailors and we don't need steam engines to sail well."

This is just what many teachers and faculty members are saying, "We don't have time for this. We are good teachers, and we can continue to serve our students well with the instructional strategies we have always used. Besides, with the time demands on us, we don't have time to learn this new technology. As good teachers, we are doing well with our students and we don't need to go through this transition."

The sailing industry never got the true benefits of steam power until they reached the constructive transformation. They altered the entire design of ships. They took down the masts, got rid of the sails, changed the whole configuration of the ship, and made it of steel. They changed the design, because to work effectively, sailing ships need a very different hull shape than steam driven ships. Once they made this transformation, and once they prepared the sailors to navigate with these new vessels, they achieved tremendous benefits from the new technology.

This situation is analogous to industries today that have just begun to experience

benefits after adopting computer and communication technologies years ago. The banking industry began by using the technology to do the same things they always did. A bank was a place where you bring money; the tellers took the money and deposited it. When tellers were given computers to manage the same transactions, the banks saw few real benefits or gains in productivity. They did not get a benefit until they used computers and communications technologies to transform their business. Banks are not banks anymore. They are financial service institutions. You can make your own deposits and use an ATM machine for withdrawals. You can do your banking from your home on the phone. You can get a lot of services from your bank that have nothing to do with depositing funds into savings account or writing checks. When banks used modern technologies to change their business model, they achieved tremendous gains in productivity.

In our schools, we are only beginning to think about how to change our learning models with these modern technologies. Most of what we are doing with computers is comparable to putting steam engines in wooden sailing ships. But these transitional phases are important steps toward using these transformational technologies for improved learning. As adaptive hybrids, like the steam engine in the wooden ship, they help us see new possibilities. NASA uses an adaptive hybrid. NASA really wants an airplane that can take off from the ground and fly into space. They have not been able to develop that technology, so what they have is an airplane bolted on to a rocket engine. That is a hybrid technology, two different technologies pasted together. It works for now, and it will get them through until they can develop the technology they want.

Hybrid technologies are being used in education all the time. We have textbooks with CD-ROMs pasted in the back of them. A more elaborate example is hosted by the Southern Regional Education Board, which has an *electronic campus*. They have developed 2,000 on-line courses among the colleges and universities in 16 different states. The colleges and universities have all agreed that these courses will be accepted for credit. They have found that 50 percent of students taking those courses are students enrolled on campus. They are living in the dorms. They are going to class in the morning across the quad, and then they are coming back to the dorm in the afternoon and taking another course online. They have created a hybrid learning environment.

The Power of Communication Technologies

It is important to recognize the power of communication technologies to bring about this transformation in education. Communication technologies support an interactive construction of information. It's not just that they are information technologies. We could call this online journal an information technology, but it's not two-way, and it does not capture the power of communication technologies to transform education. It is a new technology being used for the old one-way knowledge transmission learning mode. We will not get out of our wooden ship schools until we use communication technologies for two-way interactivity that allows us to collaboratively construct the learning experience and new knowledge.

I have a research survey going on in the conferences I attend, and I ask people

questions about communication technology: "Everyone in the room who uses a touch-tone telephone, raise your hand." Everyone uses a touch-tone phone. Behind a touch-tone phone is digital technology, computers, and billions of dollars of investments by the telecommunications industry to make that communication tool available to us.

Then I ask everyone who uses a touchtone phone to raise their hands again. "How many of you with your hands up have made the decision to use this technology because of a research article that you read?" This is the technology we use to communicate with each other every day, and no one can cite an article on its effectiveness? I have done this at a lot of meetings, and I still have not found anybody who can give me a convincing research article or evaluation study that says using telephones is a good thing to do. And, actually, I can tell you from my own inquiry into this, having worked with the telecommunications industry, that there is no research to support what you are doing. It's not there. Now that you know that there is no research to support what you are doing, how many of you will get rid of your phones?

I come from a research background. I am not knocking research. We certainly could do research to figure out how to use phones better and to make better use of telecommunications. But all of us know from our own personal experience the power of connectivity that communications technologies bring us. The power of connectivity is what fuels this constructive transformation. It is the ability that we have, when we call each other, to create the content. Phones are actually an open platform if you think about it. You have an open environment. When you are on the phone with one of your colleagues, you can engage in transactions that create new content – new knowledge and information are created and conveyed through your interaction and communication. That is one of the reasons that telephones are the most pervasive technology in this society.

By the way, we talk about the use of these technologies as a global revolution, but we should remember that over 50 percent of the world's population has never made a phone call. We live in a unique communications rich environment. In response to that untapped world market, the telecommunications industry is developing small, hand-held devices that run on low energy or solar power that will allow us all to be connected to networked learning communities anytime, anywhere. These powerful communications and information tools will go way beyond anything we have in our classrooms today.

