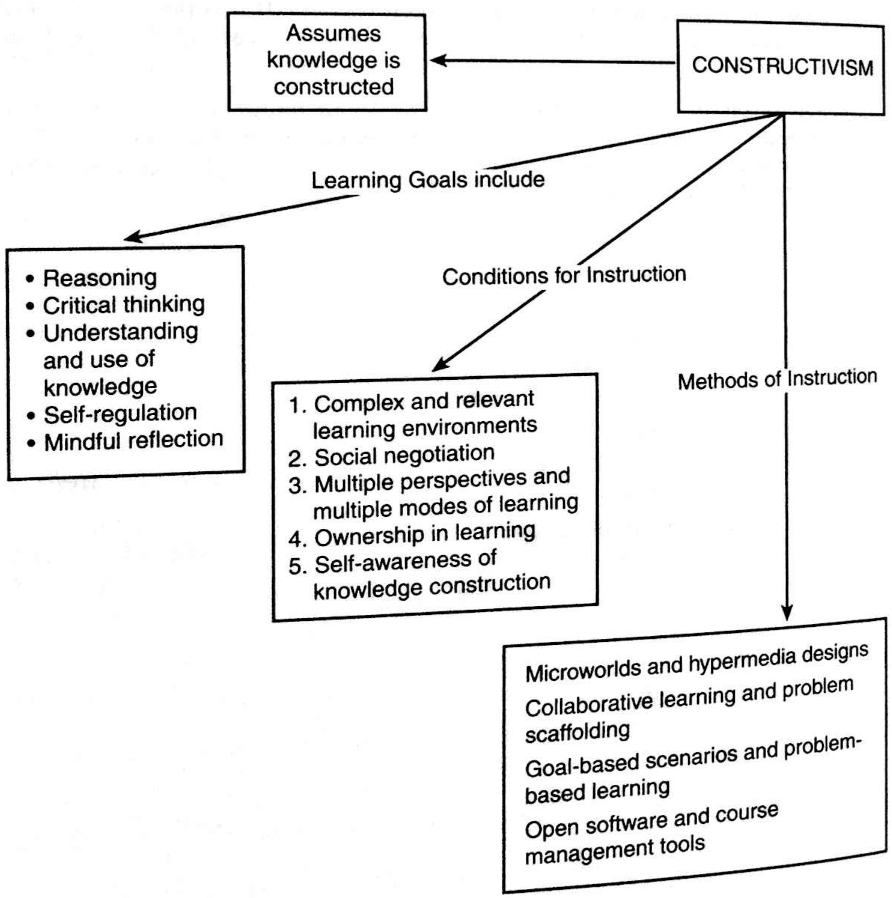
11

Constructivism



Consider these scenarios. (The scenario, Medical School, is reprinted from Chapter 10.)

• *Medical School*

At the University of Anywhere Medical School, instructors routinely face the problem of biomedical misconceptions among students. That is, medical students, despite exposure to appropriate information, continue to make diagnostic errors in many of the clinical cases that they study. Instructors have found that students, in their diagnoses, tend to oversimplify, over-rely on general theories, and disregard unique or puzzling symptoms. How to best deal with these problems is of major concern, particularly in light of the spiraling costs of medical school education. The instructors want to know how they should revise their instruction or devise new learning experiences, so that students will avoid making so many errors.

• *Olympic Games*

With the help of an instructional design student at a nearby university, Ms. Patterson designed an Internet Web site devoted to the Olympic Games. This is a topic she particularly enjoys teaching in her seventh grade classroom, especially when it's a year that the Games are actually being held. The Web site is supplemental to the activities Ms. Patterson conducts in her class.

Students can log on from school or home and explore at will. Within the Web site are links to the history of the Olympic Games, the types of games played, records set, and so on. The Web site is rich with information in graphics and text. There are also links to related Web sites; students tend to follow these when they get fascinated about some aspect of the Games. Raja, for example, was completely taken by the bobsled competition, and he researched how bobsleds were originally designed and how they are now built.

Imagine the sort of instruction that might have resulted for the Medical School scenario had we taken the application of Gagné's theory to its conclusion in the previous chapter. Although direct instruction is not a premise or a requirement of that theory, it is often the product when Gagné's theory guides the instructional design process. It is almost as if the internal organization and orderliness of the theory invites its use in a systematic and direct fashion. Such a use is also consistent with epistemic beliefs in knowledge as acquired through information processing.

Try to imagine now what instructional strategies might be proposed given a different view of learning and instruction, a view in which knowledge is assumed to be constructed rather than acquired. In this chapter, potential answers are discussed that arise from constructivist theory. As you read the chapter, you may also find it worthwhile to look back at Chapters 5, 6, and 7 to review some of the concepts that relate to or underpin constructivist theory.

Constructivism: A Contrasting Theory

"Constructivism has multiple roots in the psychology and philosophy of this century" (Perkins, 1991a, p. 20). Among those already discussed in this book are the cognitive and developmental perspectives of Piaget (see Chapter 6), the interactional and cultural emphases of Bruner and Vygotsky (see Chapter 7), and the contextual nature of learning emphasized in Chapter 5. In addition to these, constructivist researchers acknowledge the philosophies of Dewey (1933) and Goodman (1984), and the ecological psychology of Gibson (1977) as important influences on their work. Ernst von Glasersfeld (1984, 1991, 1995, 2002) has had a considerable influence on constructivist thinking in mathematics and science education, and "the work of Thomas S. Kuhn on scientific revolutions and paradigms has been a major influence on several of the constructivist sects" (Phillips, 1995, p. 6). Matthews (2003) also credits the views of Derrida and Foucault as contributors to constructivist thinking in the postmodern era.

As mentioned in Chapter 10, there is no single constructivist theory of instruction. Rather, there are researchers in fields from science education to educational psychology and instructional technology who are articulating various aspects of a constructivist theory. Moreover, constructivism is only one of the labels used to describe these efforts. Its use probably stems from Piaget's reference to his views as "constructivist" (see Chapter 6) and Bruner's conception of discovery learning as "constructionist" (see Chapter 7). Other labels include generative learning (CTGV, 1991a, 1991b; Wittrock, 1985a, 1985b), embodied cognition (Johnson, 1987; Lakoff, 1987), cognitive flexibility theory (Spiro et al., 1991, 1995), and postmodern and poststructural curricula (Hlynka, 1991; Culler, 1990). Some of the work presented in Chapter 5 under the heading of situated cognition has also been represented as constructivist (e.g., the semiotic perspective and anchored instruction). In this chapter, then, no single constructivist approach will be described. Instead, the assumptions common to the collection of approaches will be examined, together with the learning conditions and instructional methods being proposed as consistent with these assumptions.

Constructivist Assumptions About Learning

Theorists who write in the emerging constructivist tradition often contrast their ideas with the epistemological assumptions of the objectivist tradition. Objectivism is the view that knowledge of the world comes about through an individual's experience of it. As this experience grows broader and deeper, knowledge is represented in the individual's mind as an ever-closer approximation of how the world really is (see Chapter 1). In a sense, then, knowledge is thought to exist independently of learners, and learning consists of transferring that knowledge from outside to within the learner.

