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"Learning With Technology: A Constructivist Perspective"

Chapter One: Learning With Technology: Technologies For Making Meaning


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LEARNING WITH TECHNOLOGY

This book is about learning. The question that it seeks to answer is, how can technology best enhance meaningful learning? Traditionally, technologies have been used to teach students. That is, they have been used to deliver and communicate messages to students who, it is hoped, comprehend those messages and learn from them. The underlying assumption is that people learn from technology—that is, students learn from watching instructional films and television, responding to programmed instruction or computer-assisted instruction frames, just as they learn from listening to a lecture by the teacher. This view assumes that knowledge can be transmitted from the teacher to the student and that knowledge can be embedded in technology-based lessons and transmitted to the learner. Thus, students learn from technology what the technology knows or has been taught, just as they learn from the teacher what the teacher knows.

In this book, we argue that students cannot learn from teachers or technologies. Rather, students learn from thinking—thinking about what they are doing or what they did, thinking about what they believe, thinking about what others have done and believe, thinking about the thinking processes they use—just thinking. Thinking mediates learning. Learning results from thinking.

Thinking is engaged by activity. Different activities engage different kinds of thinking. That is, different kinds of thinking are required to memorize a list, read a book, understand a lecture, solve a problem, design a new product, or argue for a belief. These activities can be presented and supported by teachers and technologies. But teachers and technologies do not necessarily cause thinking, so they do not necessarily cause learning. They may, if the learner has a need or desire to learn, but they may not, if the learner is thinking about something else. How many lectures have you endured while your thoughts drifted to the weekend coming up or the celebration last night? The important point is that the role of teachers and technologies in learning is indirect. They can stimulate and support activities that engage learners in thinking, which may result in learning, but learners do not learn directly from the technology; they learn from thinking about what they are doing. Technologies can foster and support learning, we argue in this book, if they are used as tools and intellectual partners that help learners to think. What are the assumptions underlying this role for technology?

OUR ASSUMPTIONS ABOUT LEARNING

We learn from experiencing phenomena (objects, events, activities, processes), interpreting those experiences based on what we already know, reasoning about them, and reflecting on the experiences and the reasoning. Jerome Bruner (1990) called this process meaning making. Meaning making is at the heart of a philosophy of learning called constructivism that is relatively new to the field of educational technology. What is constructivism, and what do constructivists believe?
Constructivists believe that knowledge is constructed, not transmitted. Individuals make sense of their world and everything with which they come in contact by constructing their own representations or models of their experiences. Knowledge construction is a natural process. Whenever humans encounter something they do not know but need to understand, their natural inclination is to attempt to reconcile it with what they already know in order to determine what it means. Toddlers are archetypal constructivists. They constantly explore their worlds and frequently encounter phenomena that they do not understand. So they continue to explore it, familiarizing themselves with its possible functions and limitations. Parents try to intervene by teaching them lessons, but toddlers prefer to explore and learn for themselves.

Constructivists believe that knowledge cannot be simply transmitted by the teacher to the student or from us to you. In this book, we cannot “teach” you what we know. You cannot know what we know, because you have not experienced all that we have (nor us what you have), and so even if we now share an experience, our interpretation will be different from yours because we are relating it to a different set of prior experiences. In this book, we state our beliefs about learning and technology. You will interpret those beliefs in terms of your own beliefs and knowledge. You may accept them as valid or reject them as heresy (as many of our colleagues do). Teaching is not a process of imparting knowledge, because the learner cannot know what the teacher knows and what the teacher knows cannot be transferred to the learner. We believe that teaching is a process of helping learners to construct their own meaning from the experiences they have by providing those experiences and guiding the meaning-making process.

Knowledge construction results from activity, so knowledge is embedded in activity. We cannot separate our knowledge of things from our experiences with them. We can only interpret information in the context of our own experiences, so the meaning that we make emerges from the interactions that we have had. We might make meaning (constructed knowledge) about the things that we experienced. We might not. We can (and frequently do) memorize ideas that we have not experienced. Nearly every child in American schools is required to memorize the states and capitals. But they probably do not make much meaning for those facts, if they have not experienced them in a rich way. If, however, students attend a field trip to the state capital, then they construct some meaning for it, although not always the meaning that the teacher intends.

