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COGNITIVE APPRENTICESHIP IN EDUCATIONAL PRACTICE: RESEARCH ON SCAFFOLDING, MODELING, MENTORING, AND COACHING AS INSTRUCTIONAL STRATEGIES

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31.1 INTRODUCTION

Apprenticeship is an inherently social learning method with a long history of helping novices become experts in fields as diverse as midwifery, construction, and law. At the center of apprenticeship is the concept of more experienced people assisting less experienced ones, providing structure and examples to support the attainment of goals. Traditionally apprenticeship has been associated with learning in the context of becoming skilled in a trade or craft—a task that typically requires both the acquisition of knowledge, concepts, and perhaps psychomotor skills and the development of the ability to apply the knowledge and skills in a context-appropriate manner—and far predates formal schooling as it is known today. In many nonindustrialized nations apprenticeship remains the predominant method of teaching and learning. However, the overall concept of learning from experts through social interactions is not one that should be relegated to vocational and trade-based training while K–12 and higher educational institutions seek to prepare students for operating in an information-based society. Apprenticeship as a method of teaching and learning is just as relevant within the cognitive and metacognitive domain as it is in the psychomotor domain.

In the last 20 years, the recognition and popularity of facilitating learning of all types through social methods have grown tremendously. Educators and educational researchers have looked to informal learning settings, where such methods have been in continuous use, as a basis for creating more formal instructional methods and activities that take advantage of these social constructivist methods. Cognitive apprenticeship—essentially, the use of an apprentice model to support learning in the cognitive domain—is one such method that has gained respect and popularity throughout the 1990s and into the 2000s.

Scaffolding, modeling, mentoring, and coaching are all methods of teaching and learning that draw on social constructivist learning theory. As such, they promote learning that occurs through social interactions involving negotiation of content, understanding, and learner needs, and all three generally are considered forms of cognitive apprenticeship (although certainly they are not the only methods). This chapter first explores prevailing definitions and underlying theories of these teaching and learning strategies and then reviews the state of research in these area.

31.2 TERMINOLOGY AND KEY CONCEPTS RELATED TO COGNITIVE APPRENTICESHIP

One of the challenges when researching or discussing cognitive apprenticeship in general, and the techniques of scaffolding, mentoring, and coaching in particular, is getting a clear sense of how the terminology is being used. There is no standard taxonomy or classification of these social constructivist methods; for example, some refer to mentoring and/or coaching as a form of scaffolding (e.g., McLoughlin, 2002), some refer to scaffolding as an aspect of coaching (e.g., Collins, Brown, & Newman, 1989), and others maintain that they are separate strategies falling under the larger classification of cognitive apprenticeship (e.g., Enkenberg, 2001; Jarvela, 1995). Additionally, the terms *coach* and *mentor* are commonly used in everyday practice to identify people who play particular roles regardless of whether the learning support that they foster and provide truly falls within the pedagogical definitions of the terms. Whereas the work being done in this overall area appropriately tends to focus more on improving teaching and learning than on developing consistency in terminology, the terms nevertheless are important to our ability to discuss, share, and further knowledge in cognitive apprenticeship. This section presents the dominant thought and definitions related to cognitive apprenticeship, scaffolding, modeling, mentoring, and coaching.

31.2.1 Cognitive Apprenticeship

A cognitive apprenticeship is much like a trade apprenticeship, with learning that occurs as experts and novices interact socially while focused on completing a task; the focus, as implied in the name, is on developing cognitive skills through participating in authentic learning experiences. Collins et al. (1989, p. 456) succinctly define it as "learning-through-guided-experience on cognitive and metacognitive, rather than physical, skills and processes." Core to cognitive apprenticeship as a method of learning are the concepts of situatedness and legitimate peripheral participation, both described by Lave and Wenger (1991). Situated learning occurs through active participation in an authentic setting, founded on the belief that this engagement fosters relevant, transferable learning much more than traditional information-dissemination methods of learning. However, it is more than just learning by doing; situated learning requires a deeper embedding within an authentic context. Human actions of any nature are socially situated, affected by cultural, historical, and institutional factors (Wertsch, 1998). This situatedness is a key component of the learning environment and thus needs to be considered in a cognitive apprenticeship.

Learning in a cognitive apprenticeship occurs through legitimate peripheral participation, a process in which newcomers enter on the periphery and gradually move toward full participation. It is not a technique or strategy, as it tends to happen quite naturally on its own. Legitimate peripheral participation is perhaps easiest to understand through a workplace example of traditional apprenticeship. Lave and Wenger (1991) present the example of legitimate peripheral participation as apprentices learn the trade of becoming a tailor:

> Consider, for instance, the tailors' apprentices, whose involvement starts with both initial preparations for the tailors' daily labor and finishing details on completed garments. The apprentices progressively move backward through the production process to cutting jobs. (This kind of progression is quite common across cultures and historical periods.) Under these circumstances, the initial "circumferential" perspective—running errands, delivering messages, or accompanying others—takes on new significance: It provides a first approximation to an armature of the structure of the community of practice. (p. 96)

Essentially, the apprentices are learning about both the overall process of the larger task and profession and criteria for evaluating performance through the completion of small tasks. As they gain experience, they are offered larger, more central tasks to complete. Their understanding of how these tasks affect the end product in a holistic manner supports their performance, as does their knowledge of the criteria that will be used to assess the end product.