Both behavioral and cognitive information-processing theories of learning emerged from the objectivist tradition. Consider, for example, the emphasis on universal laws of learning that is one of the hallmarks of behaviorism. Behaviorists define desired learning goals independent of any learner and then proceed to arrange reinforcement contingencies that are presumed to be effective with any learner; only the type of reinforcer is assumed to vary according to the individual. Although information-processing theorists put mind back into the learning equation, they, too, appear to assume that knowledge is "out there" to be transferred into the learner. The computer metaphor itself suggests that knowledge is input to be processed and stored by learners.

In contrast to the objectivist view, then, constructivist theory rests on the assumption that knowledge is constructed by learners as they attempt to make sense of their experiences. Learners, therefore, are not empty vessels waiting to be filled, but rather active organisms seeking meaning. Regardless of what is being learned, constructive processes operate and learners form, elaborate, and test candidate mental structures until a satisfactory one emerges (Perkins, 1991a). Moreover, new, particularly conflicting experiences will cause perturbations in these structures, so that they must be constructed anew in order to make sense of the new information. This should sound much like the development and revision of mental models, as discussed in Chapter 4. In Chapter 6, Piaget referred to a similar process as schema accommodation, and other developmental theorists called it knowledge restructuring. Both Bruner and Vygotsky, as well, devised similar concepts to account for the changes in children's knowledge as they develop (see Chapter 7).

What constructivists argue strongly, however, is that knowledge constructions do not necessarily bear any correspondence to external reality. That is, they do not have to reflect the world as it really is to be useful and viable. This is consistent with the idealist or interpretist epistemology that was discussed in Chapter 1. Perhaps an example would help to illustrate this idea.

Recall from Chapter 6 the research revealing children's conceptions of the earth in relation to the sun. Because children's experience is that of a flat earth with the sun moving across the sky during the day, they typically believe that the earth is flat and that the sun revolves around it. In the constructivist view, they have constructed a perfectly viable model, which accounts well for their own experience. We know in this case that, for most people, this model is revised to reflect current understanding of the earth's relationship to the sun. As a pragmatist (see Chapter 1) would suggest, however, the current model will prevail for only as long as the collective experience of scientists supports it. Therefore, the model should not be assumed to reflect reality; instead, it should be construed as the best construction of humankind's experience of its world.

If no correspondence is presumed between reality and the learner's cognitive constructions of it, does this mean that all constructions are equally viable? Those subscribing to an idealist philosophy might say yes (see Chapter 1), but most constructivist theorists would say no. There must be limits to what sense learners make of their environment and their experience. Limits are imposed by human biological characteristics as well as by what is possible in reality. Moreover, learners must have some reliable and systematic way to test their observations and the sense they are making of the world around them (Matthews, 2003). As a consequence, many constructivist theorists adhere to Vygotsky's notions about the social negotiation of meaning (see Chapter 7). That is, learners test their own understandings against those of others, notably those of teachers or more advanced peers.

Constructivist Models of Memory

Although constructivists have described, often in detail, the epistemological assumptions underlying their work, they have been less clear about what models of memory arise from these assumptions. Cunningham (1988) explored the implications of Eco's rhizome metaphor. The rhizome is a tangle of tubers with no apparent beginning or end. It constantly changes shape, and every point in it appears to be connected with every other point. Break the rhizome anywhere and the only effect is that new connections will be grown. The rhizome models the unlimited potential for knowledge construction, because it has no fixed points (no nodes or basic representation units) and no particular organization (my own mental image of a rhizome resembles a plate of spaghetti; Eco [1976] also spoke of a jar full of marbles, which, when shaken, will produce a new configuration and a new set of connections among marbles).

Consider the differences in a rhizome-like structure of memory compared to the models that were discussed in Chapter 3. According to a network model of memory, knowledge of a concept such as heron, for example, would be stored in terms of a heron concept node, with various features connected by association. Propositional models suggest that the features are part and parcel of an understanding of herons, since propositions, rather than concept nodes, are stored. PDP models refer to the patterns of activation related to understanding of herons. But now think of herons and air traffic control. Shank (1988) argued that, through the method of juxtaposition, any two things may be linked, with meaningful relationships generated between them. In fact, interesting insights can occur in the juxtaposition of disparate ideas. But the relationships you have now generated between herons and air traffic control are not easily accounted for in current memory models, which do not adequately capture the dynamic nature of knowing. The rhizome metaphor, however, allows for infinite juxtaposition.

If the rhizome is limitless in possibility, and therefore indescribable at a global level, then we are forced to consider cognition at a more local level, as "transitory systems of knowledge" (Eco, 1984, p. 84). Particular slices of the rhizome reveal a person's knowledge at that time in that context, with no assumption of invariability over time or across contexts. This presumes that neither knowledge nor the ways in which we use to describe it are stable. Rather, "the rhizome concept alerts us to the constructed nature of our [environmental understanding] and the possibilities of different meaning, different truths, different worlds" (Cunningham, 1992, p. 171).

The connectionist models of memory (described in Chapters 3 and 8) appear to embody characteristics similar to the rhizome and may hold promise for constructivist theories. Bereiter (1991) argued, for example, that concepts "are much more like perceptions than they are like rule-defined categories" (p. 13), and that, in fact, it seems likely students do not learn rules at all. What they learn instead are connections, which, to satisfy constraints of experience and environment, come to resemble rule-based performance.

Finally, John R. Anderson, known for his ACT model of memory (see Chapter 3), is exploring new directions for the study of human cognition that seem increasingly compatible with the assumptions of constructivism. Rather than continue the atomistic analysis of cognitive mechanisms which characterized his earlier work, Anderson (1990) has proposed an approach to building a theory of cognition that focuses on the adaptation of human behavior in terms of achieving human goals. That is, Anderson assumes that "the cognitive system operates at all times to optimize the adaptation of the behavior of the organism" (1990, p. 28). This is similar to the view espoused by Bruner (1986), who stated that "meaning…is an enterprise that reflects human intentionality and cannot be judged for its rightness independently of it" (p. 158). Furthermore, ACT-R includes a mechanism of knowledge compilation, which is an accommodation process that involves creating new rules via analogy when a new problem is encountered that cannot be solved (Anderson, 1993). Anderson argues that this process is consistent with constructivist notions of how learning occurs, even though he adheres to an information-processing perspective, which many constructivists believe is antithetical to their approach (Anderson, Reder, & Simon, 2000). Empirical data are now being amassed that should begin to sort out various claims of constructivism and how they relate to previous approaches discussed in this book. These are reviewed as they pertain to the sections ahead.

Let us now turn to an examination of the instructional recommendations emanating from constructivism. Because any theory of instruction must deal with learning goals, conditions of learning, and instructional methods to bring about these conditions, it makes sense to consider what constructivist approaches propose in each of these categories.