Knowledge is anchored in and indexed by the context in which the learning activity occurs. The knowledge of phenomena that we construct and the intellectual skills that we develop include information about the context of the experience (Brown, Collins, and Duguid 1989; Lave and Wenger 1991). Information about the context is part of the knowledge that is constructed by the learner in order to explain or make sense of the phenomenon. If we had an embarrassing experience while learning about something, that embarrassing feeling becomes an
important part of the knowledge that we construct. The knowledge that a learner constructs consists of not only the ideas (content) but also knowledge about the context in which it was acquired, what the learner was doing in that environment, and what the knower intended to get from that environment. This means that abstract rules and laws (like mathematical formulae), divorced from any context or use, have little meaning for learners (except skilled mathematicians, who have used those formulae in other contexts). The meaning that we construct for ideas includes information about the experiences and the settings in which they were applied or learned. So, the more directly and interactively we experience things, the more knowledge about it we are likely to construct.

What we really understand about skills and knowledge is the application of them. When we learn how to use a skill, we store that use as a story, which is a primary medium of conversation and meaning making among humans (Schank 1986). We later recall those stories when faced with similar experiences and attempt to use those to guide activity. Constructivism argues that skills will have more meaning if they are acquired initially and consistently in meaningful contexts to which they can be related. Teaching facts and explaining concepts without using them in some context probably does not result in much meaning making.

**Meaning is in the mind of the knower.** The meaning-making process produces perceptions of the external, physical world that are unique to the knower, because each individual has a unique set of experiences that have produced a unique combination of beliefs about the world. The sense that we make of the world is necessarily somewhat different from the sense that you make of it, but we can share our meaning with others. This does not mean that we cannot share parts of our reality with others. We do so by socially negotiating shared meanings. That is, we converse with others and agree on the relative importance and meanings for things. The important point is that knowledge is not an external object that is acquired by the learner; it can only be constructed. You can experience our realities vicariously, if we tell you about them, you can even construct meaning for them, but that understanding will be your personal interpretation of our experiences that are based on your own experiences.

**Therefore, there are multiple perspectives on the world.** Since no two people can possibly have the same set of experiences and perceptions of those experiences, each of us constructs our own knowledge, which in turn affects the perceptions of the experiences that we have and those we share. Those perceptions and beliefs about the world affect our perspectives and beliefs about any subject. Why else would discussions of politics or religion evoke such strongly different perspectives about the specific subject being considered (a particular candidate, a piece of legislation, or a religious practice)? In Western societies, for instance, we have trouble understanding or accepting many of the practices of Eastern cultures because those practices rely on different perspectives and beliefs about the world that are endemic to that culture.
Meaning making is prompted by a problem, question, confusion, disagreement, or dissonance (a need or desire to know) and so involves personal ownership of that problem. What produces the knowledge construction process is a dissonance between what is known and what is observed in the world. Meaning making often starts with a problem, a question, a discrepant and inexplicable event, a curiosity, wonderment, puzzlement (Duffy and Cunningham 1996), a perturbation (Maturana and Varela 1992), expectation violations (Schank 1986), cognitive dissonance, or a disequilibrium. We can memorize ideas that others tell us, but to actively seek to make meaning about phenomena involves the desire to make sense of things. When learners seek to resolve that dissonance, it becomes their problem, not the teacher’s. Resolving dissonance ensures some ownership of the ideas and the problem on the part of the learner (a point that we will return to often in this book). That ownership makes what is learned (the knowledge that is constructed) more relevant, important, and meaningful to the learner.

Knowledge-building requires articulation, expression, or representation of what is learned (meaning that is constructed). Although activity is a necessary condition for knowledge construction, it is not sufficient. It is possible (and even common) for humans to engage in activities from which no knowledge is constructed. Why? Because they did not reflect on or think about the experience that gave rise to the knowledge construction process. For usable knowledge to be constructed, learners need to think about what they did and articulate what it meant. Usually that articulation process is verbal, but learners can construct a variety of visual or auditory representations of their experiences or understandings. Chapter 6 describes a number of computer-based tools that support this reflective process.

Meaning may also be shared with others, so meaning making can also result from conversation. Just as the physical world is shared by all of us, so is some of the meaning that we make from it. Humans are social creatures who rely on exchanges with fellow humans to determine their own identity and the viability of their personal beliefs. Social constructivists believe that meaning making is a process of negotiation among the participants through dialogues or conversations. Learning is inherently a social-dialogical process (Duffy and Cunningham 1996). Recall a conversation that you had at the last party you attended. Probably, you were exchanging stories about your experiences. Those stories were an attempt to share understanding. This social dialogue occurs most effectively within knowledge-building communities (Scardamalia and Bereiter 1993/94) or discourse communities (described in Chapter 5) where people share their interests and experiences. These people have similar experiences and enjoy discussing similar topics, so they can learn from each other because the stories they tell evoke similar experiences. These conversation communities can be a valuable source of meaning making and are described in Chapter 5.