What does this mean for school-based education? According to J. S. Brown (1998), "The central issue in learning is becoming a practitioner, not learning about practice" (p. 230). In an argument for adopting cognitive apprenticeship in formal educational settings, Enkenberg (2001) criticizes university education because the learning tends to occur separately from expert practice. This separation is problematic because expert practice is critical to real-world performance and is difficult to simply teach by lecture or explanation. For many of today's students, skills and knowledge are being taught in an abstract manner, which makes it difficult for them to apply them in concrete, real-world situations (Collins et al., 1989). The implications of this problem, taken to the extreme, are that our schools could rely solely on information transmission methods of instruction and universities could rely solely on faculty and graduate students who know many facts but are ill prepared to apply them in a practical context to provide educational experiences. Although the reality is not this extreme, many students still fail to see the relationship between traditional school-based learning and real-world applications, and many educators who are competent practitioners fail to provide learning experiences that adequately connect theory to practice. During the last two decades, educational researchers have been addressing this problem by looking for ways to integrate cognitive apprenticeship in the classroom. This research is discussed later in this chapter.

Teaching and learning through cognitive apprenticeship requires making tacit processes visible to learners so they can observe and then practice them (Collins et al., 1989). The following methods support the goals of cognitive apprenticeship.

> 1. Modeling: meaning the demonstration of the temporal process of thinking.
> 2. Explanation: explaining why activities take place as they do.
> 3. Coaching: meaning the monitoring of students' activities and assisting and supporting them where necessary.
> 4. Scaffolding: meaning support of students so that they can cope with the task situation. The strategy also entails the gradual withdrawal of teacher from the process, when the students can manage on their own.
> 5. Reflection: the student assesses and analyses his performance.
> 6. Articulation: the results of reflection are put into verbal form.
> 7. Explorations: the students are encouraged to form hypotheses, to test them, and to find new ideas and viewpoints. (Enkenberg, 2001, p. 503)

Enkenberg's list is not considered the definitive one, but it nevertheless presents various strategies that may be used in a cognitive apprenticeship. Collins et al. (1989) refer to modeling, coaching, and fading as the predominant methods of cognitive apprenticeship, with scaffolding mentioned as part of the coaching process. Note that these strategies refer to the teacher's or expert's actions; the learners in a cognitive apprenticeship are engaged in acts of observation, practice, and reflection.

31.2.2 Scaffolding Defined

The concept of scaffolding draws on the work of Vygotsky (1978), although the term first came into use in an article written by Wood, Bruner, and Ross (1976). In education, scaffolding is a metaphor for a structure that is put in place to help learners reach their goals and is removed bit by bit as it is no longer needed, much like a physical scaffold is placed around a building that is under construction and removed as the building nears completion. Whereas some believe this is an appropriate metaphor for providing support during instruction that can be removed as the learner no longer needs it (J. S. Brown, Collins, & Duguid, 1989), Duffy and Cunningham (1996, p. 183) find this metaphor "unfortunate" because "it suggests a guiding and teaching of the learner toward some well-defined (structural) end" and is teacher centered. In practice, however, scaffolding is a learner-centered strategy whose success is dependent on its adaptability to the learner's needs. Additionally, scaffolding is much more than a physical support in a learning context, addressing student learning of concepts, procedures, strategies, and metacognitive skills (McLoughlin, 2002).

Scaffolding has been described as either directive or supportive, depending on where the impetus for the support originates (Lenski & Nierstheimer, 2002). Directive scaffolding is part of a more teacher-centered approach, in which the instructor devises skills and strategies to teach specified content. Supportive scaffolding, in contrast, is learner centered and occurs as the learner coconstructs knowledge with others. In practice, the former may be manifest as a teacher providing learners with strategies of successful students, whereas the latter would involve instruction tailored to specific learner needs based on current ability and interest.

Rogoff (1990) discusses scaffolding in terms of adult structure of child's learning activities. Adults provide children with metacognitive support by breaking down tasks from those that are beyond the child (learner's) abilities into smaller, more manageable ones that are within the child's grasp. Within this method it is important to ensure that the learners' participation is still meaningful and clearly contributes to the overall goal; tasks should not be broken down and segmented to the extent that learners no longer feel like participants in the overall process or cannot see how their work contributes to the end result. There are many ways in which one may scaffold instruction, but there are a few central concepts that are common and critical to scaffolding in any form: the zone of proximal development (ZPD), intersubjectivity, and fading.