Constructivist Learning Goals

Unlike the "objectivist approach…that focuses on identifying the entities, relations, and attributes that the learner must 'know'" (Duffy & Jonassen, 1991, p. 8), the constructivist approach to identifying learning goals emphasizes learning in context. Brown et al. (1989), for example, argued that knowledge that learners can usefully deploy should be developed. Moreover, this can only be done in the context of meaningful activity. It is not enough, in other words, for students to acquire concepts or routines that lie inert, never to be called upon even in the face of relevant problems to be solved. Instead, knowledge must develop and continue to change with the activity of the learner. "'Learning [is] a continuous, life-long process resulting from acting in situations" (Brown et al., 1989, p. 33).

In this statement, we see from the start how constructivist ideas have emerged from or are consistent with theories discussed in previous chapters. That knowledge develops in context is central to the notions of situated learning (see Chapter 5), Bruner's discovery learning (see Chapter 7), and the dialectics of Vygotsky's theory (see Chapter 7).

As a start to articulating what is meant by "deployable knowledge learned in context," the CTGV (1991a) defined thinking activities to be the primary goals of concern to constructivists. Specifically, they named: "the ability to write persuasive essays, engage in informal reasoning, explain how data relate to theory in scientific investigations, and formulate and solve moderately complex problems that require mathematical reasoning" (CTGV, 1991a, p. 34). Virtually agreeing with these sentiments, Perkins (1991a) declared, "The basic goals of education are deceptively simple. To mention three, education strives for the retention, understanding, and active use of knowledge and skills" (p. 18). Put another way, "knowledge does not come into its own until the learner can deploy it with understanding" (Perkins & Unger, 1999, p. 94).

Other authors have offered variations of these goals. Spiro et al. (1991) described the need for learners to acquire cognitive flexibility, whereas Culler (1990) spoke of the need to foster poststructuralist thinking, a kind of reflective criticism. The ability to solve ill-structured problems (Jonassen, 1999), acquire content knowledge in complex domains along with critical thinking and collaboration skills (Nelson, 1999), and develop personal inquiry skills (Hannafin, Land, & Oliver, 1999) are also cited as typical constructivist goals. Finally, epistemic fluency, or the ability to identify and use different ways of knowing, is among those goals thought to be fostered by constructivist pedagogy (Morrison & Collins, 1996).

If we consider this constructivist collection of goals in light of a taxonomy such as Gagné's, what would we conclude? Are the authors cited above defining educational goals that Gagné would categorize as higher-order rule-using (problem-solving) and cognitive strategies? Dick (1991) clearly thought so when he discussed, from an instructional designer's perspective, research and development efforts of the Cognition and Technology Group at Vanderbilt and others. Goals that instructional designers might define for the Medical School scenario, for example, include diagnose hypertension, and for the A&B Agency scenario, recognize sexual harassment in the workplace. These seem to be virtually no different from goals that constructivists might define for those situations. But, as we shall see, how constructivists would proceed to design instruction to meet those goals differs in fundamental ways from how someone following Gagné's theory would proceed.

Constructivists are also interested in having learners identify and pursue their own learning goals. In the scenario Olympic Games, for example, the teacher may have some specific learning objectives in mind, but she also wants to provide students with an opportunity to explore and learn something of personal interest. Without this sort of personal freedom during instruction, someone like Raja probably would not have learned so much about a subject like bobsleds. Recall from Chapter 9 that this is a condition of learning that has been found to promote self-regulation in learning. And self-regulation is clearly desirable to constructivist educators.

Dick (1991) raised a concern, however, about the lack of attention paid by constructivists to the entry behaviors of students. Not all students are as capable as Raja to pursue an independent project, and open-ended learning environments afford an opportunity to play as much as they do to learn. Dick noted,

> Designers use analytic techniques to determine what a student must know or be able to do before beginning instruction, because without these skills research shows they will not be able to learn new skills. Why are constructivists not concerned that the gap will be too great between the schema of some students and the tools and information that they are provided? (Dick, 1991, p. 43)

In Dick's view, achievement of a goal such as diagnosing hypertension must depend upon prior knowledge of hypertensive symptoms, as well as the ability to distinguish those from similar conditions that might be attributable to some other disease. An instructional analysis would reveal not only what these prior skills are that must be acquired before the end goal can be reached, but also whether students have actually acquired the identified skills. If they have not, then remediation would be prescribed before students engaged in solving problems dependent upon those skills.

In response to Dick's concerns, Perkins (1991b) acknowledged the cognitive demands that constructivist learning goals and instruction typically place on learners. Learners must deal with complex problems, and they must "play more of the task management role than in conventional instruction" (Perkins, 1991b, p. 20). According to Perkins, however, this simply implies that teachers must coach individual students who lack adequate entry skills. "It is the job of the constructivist teacher...to hold learners in their 'zone of proximal development' by providing just enough help and guidance, but not too much" (Perkins, 1991b, p. 20). Similarly, Cunningham (1992) commented that teachers must not only coach students who lack prerequisite skills, but persuade those who are unwilling or unmotivated to engage in instruction. Just how teachers can best coach unable students and coax unwilling ones remains an open question (Driscoll & Lebow, 1992).

One possible way to deal with the lack of prerequisite knowledge and skills is to identify and ameliorate gaps within the context of the desired problem solving (CTGV, 1992). In other words, a part of solving complex problems involves determining what skills or information a learner needs to know. And learners who discover that, to solve a problem at hand, they must acquire some other skill or piece of information will be more motivated to do just that. Consider, for example, your own knowledge of the word processor or other computer software that you use regularly. Chances are that you do not know all of its possible functions and routines. Chances are even greater that to learn some of those that you do not know will require learning one or two other routines first. But it is unlikely that you will take the time to learn any of these unknown routines until you encounter a need for them. Once that need is present, however, you will learn whatever prerequisites are necessary to acquire the skill that meets your needs.

The same is probably true for learners involved in solving a complex problem like those presented by the CTGV. As students determine what subproblems must be solved in order to solve the challenge presented in an instructional video (e.g., what is the fastest way to rescue an injured eagle from a meadow to which there are no passable roads?), they discover needs for further learning (e.g., how do we determine how much fuel would be needed if an ultralight aircraft is used to fly to the meadow?). "Once these insights about need occur, then it is appropriate and beneficial to let students find environments (e.g., drill-and-practice programs) that can help them master specific types of information more efficiently" (CTGV, 1992, p. 77). Thus, the medical student who realizes, in the course of a clinical interview, that she or he cannot call to mind the symptoms of hypertension with which to compare an observed symptom will be motivated to restudy that information.

Prerequisite skills or entry learning goals, then, are not necessarily ignored by constructivists, but they are attended to largely in the context of higher-order goals. Moreover, detailed analyses of learning goals, of the sort intended to yield specific instructional objectives, are likely to be viewed by many constructivists as destroying the essence, or holistic nature, of the goal. This is because such analyses tend to result in "decontextualized" skills and knowledge where the very reason for learning them is lost or forgotten. Instead, constructivists prefer to retain their focus on higher-order goals and just make sure the necessary scaffolding is there for support when, and if, learners require it.