So, meaning making and thinking are distributed throughout our tools, culture, and community. As we interact with others in knowledge-building communities,
our knowledge and beliefs about the world are influenced by that community and their beliefs and values. Through participating in the activities of the community (Lave and Wenger 1991), we absorb part of the culture that is an integral part of the community, just as the culture is affected by each of its members. Communities of learners, like communities of practitioners, can be seen as a kind of widely distributed memory with each of its members storing a part of the group’s total memory. Distributed memory—what the group as a whole knows—is clearly more capacious than individual memories; sharing those memories makes the community more dynamic. Just as the cognitive properties of individuals vary, the cognitive attributes and accomplishments of communities also vary, depending on differences in the social organization of the groups (i.e., the ways in which members distribute cognitive responsibilities) (Hutchins 1991).

As we interact, discourse communities change our knowledge and beliefs. Just as our knowledge of the world is influenced by activities, our knowledge and beliefs are also influenced by the beliefs of our fellow practitioners. Our knowledge is naturally influenced by those with whom we converse. That is why we associate with like-minded people in social or professional groups. Learning can also be conceived of as changes in our relation to the culture(s) to which we are connected (Duffy and Cunningham 1996). As we spend more time in a club, we become more influenced by its beliefs and culture, because the group’s knowledge is distributed among the participants (Salomon 1993). Members of the group will contribute what they know when a complex task has to be performed.

Not all meaning is created equally. Constructivists do not subscribe, as many claim that they do, to the view that all meaning is equally valid because it is personally constructed (Savery and Duffy 1995).

The litmus test for the knowledge that individuals construct is its viability (Duffy and Cunningham 1996). Within any knowledge-building community, shared ideas are accepted and agreed upon. That is, meaning is reflected in the social beliefs that exist at any point in time. If individual ideas are discrepant from community standards, they are not regarded as viable unless new evidence supporting their viability is provided. Individuals are regarded as more knowledgeable because their understanding is constructed from a richer and more varied set of experiences. Bransford (1994) asked, “Who ‘ya gonna call?’ if your dog is misbehaving: a plumber, dog trainer, or brain surgeon? Presumably, the dog trainer has more viable knowledge about your dog’s behavior, while the neurosurgeon better understands your cerebral activity. Assessing the viability of anyone’s knowledge involves many criteria.

Table 1.1 contrasts fundamental differences between constructivist views of learning and traditional views of learning. We believe that constructivist views of making meaning necessarily engage different kinds of thinking. In order to engage different kinds of thinking, we must rethink the ways that we teach and the ways that we use technology in our teaching. This book is about some of the ways that educators can use technology to engage students in meaningful learning.
### Table 1.1 Constructivist Versus Traditional Learning Methods

<table>
<thead>
<tr>
<th>Constructivist</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge constructed, emergent, situated in action or experience, distributed</td>
<td>Transmitted, external to knower, objective, stable, fixed, decontextualized</td>
</tr>
<tr>
<td>Reality product of mind</td>
<td>External to the knower</td>
</tr>
<tr>
<td>Meaning reflects perceptions and understanding of experiences</td>
<td>Reflects external world</td>
</tr>
<tr>
<td>Symbols tools for constructing reality</td>
<td>Represents world</td>
</tr>
<tr>
<td>Learning knowledge construction, interpreting world, constructing meaning, ill-structured, authentic-experiential, articulation-reflection, process-oriented</td>
<td>Knowledge transmission, reflecting what teacher knows, well-structured, abstract-symbolic, encoding-retention-retrieval, product-oriented</td>
</tr>
<tr>
<td>Instruction reflecting multiple perspectives, increasing complexity, diversity, bottom-up, inductive, apprenticeship, modeling, coaching, exploration, learner-generated</td>
<td>Simplify knowledge, abstract rules, basics first, top-down, deductive, application of symbols (rules, principles), lecturing, tutoring, instructor derived and controlled, individual, competitive</td>
</tr>
</tbody>
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**MEANINGFUL LEARNING: OUR GOAL FOR SCHOOLS**