Since we have all seen that schools have the power to resist change, why do I think these technologies will give us the power to transform education? I think there are a number of reasons, similar to the forces that lead us all to use phones whether we have the research to support that use or not. These forces are going to drive changes in education whether we are ready for them or not.

Change Is Inevitable

The first reason education will be transformed is that *the web won*. What does that mean? Five or six years ago, the primary technologies deployed in schools were CD-ROMs, integrated learning systems, and other prepackaged learning

content that emulated textbooks and predefined curriculum content. They reinforced the one-way transmission of knowledge, and they buttressed the school's resistance to change. The CD was supposed to be like a complete course on a disk. You would just load it and play it.

That is not where we are today. The web "won," and it creates a very different learning environment. The web is displacing CDs and other fixed content approaches because it supports interactive communication and collaborative construction of knowledge. This is a force that schools cannot resist. The Web gives learners access to powerful learning opportunities anytime and anywhere. Learners have open access to this new learning tool, whether the schools are ready or not.

The second factor to consider is that these *interactive communication technologies give power to the learning revolution.* The learning revolution has been recently summarized in a book edited by Bransford, Brown, Cocking, & Bransford (1999) called *How People Learn*. The learning revolution is about constructivist learning, and these new communication and information technologies allow us to facilitate constructive learning in ways that we could never do before. They are becoming *cognitive amplifiers* that will accelerate learning and the development of new knowledge in the same ways that machines accelerated production during the industrial revolution.

The third reason schools will be driven to change is that we have now reached a point where *work is learning*. Work in the workplace is learning. Work in the larger community surrounding the schools is about learning every day. It's not just about putting bolts on things anymore. Recently the Ford Motor Company, which is not in the computer industry, announced that it would give high speed

computers, with Internet access and printers, to all its 350,000 employees around the world for $5 a month. They are doing that, not because they are in a computer industry, but because they believe they can no longer survive and be competitive unless their workers are knowledge workers. They must learn in the workplace and in the home to use these tools to improve their knowledge, skills, and productivity.

The fourth force is that *learning communities have no boundaries*. In a networked learning community, schools and classrooms will simply become nodes in a larger learning environment. The boundaries of the schools and classrooms with their fixed curriculum and dated texts are no longer going to limit learning.

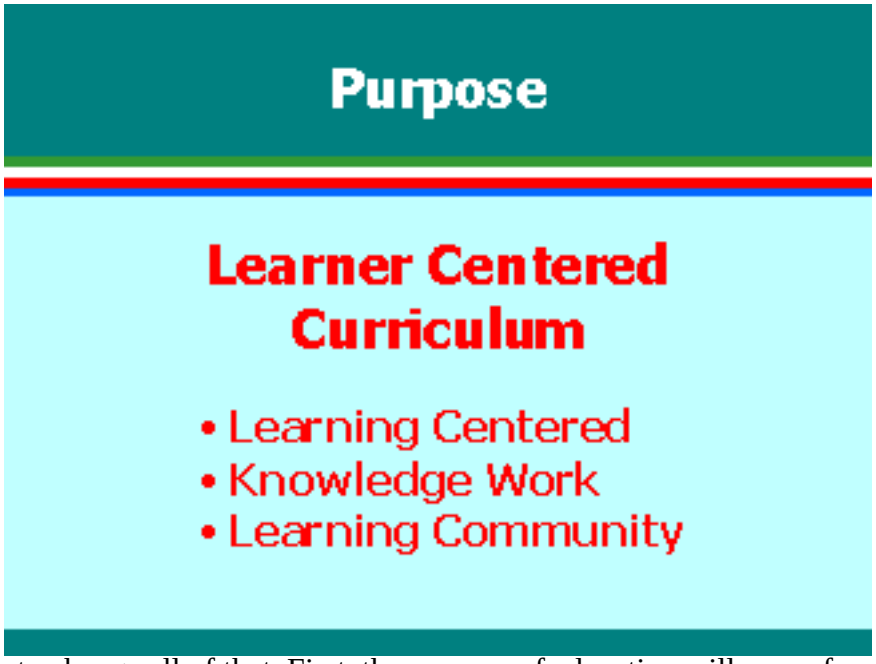
The fifth factor affecting schools is that the *home is becoming a learning place*. The home is actually a work and a learning place. We are going to see a revolution in what was once called home schooling, because there are going to be a growing number of parents working in the home. An increasing number of parents are discovering that they can make more powerful learning opportunities available to their children in the home than they can in the schools, and unless the schools change, more parents will collaborate to construct alternative learning opportunities with these technologies. Because work is learning, the home is a work and learning place, and learning communities have no boundaries, schools are going to be marginalized as learning environments if they do not change dramatically.