It seems clear from the remarks of constructivist researchers that constructivist learning goals are best met through a variety of instructional conditions that differ from any proposed by theorists like Gagné. Let us now consider what these might be.

Constructivist Conditions for Learning

If problem solving, reasoning, critical thinking, and the active and reflective use of knowledge constitute the goals of constructivist instruction, what are the learning conditions likely to bring these goals about? Again we see a variety of recommendations from the numerous researchers attempting to articulate constructivist theory. Moreover, many of these recommendations embody instructional principles that were originally derived from theories already discussed. Finally, as we shall also see, they largely emphasize the process of learning, rather than the products of learning. Collectively, these recommendations include the following:

1. *Embed learning in complex, realistic, and relevant environments.* See, for example, Duffy and Cunningham (1996), CTGV (1991a, 1992); Hannafin (1992), Honebein (1996); Honebein, Duffy, and Fishman (1993); and Lebow and Wager (1994). This condition also finds support in schema theory and mental models research (Chapter 4) as well as situated cognition (Chapter 5).

2. *Provide for social negotiation as an integral part of learning.* This learning condition is inherent in Piaget's theory (Chapter 6), Vygotsky's and Bruner's theories (Chapter 7), and situated cognition theory (Chapter 5). It also derives from the work of Cunningham (1992; Duffy & Cunningham, 1996), Honebein (1996; Honebein et al., 1993), CTGV (1990), and the Language Development and Hypermedia Group (1992a, 1992b), among others.

3. *Support multiple perspectives and the use of multiple modes of representation.* The juxtaposition of instructional content to provide for multiple perspectives is one of the central themes in Spiro's cognitive flexibility theory (Spiro et al., 1991, 1995). Providing for the use of multiple modes of representation in learning is supported by the work of researchers such as Cunningham (1992; Duffy & Cunningham, 1996), Honebein (1996), and Gardner (1983, 1985).

4. *Encourage ownership in learning.* Much of the work on self-regulated learning (Chapter 9) is consistent with this recommendation. See also Duffy and Cunningham (1996), Honebein (1996), and Lebow (1993).

5. *Nurture self-awareness of the knowledge construction process.* Cunningham (1987, 1992) called such self-awareness "reflexivity" and noted that consciously adopting different ways of constructing knowledge enables one to see what is illuminated or hidden by any particular way.

Let us examine each of these constructivist conditions in some detail.

Complex and Relevant Learning Environments. *"Students cannot be expected to learn to deal with complexity unless they have the opportunity to do so"* (CTGV, 1991a, p. 36; emphasis theirs). This bold statement undoubtedly reflects the opinions of most constructivist authors, who further believe that simplifying tasks for learners will prevent them from learning how to solve the complex problems they will face in real life. For problem-solving skills to be maximally facilitated, they argue, learners must cope with very complex situations. Remember from Chapter 5 that Schoenfeld's students believed math problems were virtually unsolvable if they could not be solved in 5 minutes or less (Schoenfeld, 1988). Experience with only simple problems can lead to such beliefs, whereas experience with more complicated and realistic problems can prevent such erroneous ideas.

What complex problems entail seems to depend largely upon the subject matter within which problem solving and reasoning are being learned. To a somewhat lesser extent, perhaps, they also depend upon the ages and characteristics of the targeted learners. The video-based learning environments that the CTGV (1990, 1991a, 1993) developed for mathematical problem solving, for example, contain problems of more than 15 interrelated steps. All of the information required to solve these problems is incorporated into each video, but the students must decide what information is relevant and how various pieces fit together. Initially used with fifth and sixth grade students, the videos have apparently been adapted successfully for use with first and second graders (CTGV, 1991b).

Learning environment complexity can also be conceived in terms of both the tools and the content of learning (Perkins, 1991a, 1991b). With respect to content, much constructivist instruction aims to debunk students' naive conceptions or misconceptions, particularly in the areas of science and mathematics. To do this, situations must make plain the inconsistencies and inadequacies of the learners' models and "challenge [them] either to construct better models or at least to ponder the merits of alternative models presented by the teacher" (Perkins, 1991b, p. 19). But what should such situations look like?

This is where the tools of a rich learning environment come in. Specifically, Perkins proposed that "construction kits" and "phenomenaria" be widely used in the classroom (1991a; see also Wilson, 1996). Construction kits enable learners to assemble "not just things, such as TinkerToys, but more abstract entities, such as commands in a program language, creatures in a simulated ecology, or equations in an environment supporting mathematical manipulations" (Perkins, 1991a, p. 19). So, for example, Legos, learning logs, and software such as *Geometric Supposer* would be considered construction kits (Wilson, 1996).

Similarly, phenomenaria enable students to observe various phenomena and to manipulate concepts and assumptions within those phenomena. The popular software series *SimCity* and *SimEarth* are good examples of phenomenaria. *SimCity* is a simulation of real-world cities that allows students to explore what it means to build and manage all the various aspects of city life. Unlike simulations that are carried out for scientific investigation or technical purposes, phenomenaria emphasize the instructional nature of simulations (Wilson, 1996).

An alternative argument for complex learning environments comes from research on how people learn to solve problems in "ill-structured domains" (Spiro et al., 1991, 1995; see also Spiro & Jehng, 1990; Jonassen, 1997, 1999). Unlike solving an algebraic problem, for example, diagnosing a medical problem depends more on heuristics than on well-formed rules. Furthermore, a doctor (unlike a mathematician) has no proven means for determining whether a diagnosis is correct. Although a prescribed treatment may appear to be successful in curing the patient, at least two other possibilities are often equally plausible. The treatment may be ineffective and the patient got better on his or her own or the treatment effectively cured the problem, but the problem was not what was originally diagnosed. Doctors must be prepared to accept either of these possibilities if additional evidence seems to warrant it.

Spiro and his colleagues documented the tendency of medical students to oversimplify the concepts and principles comprising diagnostic medicine. They argued that "instructional focus on general principles with wide scope of application across cases or examples" (Spiro et al., 1991, p. 27) was the cause. Part of the solution, therefore, should be to retain, in medical instruction, the complexity inherent in this ill-structured domain. In order to do this, cases should be studied as they really occurred, "not as stripped down 'textbook examples' that conveniently illustrate some principle" (Spiro et al., 1987, p. 181). In learning about hypertension, then, medical students might best examine multiple case histories of hypertensive patients, so that the full range of their symptoms might be illustrated.

Jonassen (1997, 1999) offered an instructional design model for developing instruction to teach problem solving in both well-structured and ill-structured domains. With respect to ill-structured problems, he recommended that a context analysis be conducted to lay out the nature of the problem domain and the constraints that might affect problems in the domain. In a domain such as medical diagnostics, for instance, an increase in malpractice suits could certainly affect doctors' use of additional tests to verify an initial diagnosis. Jonassen suggested that these kinds of constraints be introduced during instruction as students pondered case problems.