Our assumption in this book is that the primary goal of education at all levels should be to engage students in meaningful learning, which occurs when students are actively making meaning. While schools play a variety of important social, custodial, and organizational roles in communities, we assume that their primary obligation should be to help students to learn how to recognize and solve problems, comprehend new phenomena, construct mental models of those phenomena, and, given a new situation, set goals and regulate their own learning (learn how to learn). This book is devoted to describing how technology can be used to foster those goals. Figure 1.1 illustrates the interaction of five interdependent attributes of meaningful learning. If we accept that our goal, as technology-using educators, is to support meaningful learning, then we should use technologies to engage students in active, constructive, intentional, authentic, and cooperative learning. These attributes of meaningful learning will be used throughout the remainder of the book as the goals for using technologies, as well as the criteria for evaluating the uses of technology. Let’s examine these attributes a little more closely.
- **Active (Manipulative/Observant)** Learning is a natural, adaptive human process. Humans have survived and therefore evolved because they were able to learn about and adapt to their environment. Humans of all ages, without the intervention of formal instruction, can develop sophisticated skills and construct advanced knowledge about the world around them when they need to or want to. When learning about things in natural contexts, humans interact with their environment and manipulate the objects in that environment, observing the effects of their interventions and constructing their own interpretations of the phenomena and the results of the manipulation. For instance, before playing sandlot baseball, do kids subject themselves to lectures and multiple-choice examinations about the theory of games, the aerodynamics of orbs, and vector forces of bats? No! They start swinging the bat and chasing fly balls, and they negotiate the rules as they play the game. Through formal and informal apprenticeships in communities of play and work, learners develop skills and knowledge that they then share with other members of those communities with whom they learned and practiced those skills. In all of these situations, learners are actively manipulating the objects and tools of the trade and observing the effects of what they have done. Children who consistently hit foul balls will adjust their stance or handgrip on the bat continuously to manipulate the flight path, and they will observe the effects of
each manipulation. Real learning requires active learners—people engaged by a meaningful task (not just pressing the space bar to continue) in which they manipulate objects and the environment in which they are working and then observe the results of their manipulations.

- **Constructive (Articulative/Reflective)** Activity is necessary but not sufficient for meaningful learning. Learners must reflect on their activity and observations to learn the lessons that their activity has to teach. New experiences often provide a discrepancy between what learners observe and what they understand. They are curious about or puzzled by what they see. That puzzle is the catalyst for meaning making. By reflecting on the puzzling experience, learners integrate their new experiences with their prior knowledge about the world, or they establish goals for what they need to learn in order to make sense out of what they observe. Learners begin constructing their own simple mental models to explain their worlds, and with experience, support, and more reflection, their mental models become increasingly complex. Ever more complex models will enable them to reason more consistently and productively about the phenomena they are observing. The active and constructive parts of the meaning-making process are symbiotic. They both rely on the other for meaning making to occur.

- **Intentional (Reflective/Regulatory)** All human behavior is goal directed (Schank 1994). That is, everything that we do is intended to fulfill some goal. That goal may be simple, like satiating hunger or getting more comfortable, or it may be more complex, like developing new career skills or studying for a master’s degree. When learners are actively and willfully trying to achieve a cognitive goal (Scardamalia and Bereiter 1993/94), they think and learn more because they are fulfilling an intention. Articulating that intention is essential for meaningful learning. Technologies have traditionally been used to support teacher goals, but not those of learners. Technologies need to engage learners in articulating what their learning goals are in any learning situation, and then support them. Technology-based learning systems should require learners to articulate what they are doing, the decisions they make, the strategies the use, and the answers that they found. When learners articulate what they have learned and reflect on the processes and decisions that were entailed by the process, they understand more and are better able to use their constructed knowledge in new situations.

- **Authentic (Complex/Contextual)** The greatest intellectual sin that educators commit is to oversimplify ideas in order to transmit them more easily to learners. In addition to removing ideas from their natural contexts for teaching, we also strip ideas of their contextual cues and information and distill the ideas to their "simplest" form so that students will more readily learn them. But what are they learning? That knowledge is divorced from reality, and that the world is a reliable and simple place? However, the world is not a reliable and simple place, and ideas rely on the contexts they occur in for meaning. At the end of chapters, textbooks insert the ideas taught in the chapter into some artificial problem context. However, learners often fail to solve the problems because the ideas were learned as algorithmic procedures without any context, so they have no idea how to relate the ideas to new contexts. Additionally,
these textbook problems are constrained, practicing only a limited number of activities that were introduced in the chapter, so when they are faced with complex and ill-structured problems, students do not know where to begin.