The final force driving change in schools is kid power. *The kids get it!* Kids know they are learning with these technologies. They are learning to become nonlinear learners, and they are learning it fast. I work with technology, but my kids play with technology. Kids come into the schools recognizing that they have more powerful learning opportunities available out of school than they have in school. And the school's emphasis on the single mode of one-way knowledge transmission from old to young is losing even more credibility with them than it had lost before.

So if these changes are inevitable, what will change? There are a lot of side-by-side charts that compare new ways of teaching and the old ways. The old way was teacher centered—the new way is student centered and so on.

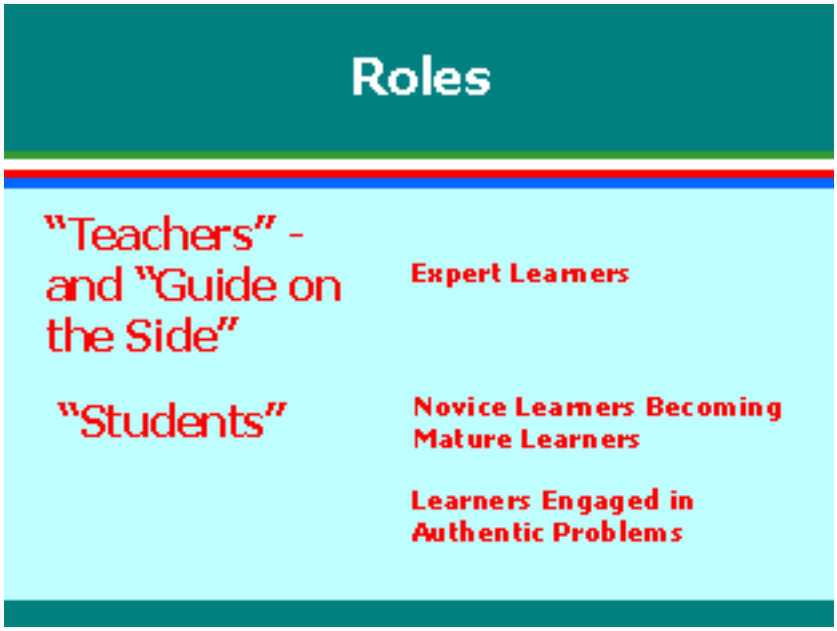
Using New Technologies to Change Education

I think we will use these new



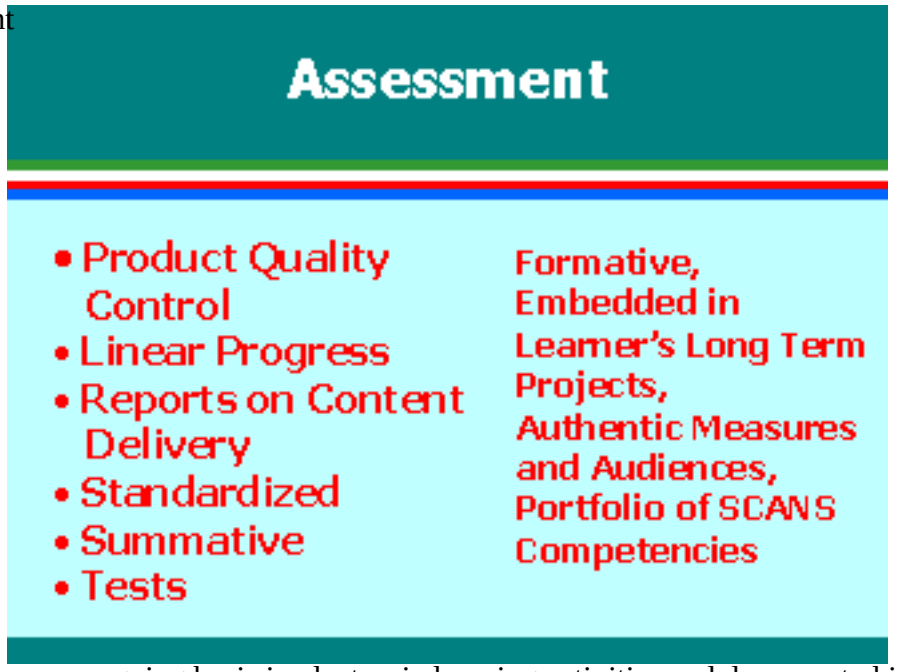
technologies to change all of that. First, the purpose of education will move from being curriculum driven to being learning centered. Learning is a verb, not a noun—*learning* centered, not learner centered. The focus will be on the learning and collaborative knowledge construction in which we engage. It will not be driven by a fixed, structured curriculum. It will be driven by knowledge work in a networked learning community.