Sometimes, complex and realistic learning environments are taken to mean the same thing as authentic, or real-world, learning environments. Certainly, there is value in learners practicing their skills in an authentic performance context, as when young musicians play in an orchestra recital at their school. But they would have difficulty becoming proficient players if all their practice occurred in that context. Thus, Anderson, Reder, and Simon (2000) sounded a cautionary note about complex learning situations, echoing Jonassen's (1999) belief that a restrictive conception of authentic will result in learning environments that are authentic only in a narrow context (p. 221).

Social Negotiation. "...learning in most settings is a communal activity, a sharing of the culture" (Bruner, 1986, p. 127). Or, to paraphrase Vygotsky and situated cognition theorists, higher mental processes in humans develop through social interaction. Because constructivists hold to these beliefs about learning and thinking, they emphasize collaboration as a critical feature in the learning environment. Collaboration is not just a matter of asking students to work together in groups or to share their individual knowledge with one another. Rather, collaboration enables insights and solutions to arise synergistically (Brown et al., 1989) that would not otherwise come about. For example, can you recall a situation in which, but for the efforts of a group, some problem would have gone unsolved? No single member of the group would have had the wherewithall to independently generate an effective solution, but the members together had the necessary knowledge.

Another important function of collaboration in learning environments is to provide a means for individuals to understand point of view other than their own. Cunningham (1992), for example, argued that dialogue in a social setting is required for students to come to understand another's view. Listening, or reading privately, is not sufficient to challenge the individual's egocentric thinking. Echoing Cunningham's view, the Language Development and Hypermedia Group (1992a, 1992b) described instruction as a matter of nurturing processes by which learners develop and defend individual perspectives while recognizing those of others. What happens in learning, then, is the transmission or sharing of cultural knowledge, i.e., how concepts in a particular culture are understood and applied by its members.

As an example, consider how medical interns can be brought together to discuss symptoms noticed in a particular case. Having taken note of different things, they may propose alternative treatments, which they must then justify to their peers. Similarly, students involved in solving a challenge such as those proposed in the CTGV's instructional videodisks may propose alternative solutions and then justify the reasoning behind their proposals. Hearing a variety of other perspectives helps learners to judge the quality of their own solutions and to learn perhaps more effective strategies for problem solving.

The communicative aspect of collaboration during learning can also have the effect of transforming all parties involved (Pea, 1994; Edelson, Pea, & Gomez, 1996). Most constructivist researchers have argued forcefully against a transmission view of communication, i.e., communication as a message sent by one person and received by another. Rather, they have conceived of communication as a representation of shared belief—participants in sociocultural communities perpetuating their culture (see Chapter 5). Pea and his colleagues, however, proposed a transformative view of communication that they believe is facilitated through constructivist conditions of learning. According to a transformative view, "The initiate in new ways of thinking and knowing in education and learning practices is transformed by the process of communication with the cultural messages of others, but so, too, is the other (whether teacher or peer) in what is learned about the unique voice and understanding of the initiate" (Pea, 1994, p. 288).

Imagine, for example, what would happen if Raja, in the scenario Olympic Games, found a Web site on the Internet for the Jamaican bobsled team, which allowed him to communicate with various members of the team. The richness of his learning about bobsledding as an Olympic sport would be tremendously enhanced. But the transformation would hold in both directions—from the team to Raja, and from Raja to the team. His unique voice and communications could have untold effects on team members' views of themselves and their sport, on the information they provide on their Web site, and so on.

According to Edelson et al. (1996), advances in technology starting with the personal computer have "assisted in broadening the form that collaboration takes to include not just discussion but the sharing of artifacts and cooperative work across time and distance" (p. 152). Moreover, the potential is there for technology to play a "revolutionary role in supporting new forms of learning conversations in educational settings" (Edelson et al., 1996, p. 152). Indeed, a whole new genre of research and application has emerged as computer-supported collaborative learning (CSCL; Koschmann, 1996).

Multiple Perspectives and Multiple Modes of Learning. Characteristic of ill-structured content domains are cases or examples that are diverse, irregular, and complex (Spiro et al., 1991, 1995; Feltovich et al., 1996). General principles do not apply widely across cases, nor is it possible to use a single analogy or model to represent all cases or content in the domain. When learners attempt to apply, to ill-structured domains, the strategies they have used effectively for understanding well-structured domains, they make errors of oversimplification, overgeneralization, and overreliance on context-independent representations (Spiro et al., 1988).

In the biomedical domain, for example, which Spiro and his colleagues have contended is ill-structured, students who use only the metaphor of the machine to help them understand how the body functions tend to analyze cases only partially. The same is true among students who understand bodily functions only in terms of organicist metaphors. The point Spiro makes is that neither metaphor is wrong, but neither metaphor captures all aspects of body functions.

Remember the difficulties inherent in selecting pedagogical models for helping students to develop mental models of complex phenomena (see Chapter 4). Whereas mental models researchers proposed the use of one model, pointing out its limitations, or a series of models to illustrate different aspects of the phenomenon, Spiro and his colleagues advocated the use of multiple forms of models, multiple metaphors and analogies, and multiple interpretations of the same information. These are the hallmarks of Cognitive Flexibility Theory (Spiro et al., 1991, 1995; Feltovich, et al., 1996). "Revisiting the same material, at different times, in rearranged contexts, for different purposes, and from different conceptual perspectives is essential for attaining the goals of advanced knowledge acquisition" (Spiro et al., 1991, p. 28). Spiro called this multiple juxapositions of instructional content, or "criss-crossing the landscape," and suggested that hypermedia provides an excellent tool for achieving it. A rich and flexible knowledge base can be built that enables learners to systematically explore multiple models and multiple interpretations. You can see how advantageous this might be for medical students. They would be able to examine a single case from many different vantage points and see firsthand the effect of reinterpreting a particular symptom.

It is now largely accepted among contructivists that hypermedia can be effectively used to encourage students to think about ideas, theories, literary works, or whatever, from a variety of perspectives (e.g., Cunningham, 1992). In a sense, books such as this one about theories of learning are written with much the same goal in mind. Many of the same questions about learning are tackled by different theorists from different perspectives, and different metaphors for learning function to highlight different aspects of the same content. The actual juxtaposition of ideas, however, is largely in your hands as the reader. It would be unwieldy for me, as the author, to revisit content to the extent that you, as the reader, can do very easily. For this reason, perhaps, many constructivist theorists have turned to emerging technologies as the most promising means by which to implement essential learning conditions.

Finally, using multiple modes of representation can serve as a means of juxtaposition. That is, viewing the same content through different sensory modes (such as visual, auditory, or tactile) again enables different aspects of it to be seen. It is also worth noting that multiple modes of representation have now received support as an instructional strategy from cognitive information-processing theory, educational semiotics, and biological theories, as well as from constructivism.