A great deal of recent research (described in Chapters 3, 4, and 7) has shown that learning tasks that are situated in some meaningful real-world task or simulated in some case-based or problem-based learning environment are not only better understood, but also are more consistently transferred to new situations. Rather than presenting ideas as rules that are memorized and then applied to other canned problems, we need to teach knowledge and skills in real-life, useful contexts and provide new and different contexts for learners to practice using those ideas. And we need to engage students in solving complex and ill-structured problems as well as simple problems (Jonassen 1997). Unless learners are required to engage in higher-order thinking, they will develop oversimplified views of the world.

• Cooperative (Collaborative/Conversational) Humans naturally work in learning and knowledge-building communities, exploiting each others’ skills and appropriating each others’ knowledge. In the real world, humans naturally seek out others to help them to solve problems and perform tasks. Then why do educators insist that learners work independently all of the time? Schools generally believe that learning is an independent process, so learners seldom have the opportunity to “do anything that counts” in collaborative teams, despite their natural inclinations. When students collaborate without permission, they may even be accused of cheating. However, we believe that relying solely on independent methods of instruction cheats learners out of more natural and productive modes of thinking. Often, educators will promote collaborative methods of learning, only to resort to independent assessment of learning. Learners, they believe, must be accountable for their own knowledge, so even if you agree, at least in principle, with collaborative learning principles, the hardest part of applying your beliefs will be assessing learners. Throughout this book, we will provide vignettes on how groups as well as individuals may be assessed. We cannot forget that most learners are strategic enough to know “what counts” in classrooms, so if they are evaluated individually, collaborative instruction may fail because students realize that group outcomes are not important.

Collaboration most often requires conversation among participants. Learners working in groups must socially negotiate a common understanding of the task and the methods they will use to accomplish it. Given a problem or task, people naturally seek out opinions and ideas from others. Technologies can support this conversational process by connecting learners in the same classroom, across town, or around the world (see Chapter 5). When learners become part of knowledge-building communities both in class and outside of school, they learn that there are multiple ways of viewing the world and multiple solutions to most of life’s problems. Conversation should be encouraged. In classrooms that focus on individual learning, however, it is too often discouraged. In those classrooms, students know that the important views are those espoused by the textbook or the teacher, so conversation may be difficult to foster.

As is depicted in Figure 1.1, these characteristics of meaningful learning are interrelated, interactive, and interdependent. That is, learning and instructional activities should engage and support combinations of active, constructive, inten-
tional, authentic, and cooperative learning. Why? Because we believe that these characteristics are synergetic. That is, learning activities that represent a combination of these characteristics result in even more meaningful learning than the individual characteristics would in isolation.

There are many kinds of learning activities that engage meaningful learning, just as there are teachers who have for years engaged students in meaningful learning. We argue throughout this book that technologies can and should become the tools of meaningful learning. Technologies afford students the opportunities to engage in meaningful learning if used as learning tools. These characteristics of meaningful learning are used throughout the remainder of the book as criteria for evaluating the use of different technologies. In the next section, we describe the assumptions about technologies that underlie their use as learning tools.

OUR ASSUMPTIONS ABOUT TECHNOLOGY

Traditional Conceptions of Educational Technologies

Educational technologies have been traced historically to the advent of movable type in the fifteenth century, to illustrations in seventeenth-century books, and to slate chalkboards in eighteenth-century classrooms. Educational technologies in the twentieth century include first lantern slide projectors, later radio, and then motion pictures. Chapter 3 describes the development of educational television in the 1950s and 1960s. During the same period, programmed instruction emerged as the first true educational technology—that is, the first technology developed specifically to meet educational needs. With every other technology, including computers, educators recognized its importance and debated how to apply each nascent commercial technology for educational purposes. Unfortunately, the most obvious way to use technologies was to have them teach in the same ways that teachers had always taught, making them substitute teachers. That meant that knowledge was embedded in the technology (e.g., the content presented by films and TV programs or the teaching sequence in programmed instruction), and the technology presented that knowledge to the student. The students’ role was to learn the knowledge presented by the technology, just as they learned knowledge presented by the teacher. The role of the technology was to deliver lessons that teach learners, just as trucks deliver groceries to supermarkets (Clark 1983). The logic is: If you deliver groceries, people will eat; if you deliver instruction, students will learn.

