Learning With Technology

A Constructivist Perspective

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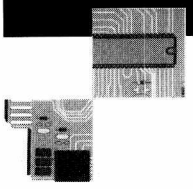
PREFACE



Constructivism is a relatively new idea to education. It is an even newer idea to educational technology. It is so new to some educational circles that some people perceive it as a fad. We think not. Constructivism is an old idea to sociology and art. And as a way of understanding the learning phenomenon, it is ageless. People have always constructed personal and socially acceptable meaning for events and objects in the world. Since evolving from the primordial ooze, humans have interacted with the world and struggled to make sense out of what they saw. The popular Chinese proverb about forgetting what you tell me and understanding what I do bears witness to the ageless belief that knowledge/meaning/understanding do not exist outside of meaningful, intentional activity. People naturally construct meaning. Formal educational enterprises that rely on the efficient transmission of prepackaged chunks of information are not natural. Yet they are pandemic. The modern age values understanding less than it does the efficient transmission of culturally accepted beliefs. It doesn't have to be that way. Modernism can support meaning making as well. This book looks at how modern technologies, such as computers and video, can be used to engage learners in personal and socially co-constructed meaning making.

For many, constructivism represents a new way of conceiving the educational experience. Yet constructivism, as a philosophy and as a pedagogy, is now widely accepted. This is a time of theoretical foment, where nearly all of the contemporary theories of learning (constructivism, situated learning, social cognition, activity theory, distributed cognition, ecological psychology, and case-based reasoning) all share very convergent beliefs about how people naturally come to know. This book is not about theory, but it shares the beliefs of these theories.

Learning With Technology is about how educators can use technologies to support constructive learning. In the past, technology has largely been used in education to learn *from*. Technology programs were developed with the belief that they could convey information (and hopefully understanding) more effectively than teachers. But constructivists believe that you cannot convey understanding. That can only be constructed by learners. So this book argues that technologies are more effectively used as tools to construct knowledge *with*. The point of this book is that technology is a tool to think and learn *with*.

How can technologies be used as meaning-making tools? After describing the assumptions of constructivism in Chapter 1, we describe six ways (in six chapters) that technology can support personal and social meaning making. In Chapter 2, we show how learners who articulate a personally meaningful goal or intention can explore the Internet in search of ideas that help them to construct their own understanding. Sharing their own understanding by constructing personal and group Web sites completes the knowledge construction cycle.

Chapter 3 describes numerous activities in which students can use video cameras, editors, and digitizers to represent their ideas. Constructing video presentations requires that learners articulate an idea well enough to represent it through video. In this chapter, video is used not to teach students, but rather as a tool that learners can teach and learn with. Students are natural video producers.

From video, Chapter 4 adds sound, graphics, and multimedia computers as tools that students can use to represent what they know. While producing multimedia programs, students become sensitive to the needs and desires of the audience for whom they are producing. And they work harder using more skills without complaint than they ever would with pencil and paper. Multimedia represents a new form of literacy that students will only learn by participating in the production of multimedia.

This book assumes that intentional learners are effective learners. When students declare an intention and desire to learn, they become a force. This force emerges most naturally in learning communities. Chapter 5 describes some of the ways that technologies can be used to support the development of learning communities. Conferencing systems are tying students together into a potentially massive, singular community of learners. They can communicate with any other students at any time anywhere in the world.

Chapter 6 briefly describes how technologies can be used as knowledge reflection and representation tools. It is an updated distillation of many of the ideas presented originally in *Computers in the Classroom: Mindtools for Critical Thinking* (Merrill/Prentice Hall, 1996).

Chapter 7 integrates all of the other technologies into constructivist learning environments, which are problem- or project-based activities that use all of the technologies to engage students in the most meaningful kinds of learning possible.

Chapter 8 stimulates the reader to reflect on the ideas presented in the rest of the book and to consider the knottiest of questions for most educators: How do we assess the constructive learning that learners do? To help answer that question, we provide a number of rubrics for assessing constructive learning with technology.

We live in the information age. In order to function in that world, students must learn how to be information producers, not just consumers. This book provides a new look at how educational technologies can support the knowledge construction process rather than the knowledge reproduction process. When educational technologies are used as knowledge construction tools, students are naturally and necessarily engaged in meaningful learning, which should be the goal of all educators.