Ownership in Learning. Arranging instruction to meet individual student needs is not an idea new to constructivism. It has been a recurring theme throughout not only this book, but also learning theory development in general. What distinguishes the constructivist perspective is the placement of the student as "the principal arbiter in making judgments as to what, when, and how learning will occur" (Hannafin, 1992). In other words, students are not passive recipients of instruction that has been designed for them. Instead, they are actively involved in determining what their own learning needs are and how those needs can best be satisfied. As Perkins (1991b) put it, "Students are not likely to become autonomous thinkers and learners if they lack an opportunity to manage their own learning" (p. 20). Thus, it is important to facilitate student ownership in learning (Duffy & Cunningham, 1996; Honebein, 1996; Hannafin, Land & Oliver, 1999).

Consider the following report of a project with elementary school students:

> In Harel and Papert's [1992] work, elementary school students who displayed a great dislike for fractions tackled the task of learning about fractions with great enthusiasm when their role was changed from students to software designers. They were asked to design a computer program in LOGO (software they were already familiar with) that would teach the basics of fractions to children one year younger than themselves. In order to do this, they first had to teach themselves what was important to know about fractions. When the project was complete, the students had learned not only about fractions, but also about software design and instructional design. (Honebein et al., 1993, p. 9)

This example is remarkably similar to one cited in an earlier chapter in which an elementary school teacher had students produce videotapes to teach their peers about topics in science. In both cases, the students have an investment in the project, making their own decisions and evaluating their own progress. The teacher is there to serve as coach and resource, sharing in the learning process rather than controlling it.

Ms. Patterson, in the Olympic Games scenario, is also facilitating student ownership by providing the Web site and encouraging students to identify and investigate topics of interest to them. A likely outcome is enhanced learning and motivation.

Whether students are prepared to take ownership and manage their own learning is a question posed by critics of contructivism. Clark (1982) reviewed research on student attitudes toward and preferences for particular instructional strategies and concluded that students are not the best judges of their own learning needs. For the most part, they preferred methods that were not well suited for facilitating their individual achievement. Many investigators of learner control in computer-based instruction have reached much the same conclusion (Steinberg, 1989). When given options, learners apparently choose the quickest route through the instruction, whether or not that route best meets their learning needs.

Two issues are raised by these findings. The first concerns whether students are capable of making effective judgments about their own learning needs and how to satisfy them, whereas the second concerns whether they are willing to do so. A tacit assumption of constructivist learning environments is that students possess whatever metacognitive skills are necessary to successfully navigate in those environments (Hannafin, 1992). If they do not, then designers of these environments should embed aids to students that will help them navigate lessons. These might include, for example, an organizing theme, various forms of help, advice, hints, or guided reflection.

Perkins (1991b) agreed that students must often be assisted in managing learning tasks and referred to the classic solution of scaffolding, or coaching, mentioned earlier. Exactly how to do this, particularly by one teacher with a number of students, is less clear and is indicated by Driscoll and Lebow (1992) as a pressing problem for constructivist researchers to solve.

As for the concern that students do not all "buy into" the notion of managing their own learning, it has already been suggested that teachers must persuade them. To do this requires that a "teacher or instructional designer approach the double agenda as such, engaging students constructively in thinking both about X [the content] and about the learning process reflectively" (Perkins, 1991b, p. 20).

Finally, perhaps one of the reasons that students have difficulty navigating a learning environment or try not to do so on their own accord is that such environments have typically been decontextualized. Without a meaningful context to guide them, learners are left to figure out "what the teacher wants" or "what will be on the test." When that happens, learning tasks become tests of endurance, something "to be gotten through." On the other hand, "tasks that are thought to be difficult when attempted in a decontextualized environment become intuitive when situated in a larger framework" (Honebein et al., 1993), that is, a more authentic context. The reasons become clear as to why information and skills should be learned, and their learning advances the students toward the achievement of some larger goal, like the production of videotapes to teach peers what they have learned.

Self-Awareness of Knowledge Construction. Cunningham (1987, 1992; Language Development and Hypermedia Group, 1992a, 1992b) defined reflexivity as *"the ability of students to be aware of their own role in the knowledge construction process."* Awareness of one's own thinking and learning processes is a capability cognitive information-processing theorists have commonly called metacognition (see Chapter 3). Helping learners to become more aware of their thinking processes is thought by many, including Gagné, to be essential in the development of mindful, strategic behavior or cognitive strategies. Although constructivists might well agree with cognitive information-processing theorists on the definition and importance of metacognition, they mean something more by reflexivity.

With reflexivity, a critical attitude exists in learners, an attitude that prompts them to be aware of how and what structures create meaning. With this awareness comes the ability to invent and explore new structures or new interpretive contexts. In other words, when learners come to realize how a particular set of assumptions or worldview shapes their knowledge, they are free to explore what may result from an alternate set of assumptions or a different worldview.

The goal of reflexivity is partly supported by the juxtaposition of instructional content and the resulting emphasis on multiple perspectives. It is also very much related to ownership in instruction and the learner's subsequent commitment to a particular perspective.

Consider, for example, the different views of learning that are presented in this book. What do they each imply about your own learning of their assumptions and principles? From a cognitive information-processing point of view, you might be expected to treat the book as declarative knowledge to be acquired, with different schemata about the various theories constituting the result of your learning efforts. By contrast, from a constructivist point of view, you might be expected to recognize that all these theories are constructed to make sense of the phenomenon of learning. Their different assumptions lead to different pictures of learning, and consequently, of instruction. From discussion with your classmates and others, you might develop a personal view as to what theory (or theories) is the most right or useful. Or you may reject the assumptions upon which all these theories have been built in order to pose a new set of assumptions and explore a potentially new theory of learning.

It should be noted that this contrast between constructivist and information-processing theory has been drawn rather sharply to illustrate the point of reflexivity. Not everyone would agree with my distinctions, but the very debate that would be prompted by such disagreement would serve to further illuminate both positions.

Nurturing self-awareness of knowledge construction, then, is a learning condition that constructivists assert is essential to the acquisition of goals such as reasoning, understanding multiple perspectives, and committing to a particular position for beliefs that can be articulated and defended.

Summary. Displayed as a summary in Table 11.1 are the learning goals associated with constructivism, together with the learning conditions presumed to bring about those goals. We are now ready to consider the third element in constructivist instructional theory: specific methods of instruction. Suggested methods are also presented in Table 11.1.

Constructivist Methods of Instruction

Some methods have already been suggested that are shown or likely to be effective in implementing the conditions constructivists believe are essential for learning. Others—including microworlds and hypermedia designs, collabora-

TABLE 11.1 ***A Summary of Goals, Conditions of Learning, and Instructional Methods Consistent with Constructivism***

Instructional Goals	*Conditions of Learning*	*Methods of Instruction*
Reasoning Critical thinking	Complex, realistic and relevant environments that incorporate authentic activity	Microworlds, problem-based learning
Retention, understanding, and use	Social negotiation	Collaborative learning, Bubble Dialogue
Cognitive flexibility	Multiple perspectives and multiple modes of learning	Hypermedia
Self-regulation	Ownership in learning	Open-ended learning environments, collaborative learning, problem-based learning
Mindful reflection, epistemic flexibility	Self-awareness in knowledge construction	Bubble Dialogue, role plays, debates, collaborative learning

tive learning and problem scaffolding, goal-based scenarios and problem-based learning, and open software and course management tools—serve to implement multiple conditions simultaneously. Each merits a brief discussion. Before proceeding, however, it is important to note that there has been an explosion of activity over the last few years in the design and use of these types of learning environments. It would be impossible to describe them all in this chapter. Therefore, I have tried to give you a sense as to what they are like and urge you to look up original sources for more information. It is also important to realize that, as I write this, more project reports and descriptions of projects exist than empirical data showing their effectiveness.