The introduction of computers in classrooms followed the same pattern of use. Before the advent of microcomputers in the 1980s, mainframe computers were used to deliver drill-and-practice and simple tutorials for teaching students lessons. When microcomputers began populating classrooms, the natural inclination was to use them in the same way. A 1983 national survey of computer uses showed that drill-and-practice was the most common use of microcomputers (Becker 1985), along with learning to program in BASIC. Drill-and-practice represented the tutor role for computers, while programming represented the tutee role, where students learned by teaching the computer (Taylor 1984). This was a powerful idea, but unfortunately, BASIC was a limited medium and, as we shall argue throughout
this book, learners should use technologies as media for representing what they know and for teaching each other.

During the early 1980s, educators began to perceive the importance of computers as productivity tools. The growing popularity of word processing, databases, spreadsheets, graphics programs, and desktop publishing were enabling businesses to become more productive. So students in classroom began using word processing, graphics packages, and desktop publishing programs. This tool conception pervaded computer uses, according to a 1993 study by Hadley and Sheingold, which showed that well-informed teachers were extensively using text-processing tools (word processors), analytic and information tools (especially databases and some spreadsheet use), and graphics tools (paint programs and desktop publishing), along with instructional software (including problem-solving programs along with drill-and-practice and tutorials).

The development of inexpensive multimedia computers and the eruption of the Internet in the mid-1990s quickly changed the nature of educational computing. Communications and multimedia, little used in 1993, have dominated the role of technologies in the classroom over the past few years. Unfortunately, their roles in education have been naturally conceived as teachers and sources of knowledge, rather than tools for learning. As we argue in Chapters 4 and 5, multimedia and computer-mediated communications are among the most powerful learning tools that students can use.

Our conception of educational computing and technology use, described in the next section, does not conceive of technologies as teachers. Rather, we believe that in order to learn, students should share the role of representing what they know, rather than memorizing what teachers and textbooks know. Technologies provide rich and flexible media for representing what students know and what they are learning. A great deal of research on computers and other technologies has shown that they are no more effective at teaching students than teachers, but if we begin to think about technologies as learning tools that students learn with, not from, then the nature of student learning will change.

Our Conception of Educational Technologies

The ways that we use technologies in schools should change, from their traditional roles of technology-as-teacher to technology-as-partner in the learning process. Before, we argued that students cannot learn from technology, but that technologies can support meaning making by students. That will happen when students learn with technology. But, how do students learn with technologies? How can technologies become intellectual partners with students? If you agree with this role for technologies, then you must make a different set of assumptions about what technologies are and what they do. Throughout this book, we assume that:

- Technology is more than hardware. Technology consists of the designs and the environments that engage learners. Technology can also consist of any reliable technique or method for engaging learning, such as cognitive learning strategies and critical thinking skills.
• Learning technologies can be any environment or definable set of activities that engage learners in active, constructive, intentional, authentic, and cooperative learning.
• Technologies are not simply conveyors or communicators of meaning. Nor should they prescribe and control all of the learner interactions.
• Technologies support learning when they fulfill a learning need—when interactions with technologies are learner-initiated and learner-controlled, and when interactions with the technologies are conceptually and intellectually engaging.
• Technologies should function as intellectual tool kits that enable learners to build more meaningful personal interpretations and representations of the world. These tool kits must support the intellectual functions that are required by a course of study.
• Learners and technologies should be intellectual partners in the learning process, where the cognitive responsibility for performing is distributed to the part of the partnership that performs it the best.

How Technologies Foster Learning
If technologies are used to support learning in the ways that we have described, then they will not be used as delivery vehicles (such as in computer-assisted instruction, tutorials, drill-and-practice) (Jonassen, Campbell, and Davidson 1993). Rather, technologies should be used as engagers and facilitators of thinking and knowledge construction. Some useful roles for technology in learning include:

• Technology as tools to support knowledge construction:
  for representing learners’ ideas, understandings, and beliefs
  for producing organized, multimedia knowledge bases by learners
• Technology as information vehicles for exploring knowledge to support learning-by-constructing:
  for accessing needed information
  for comparing perspectives, beliefs, and world views
• Technology as context to support learning-by-doing:
  for representing and simulating meaningful real-world problems, situations and contexts
  for representing beliefs, perspectives, arguments, and stories of others
  for defining a safe, controllable problem space for student thinking
• Technology as social medium to support learning by conversing:
  for collaborating with others
  for discussing, arguing, and building consensus among members of a community
  for supporting discourse among knowledge-building communities
• Technology as intellectual partner (Jonassen 1996) to support learning-by-reflecting:
  for helping learners to articulate and represent what they know
  for reflecting on what they have learned and how they came to know it
for supporting learners' internal negotiations and meaning making
for constructing personal representations of meaning
for supporting mindful thinking