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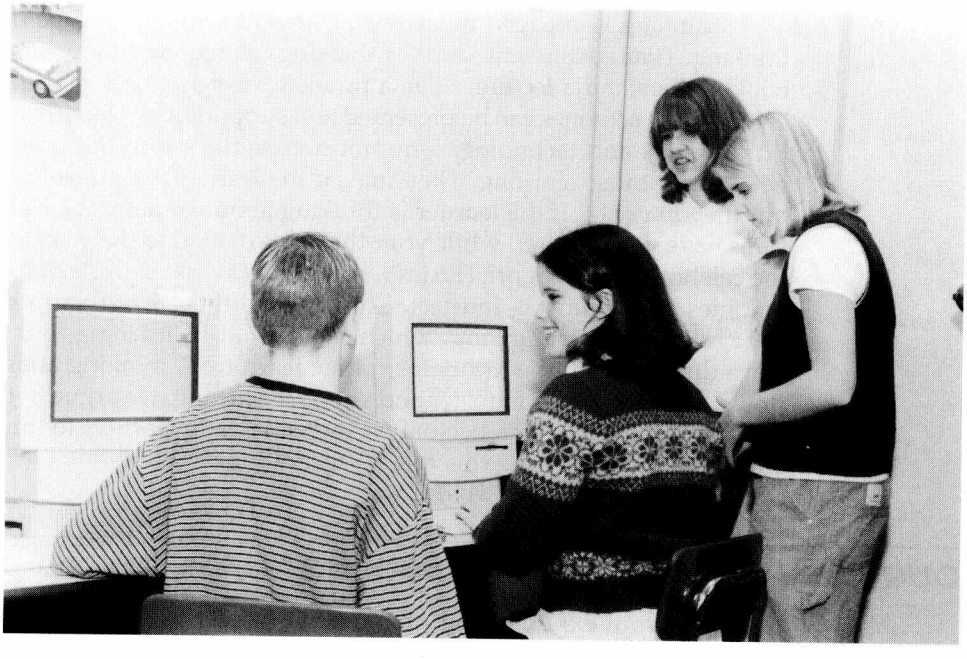
Contents

Chapter 1

Learning With Technology: Technologies For Meaning Making



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

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

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.

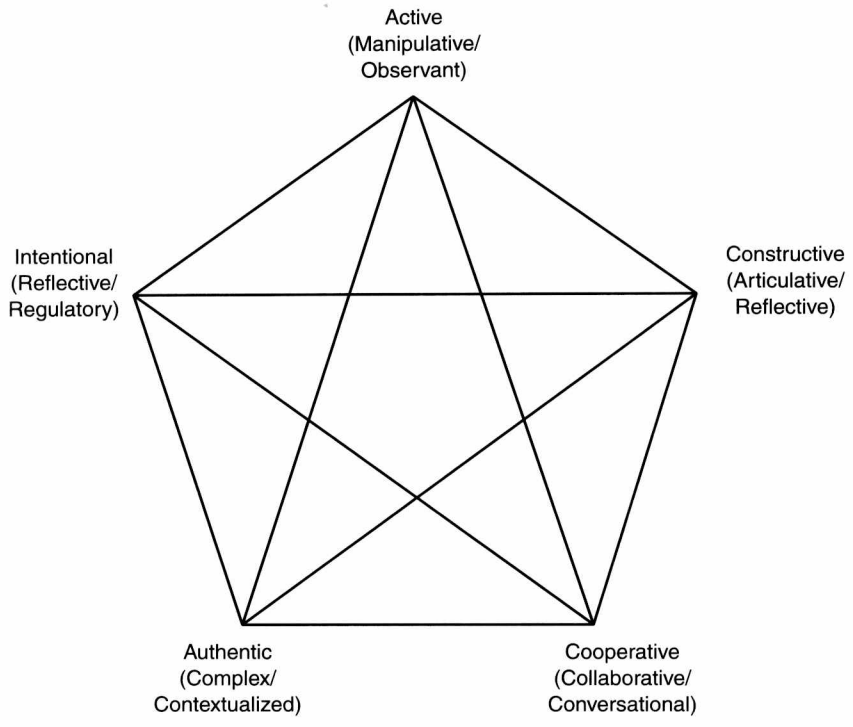


Figure 1.1 Five Attributes of Meaningful Learning Are Interdependent

• **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 puzzlement 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-