Microworlds and Hypermedia Designs. As the name implies, microworlds are small but complete subsets of real environments that promote discovery and exploration (Papert, 1981). Their design has been influenced by research on mental models (see Chapter 4) as well as theoretical developments leading to the emergence of constructivism. Microworlds have two essential characteristics that distinguish them from similar concepts, such as simulations (Rieber, 1991b; see also Rieber, 1996). That is, they embody the simplest working model of a domain or system, and they offer a point of entry that matches the learner's cognitive state. LOGO, for example, perhaps the most widely researched microworld currently in existence, permits children to explore and discover the world of computer programming by writing commands that drive a "turtle" (Papert, 1980).

In *ScienceVision*, an interactive videodisk-based microworld, students conduct scientific experiments of the sort that would generally be precluded from middle school instruction because of prohibitive expense, time requirements, or potential danger to the students (Tobin & Dawson, 1992). For example, in the study of ecology, students can investigate what it would take to convert a mining site to farmland. Through simulation, they analyze soil samples, plant and monitor various crops, and conduct cost-benefit analyses based on their findings.

Because interactive videodisk microworlds are themselves expensive to design and produce, some researchers and instructors are turning to hypermedia as a less expensive and more widely available alternative. Hypermedia designs typically run on microcomputers, which can be networked and therefore accessed by several learners at once. Design strategies include representing a vast body of information about the topic of interest, including such types of information as autobiographical data, descriptions, definitions, photographs or graphic designs, interviews or other samples of research data, and the like. For example, in the Lab Design Project (Honebein, Chen, & Brescia, 1992), graduate students investigate the sociology of a building by exploring different aspects of it that are represented in the hypermedia data base. They can call up from the data base the types of information they would actually collect if they were to do research in a real building (Honebein et al., 1993).

At the least, microworlds and hypermedia provide rich, student-centered learning environments in which authentic activity is stressed. Depending upon their use in an instructional context, they may also support conditions of social negotiation (e.g., Emihovich, 1981) and nurturance of reflexivity (Rieber, 1991a, 1991b).

Collaborative Learning and Problem Scaffolding. Collaborative learning has already been discussed to some extent, with mention made of the extensive advances in computer-supported collaborative learning. Much of the impetus for CSCL can be attributed to an area of study known as computer support for collaborative work (or CSCW; Galegher & Kraut, 1990). A fundamental assumption of CSCW is that computers and their related technologies can "facilitate, augment, and even redefine interactions among members of a work group" (Koschmann, 1994, p. 219). Software designed to be used by groups to facilitate and manage the interaction among group members is known as groupware.

Such collaborative technologies are now finding their way into instruction to support learning of students engaged in a learning task as members of a group. CSCL applications have been designed for use within a classroom (e.g., CSILE; see Chapter 5) and to connect learners across classrooms and outside of classrooms (e.g., the Collaborative Visualization project, or CoVis; Pea, 1993a).

An advantage of collaborative technologies that are Web-based is that they can provide problem scaffolding (Hannafin et al., 1997) in the form of virtual access to knowledge experts and on-line support to make thinking visible. In this way, students can identify learning goals, conduct investigations, keep track of their progress, think about their ideas and those of others, and communicate to others within and outside the immediate learning community.

Goal-Based Scenarios and Problem-Based Learning. The Goal-Based Scenarios (GBS) framework (Schank et al., 1993/1994, 1999; Bell, Bareiss, & Beckwith, 1993/1994; Kass et al., 1993/1994) is an example of a computer-based learning environment but with a different emphasis than the collaborative technologies. GBSs present a clear and concrete goal to be achieved (e.g., composing a piece of music, designing a car, starting a business, eradicating a disease) and provide a task environment where learners learn and practice target skills. Schank et al. (1993/1994, 1999) use the metaphor of a mission to describe GBS, in that there is a mission context (including a cover story and explicit statement of the mission) and a mission structure. The mission structure includes a focus and operations to be carried out to achieve the mission. The GBS is similar in many respects to anchored instruction (see Chapter 5), but GBS researchers claim that learners are participants in the goal scenario, rather than observers of the video-based anchored instruction.

They assume roles within the mission and essentially engage in a real-time simulation.

Problem-based learning (PBL; Duffy & Jonassen, 1992; Savery & Duffy, 1996; Nelson, 1999) has recently re-emerged as a constructivist method after a long history of use in medical education. Like other collaborative technologies, students in problem-based learning work in groups, and like GBSs, groups work to solve a "real" problem. Unlike these other approaches, however, learners may seek out a variety of resources, technological and otherwise, to help them arrive at possible solutions. The emphasis in PBL is to provide a problem-solving process that students may use systematically to identify the nature of the problem, assign tasks to be completed, reason through the problem as data and resources are gathered and consulted, arrive at a solution, and then assess the adequacy of the solution. Once the problem is concluded, the learners also reflect on their reasoning, their strategies for resource gathering, their group skills, and so forth.

Software Shells and Course Management Tools. Software shells are largely empty of content, providing instead functions that can be readily adapted to the user's intended application. A tool known as Bubble Dialogue is an example (Language Development & Hypermedia Group, 1992a, 1992b). Through Bubble Dialogue, students create conversations among comic strip characters, including thoughts that would not be said out loud. In this way, they have the opportunity to express "personal (perhaps naïve) views of the world, to contemplate multiple perspectives in both public and private domains and to accommodate their own thinking to contrary views" (Language Development and Hypermedia Group, 1992a, p. 44).

The authors of Bubble Dialogue have found the tool useful in facilitating dialogue among grade school children about the long-standing conflict in Northern Ireland and among preservice teachers about teaching strategies. Moreover, the permanent archive created by the program facilitates later editing or reflection and supports the development of literacy.

The STAR LEGACY is another sort of software shell that is designed to support flexibly adaptive learning environments (Schwartz, Lin, Brophy, & Bransford, 1999). It makes explicit a learning cycle that embodies a problem solving process—from accepting a learning challenge, to generating ideas, to testing one's understanding, and finally to learners publishing the results of their thinking for others to consider. STAR LEGACY helps teachers and learners to see where they are and reflect on the learning process. Successive use of the legacies left by each group of students enables progressive deepening of understanding about the topics under study.