Technologies are applications of human knowledge to real-world problems. They are tools for supporting human needs. Computer technologies such as word processors, spreadsheets, desktop publishing, and computer-assisted design programs all enhance the productivity of their users. Most knowledge construction (and reproduction) requires producing communications, designing materials, or managing resources. Technologies as tools extend humans' functional capabilities.

Computer-based technologies are also used as information access tools. Within a few years, virtually all technical information will be stored online. Literacy for the next generation will require knowing how to use and manipulate these tools to locate and access multiple forms of information (see Chapter 2). Internet search engines enable increasingly sophisticated search strategies. Learners need to know how to use sophisticated search tools in order to access and manipulate information.

Using technologies as context means creating and representing contexts and situations from which learners can problem-solve and construct knowledge. Technologies, such as Case-based learning environments (see Chapter 7) and microworlds (Chapter 6) seek to provide rich and situated problem spaces for learners to investigate while solving meaningful, real-world problems.

Certainly the fastest-growing use of technologies is the interconnection of communities of learners (see Chapter 5). Students are now able to converse and collaborate with other students all over the world. Communal learning experiences are no longer limited to students in the same classroom. Using technologies as social media will increasingly define global learning communities.

However, technologies can do more than extend the capabilities of humans; they can amplify them. Using technologies as cognitive tools extends learners' cognitive functioning by engaging learners in thinking while constructing knowledge of which they would not otherwise have been capable (Pea 1985). Cognitive tools (see Chapter 6) are computational devices that can support, guide, and extend the thinking processes of their users (Derry and Lajoie 1993) if the users are in control of the computers, rather than being controlled by the computers. Computers and videoplayers are knowledge construction tools that engage learners in critical thinking about what they are learning.

Our conception of technologies is broad. In it, the user and the hardware technologies (computers, video, etc.) blend together to form a single entity with distributed intelligence, where learners contribute what they do best and technologies contribute what they do best—the learner is in charge. When students learn from technology, such as watching instructional television or interacting with computer-assisted instruction, both the technology and the learners assume roles that can better be fulfilled by the other. Technologies present information, ask questions, and judge answers (all of which humans do better), while students receive, store, and retrieve information (all of which computers do better). What results in learners is inert, unusable knowledge. Our goal in this book is to reconceptualize the roles of technologies in learning as tools for learners to construct their own meaning.
Assumptions About Assessing and Evaluating Learning With Technologies

If you agree that learning is or should be an active, constructive, intentional, authentic, and cooperative process, and if you agree that technologies should be used as learning tools for students to learn with, then you must probably also challenge your beliefs about how to assess and evaluate learning by students. Why? Because instructional theory insists that if learning is an active, constructive, intentional, authentic, and cooperative process, so should the ways in which we assess learners and the criteria that we use to evaluate them. That is a difficult requirement intellectually, socially, and politically. We traditionally assess students for the amount of knowledge that they have acquired from the teacher and the textbook. Constructivism suggests that we need to assess the meaning that learners have co-constructed from their interactions with the world. How is that different? The meaning and interpretations that individuals and groups construct will all vary somewhat from each other. So what is the right answer? There probably will not be a single correct answer. How can we know when students have learned? Probably by assessing learning while it is occurring. Assessment, from a constructivist perspective, is process-oriented. Assess learning as it is occurring, rather than separating assessment from learning, focusing not only on what students have learned (their knowledge), but also on the ways that students learn. Assessing the strategies and tactics that students use to learn will predict how well they will be able to learn and solve problems in new situations.

If we believe that the ways that we assess learning should change, we also need to rethink the ways that we evaluate that learning. Evaluation places a value on the kinds of learning that has occurred. Traditionally, we assign a letter grade based on the percentage of ideas that are remembered or understood (90 percent is excellent, 80 percent is above average, etc.). From a constructivist perspective, student knowledge must be evaluated based on its viability. Does it make sense, is it well founded and justified by the learners, is it well represented by the learners, can it be applied meaningfully, and is it consistent with the standards (scientific or literary) that are accepted by the field? This form of assessment, described in Chapter 8, is more difficult and time consuming than traditional forms of assessment and evaluation, which seek to commoditize knowledge as something that can be acquired. Traditional assessment asks, how much knowledge did students acquire?