Our roles will change. We have been working to replace the teacher as "sage on the stage" with the teacher as a "guide on the side"—but being a guide on the side is the wrong place for educators. The teacher will become an expert learner organizing and leading others in networked learning communities. Students will become novice learners growing to mature learners in a collaborative learning environment with expert learners. The roles must change. Any time we put teachers and students in predefined courses with a linear design, bound by dated texts, credit hours and static tests of factual recall, we are still on a wooden sailing ship. What we are moving toward is authentic, long-term projects, asynchronous learning, knowledge-work and nonlinear learning. "Just-in-time," consumable information used for specific purposes, instead of "just-in-case" facts packed into our heads at an early age that few of us can recall.



Most of our children who play with video games are really learning to be nonlinear learners. They can jump around through different stages of the learning process. They do not play games straight through the way we would. As nonlinear learners, they will not read from the beginning of the book to the end, or study through a sequential series of courses organized to support a linear progression of learning. They are learning to access and use knowledge when and where they need it.

Assessment will be



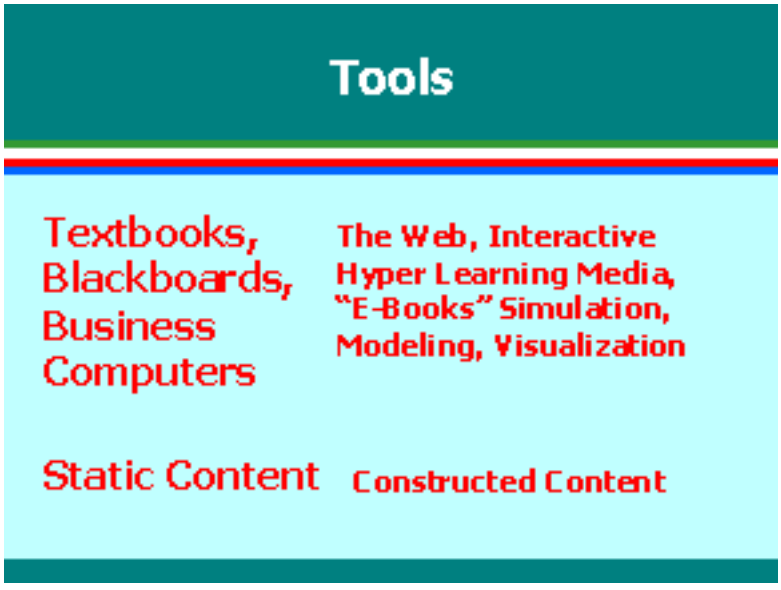
embedded on an ongoing basis in electronic learning activities and documented in digital portfolios. We will move from a standard, one-size-fits-all curriculum to mass customization in education. We are already seeing this in other industries—the automobile industry, the clothing industry. You can go on-line now and buy clothes that are custom-made to your style, shape, and dimensions. It is called mass customization, and we are going to have education that follows that

model. These modern learning technologies give us for the first time the power to truly individualize learning.

The relationships and rules that define education will change. The boundaries of schools, classrooms, grade levels, and class time, will no longer prevail. As long as we think in those terms, we are still on the wooden ships. Education is going to take place in learning centers that are nodes in a networked learning community. It will still be a safe, structured place for the children to be, but with long-term complex tasks—powerful learning tasks that children could never engage in before, but that are now possible with these technologies that give them the scaffolding and resources to accelerate their learning.

The web, as a

networked learning environment, linking learning centers, anytime, anywhere is what we are moving to. The tools will change—textbooks, blackboards, and business computers will fade from use. These business computers are going to have to change. They are a great hybrid technology for now. We are using them to make the transition, but imagine if I walked into that surgery room with a laptop computer and said, "I have a laptop computer here with business applications on it, and it will revolutionize the way you practice surgery." They would throw me right out of there.



We will develop tools and technology that are specifically designed for learning, and we need to collaborate with business partners to develop those resources and to develop the web as a learning environment. We will deploy interactive learning media in place of textbooks, hand-held personal digital assistants, simulation, visualization, and modeling. We need to work with industry to do that.

We are going to move from static, text-driven content in a fixed curriculum to learning content that is constructed by the learners. Our former teachers and their students—these new expert learners and their novice learners—collaboratively working in these networked learning communities will construct this content.

So these are the possibilities. They begin when each one of us takes a step toward preparing educators who can become expert learners in a networked learning community. Pierre Boulez said recently, "The future is the present slightly modified." Each one of you can help us take a step forward into the future. The choice is yours. We have the technology. We have the knowledge. We have the support. Define your vision and make it happen.

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