Finally, the course management tool known as Construe (Lebow et al., 1996; Gilbert & Driscoll, 1998) is a software shell that is designed to enable course instructors to mount Web-based courses with constructivist principles already designed in. For instance, an informational data base is present in the form of on-line articles that can be searched easily by author or keyword. A variety of reports provides the means for learners to publish on-line their thoughts and opinions on the articles as they read them, to describe projects in which they are engaged, and to bring new resources to the class that may benefit members. A computer conferencing system is also available so that learners can discuss articles and projects as the semester proceeds. These features together provide a public, on-line learning environment in which the artifacts produced stand as evidence of the knowledge-building within the community.

Walter Wager, one of the developers of Construe, tells interested colleagues that using Construe does not assure a constructivist learning environment (personal communication, September 1998). The software can, after all, be used to support very traditional instructional strategies. However, as one who has herself employed Construe in a graduate course, I am convinced that the use of all the software's features as an integrated system guarantees a very powerful learning environment that will yield learning outcomes consistent with constructivism.

Summary. It is probably no accident that constructivism is gaining popularity and momentum at the same time interactive, user-friendly computer technologies are becoming widely available. The computer offers an effective means for implementing constructivist strategies that would be difficult to accomplish in other media. However, this is not to imply that other media cannot also be effectively employed within constructivist pedagogy. The discussion that is facilitated by Bubble Dialogue, for example, can also occur in well managed debates and role plays. Moreover, projects need not be situated in hypermedia data bases to provide authentic activity. However, it is likely that a variety of resources and time will be required to effectively implement most constructivist principles.

Conclusion

Constructivism has taken such a strong hold in many areas of education today that it seemed appropriate to discuss it within its own chapter, despite the fact that it is not one theory but a multitude of approaches. As these approaches develop and proliferate, it also becomes less clear as to whether constructivism is a theory or a philosophy (Lebow, 1993). As a theory, it may indeed be incommensurable with an instructional theory such as Gagné's, because the two would have been built from opposing assumptions. But as a philosophy, constructivism may be viewed as not competing with other instructional theories, but providing them with an alternative set of values that deserve serious consideration.

These values, according to Lebow (1993), form the basis for five principles which should perhaps be incorporated into any theory of instruction:

> (a) Maintain a buffer between the learner and the potentially damaging effects of instructional practices in use, (b) provide a context for learning where the needs for both autonomy and belongingness are supported, (c) embed the reasons for learning something into the learning activity itself, (d) support self-regulation through the promotion of skills and attitudes that enable the learner to assume increasing responsibility for the developmental restructuring process, and (e) strengthen the learner's tendency to engage in intentional learning processes. (pp. 4–5)

Much remains to be done to articulate constructivist theory and determine its place in the broader framework of learning and instructional theory. Theory and conjecture continue to far outstrip empirical findings. It is not difficult to understand why, when one considers how difficult it can be to implement and study constructivist pedagogy. Hickey, Moore, and Pellegrino (2001) noted that teachers did not always implement the constructivist curriculum (in this case, the Jasper series) as the developers intended. "Most teachers reported or were reported to have used 'fact sheets' to structure the problem-solving activity, and in one of the classrooms, the Jasper activity was largely reduced to having students compete with each other in answering questions on the fact sheets" (Hickey, Moore, & Pellegrino, 2001, p. 634). However, when the curriculum was implemented as intended, positive consequences for student learning were generally the result.

Constructivism is not without its critics, however. Matthews (2003) questioned the validity of the constructivist world view in light of findings reported by Chall (2000) that teacher-centered approaches were more effective than student-centered approaches for enhancing academic achievement. Likewise, Anderson, Reder, and Simon (2000) examined some of the claims of constructivism and found them to be wanting. In their opinion, constructivism offers little that is new and ignores much that is known. However, there is broad consensus on several points (Anderson, Reder, & Simon, 2000):

- Only the active learner is a successful learner.
- Learning from examples and learning by doing enable learners to achieve deep levels of understanding.
- Learning with understanding is what is desired, not rote learning.
- The social structure of the learning environment is important.

In time, research on constructivism should provide the empirical evidence needed to evaluate its claims and implications for teaching and learning.

A Constructivist Perspective on "Kermit and the Keyboard"

The story "Kermit and the Keyboard" illustrates many aspects of a constructivist learning environment. The learning goal of playing the keyboard skillfully, using a variety of backgrounds and voices to achieve a desired sound, is complex and involves use of knowledge, critical thinking, and self-regulation. The physical skill of actually playing the instrument is not well addressed by constructivist theory, but the cognitive skills associated with it are. Kermit has complete ownership over his own learning. He decides what he wants to learn and how he will go about doing it. The learning environment is certainly complex, and Kermit has a variety of information resources available to him (such as the keyboard manual, the fake books, the music instruction books, his wife, and online chat groups and web sites). When he works on a particular song and reaches a section that is difficult to play, he can resort to exercises in the music instruction books to help him develop the necessary skill. In addition, when he is ready to learn a new feature on the keyboard, he can consult the manual for relevant information and diagrams showing him how that feature functions. When understanding proves difficult, there are the on-line resources or his wife to help him overcome the problem.

Kermit epitomizes the constructivist learner in that he comes to the learning task already motivated and with enough relevant prior knowledge to be successful in his learning efforts. Interestingly, we can see the failure of this environment to support Kermit when he makes a lot of mistakes during his practice sessions. There is no systematic scaffolding as recommended by constructivist theory for when learning and performance fail. As a consequence, Kermit does not overcome his errors, nor does he persist in attempting those songs on which he makes many mistakes.

Theory Matrix

Theory	Constructivism
Prominent Theorists	D. J. Cunningham (see also Chapter 5); D. Jonassen Learning Technology Center at Vanderbilt; D. Perkins; E. von Glasersfeld (radical constructivism);
Learning Outcome(s)	Reasoning, critical thinking, understanding and use of knowledge, self-regulation, mindful reflection
Role of the Learner	Active constructor of knowledge, making meaning of the world surrounding him or her
Role of the Instructor or Instructional Designer	Provide complex and realistic learning environments that challenge learners to identify and solve problems Support learners' efforts and encourage them to reflect on the process
Inputs or Preconditions to Learning	Ill-structured problems, information and technology resources to support problem-solving; ability to be self-directed or conditions to support becoming self-directed
Process of Learning	Besides referring to structuring and restructuring knowledge and the dynamic nature of knowledge, constructivists are vague about the process of learning

Suggested Readings

Koschmann, T. (Ed.). (1996). *CSCL: Theory and practice of an emerging paradigm.* Mahweh, NJ: Lawrence Erlbaum Associates.

Steffe, L. P., & Gale, J. (Eds.). (1995). *Constructivism in education.* Hillsdale, NJ: Lawrence Erlbaum Associates.

The Journal of the Learning Sciences. (1993/1994). Special issue: Goal-based scenarios, 3(4).

The Journal of the Learning Sciences. (1993/1994). Special issue: Computer support for collaborative learning, 3(3).

Wilson, B. G. (Ed.). (1996). *Constructivist learning environments: Case studies in instructional design.* Englewood Cliffs, NJ: Educational Technology Publications.

Reflective Questions and Activities

1. Contrast the epistemologies underlying Gagné's instructional theory and constructivism, with a view toward determining their compatibility or incompati-