Most evaluation methods argue that more is better. Assessment from a constructivist perspective seeks to know what the learner knows. Because meaning making is a complex and multifaceted phenomenon, assessment of learners’ knowledge must also be multifaceted and multimodal. No single measure can begin to assess the complexity of human understanding, especially a multiple-choice measurement. So, we need to develop more diverse and complex ways of assessing learning. Is this possible? Isn’t there already too much to accomplish in a school day or year? It is possible, if you let the technologies provide the means of assessment. That is, you should assess student-constructed knowledge bases produced with technologies.

In Chapter 8, we provide some rubrics for assessing meaningful learning with technologies. As students use technologies as learning tools (as described
throughout the remainder of the book), they will produce technology-based artifacts—student-constructed knowledge bases. These knowledge bases are rich, multimodal indicators of what students have learned. They are activity-based (i.e., embedded in activity). They require learners to articulate and reflect on what they know and believe. They are complex, and given the opportunity, they will usually describe some authentic problem. Student perspectives are necessarily more authentic to them. Assessment does not have to be a separate process that occurs after learning has occurred. Technologies afford student representations of what they know. If you assess those constructions, students will learn quickly that the ways that they use technologies are not only more fun and engaging than traditional recitation methods, they also count. Throughout this book, we will provide boxed recommendations about how to use technologies to assess learning or how to assess what students have constructed.

CONCLUSIONS

An underlying assumption of this book is that the most productive and meaningful uses of technology will not occur if technologies are used in traditional ways—as delivery vehicles for instructional lessons. Technology cannot teach students. Rather, learners should use the technologies to teach themselves and others. They learn through teaching with technologies. Meaningful learning will result when technologies engage learners in:

- Knowledge construction, not reproduction
- Conversation, not reception
- Articulation, not repetition
- Collaboration, not competition
- Reflection, not prescription

The remainder of this book describes how technologies can be used to support meaningful learning in schools from a constructivist perspective. Although the focus of the book is K–12, most of the ideas that we present are also valid for universities, corporations, and other learning agencies.

THINGS TO THINK ABOUT

If you would like to reflect on the ideas that we presented in this chapter, consider your responses to the following questions and compare them with the responses of others.

1. If learners cannot know what the teacher knows because they do not fully share a common knowledge and experience base, how can we be certain that students learn important things? For instance, if you want to teach students about the dangers of certain chemical reactions in the lab, how do you ensure that learners know and understand those important lessons?
2. Is it possible to learn (construct personal meaning) without engaging in some overt activity; that is, is it possible to learn simply by thinking about something? What are you thinking about? Can you give an example?

3. When learners construct knowledge, what are they building? How is it possible to observe the fruits of their labor, that is, the knowledge they construct?

4. Recall an event from your childhood. What do you remember? Where did your remembrance occur? What meaning did it have at the time? How has that meaning changed over time?

5. Think about a recent controversial topic that you have heard or read about. What are different sides arguing about? What do they believe? What assumptions do they make about what is causing the controversy? What prompted those beliefs?

6. Radical constructivists argue that reality exists only in the mind of the knower. If that is true, is there a physical world that we live in? Prove it.

7. Some educators argue that we learn much more from our failures than from our successes. Why? They believe that we should put students in situations where their hypotheses or predictions fail. Can you think of a situation in which you learned a lot from a mistake?

8. Recall the last difficult problem that you had to solve. Did you solve it alone, or did you solicit the help of others? What did you learn from solving that problem? Can that learning be used again?

9. Can you learn to cook merely from watching cooking shows on television? What meaning do you make from the experiences that you observe? Will the experience that you have when you prepare a dish be the same as that of the television chef? How will it be different?

10. Technology is the application of scientific knowledge, according to many definitions. Can you think of a teaching technology (replicable, proven teaching process) that does not involve machines?

11. Can you calculate the exact square root of 2,570 without a calculator? Does the calculator make you smarter? Is the calculator intelligent?

12. Describe the difference in thinking processes engaged by a short answer versus a multiple-choice test question. Are they different? Are they assessing knowledge? Is that knowledge meaningful? Why or why not?

13. Have you ever produced your own video, movie, slide show, or computer program? How did it make you think? How did it make you feel?

REFERENCES