31.2.2.1 Zone of Proximal Development. The ZPD is a concept put forth by Vygotsky (1978), who suggested that learning activities should provide adequate challenges to the learner based on his or her current knowledge state but at the same time not be so challenging as to be unattainable. The ZPD is a dynamic region that is just beyond the learner's present ability level; as learners gain new skills and understanding, their ZPD moves with their development. This space between actual and potential performance is assessed through social interaction between the learner and someone who is more experienced—potentially a teacher, parent, or even an advanced peer. Rogoff (1990) adds that cultural learning and development, in addition to individual cognitive development, occur a result of teaching and learning in the ZPD: "Interactions in the zone of proximal development are the crucible of development *and* of culture, in that they allow children to participate in activities that would be impossible for them alone, using cultural tools that themselves must be adapted to the specific practical activities at hand" (p. 16). This observation again stresses the situated nature and social interconnectedness of learning through cognitive apprenticeship.

The ZPD is a critical concept to consider when providing scaffolding. Scaffolding affects learners both cognitively and emotionally, impacting not just learner skill and knowledge, but also learner motivation and confidence when approaching a task. Cognitively, it supports the selection of activities and the use of a variety of assists to ensure that learning takes place, such as hints, models, analogies and demonstrations. Emotionally, it helps students keep from getting mired in feelings of failure through the various supports that are focused on learner success (Bean & Patel Stevens, 2002). Both cognitively and emotionally, these successes rely on scaffolding that is directed appropriately at the learner's current ability level. In other words, it must occur within the learner's ZPD.

The learner may write off some tasks as too easy and lose interest quickly, whereas other tasks may seem so daunting at the onset—even if the learner does possess the technical capability to succeed—that the learner may essentially declare defeat before even trying. Optimal instruction and learning tasks occur in the middle zone, which is neither too simple nor too difficult and is open for learning. I liken this situation of finding the appropriate middle zone to a parent teaching a child to swim, a learning situation that often relies on scaffolding. Initially, the task may be broken into smaller pieces by the parent; the child may practice kicking with the assistance of a kickboard, breathing while holding onto the side of the pool, and arm strokes while being supported afloat by the parent. To do all three parts together initially would be too difficult for the child, but once they are individually mastered the child may try them together as a coordinated whole with the assistance of inflatable water wings, which ensure that he or she will not sink. When the parent determines that the child has the necessary skills to swim on his or her own, the child may still be nervous and uncertain of the ability both to stay afloat and to move forward—yet without trying, the child will never know if he or she can succeed. Additionally, the parent must observe the child in motion to diagnose any difficulties. Thus, the adult provides the child with small challenges that are constantly being adjusted to match the child's ability and confidence. Initially the parent may stand 2 ft from the child and challenge him or her to swim; this distance provides a small challenge but keeps the parent close enough for the child to feel safe. On success, the parent may challenge the child again, this time continuously moving backward as the child moves forward, maintaining or perhaps increasing the distance between them. The child is not only learning the mechanics of swimming, but also learning that he or she can succeed at swimming alone. Gradually the child realizes that he or she does not need the parent's assistance any more and sets new, independent learning goals, such as swimming from one side of the pool to another. Throughout this example the parent's role is to determine an appropriate challenge for the child and the necessary support for learning and achievement.

Tharp and Gallimore (1988) discuss learning as a four-stage model that involves progress through the learner's ZPD and returns recursively to the first stage with each new concept learned. Stage I occurs firmly within the learner's ZPD, with assistance being provided by more experienced others, often through directions and modeling. In Stage II, learners begin to help themselves and the expert scaffolding recedes. At the end of Stage II learners have succeeded in the task at hand and thus have passed through the ZPD; learners then engage in a process of internalization (Stage III) and, finally, deautomatization of performance (Stage IV), which leads back recursively to Stage I. This model demonstrates the dynamic nature of learning and the ZPD.

Assisting students within their ZPD is a personalized process. The ZPD is not determined by age or grade level, which is how schools normally approach instruction; learners will have different individual needs. A task that is too difficult and requires scaffolding for one third-grade student may be completed without any assistance by a peer. Individual learners have been found to have different scaffolding needs as well (Roehler & Cantlon, 1997); for example, students with a narrower ZPD may need more frequent and detailed assistance (Day & Cordon, 1993). This reliance on individualization can prove challenging for teachers who have many children in a class, each with different needs.

31.2.2.2 Intersubjectivity. Scaffolding requires shared understanding among participants in the learning situation. Vygotsky (1977) stated that the processes of knowing and understanding are connected to one's sociohistorical experience; knowledge is shaped by the individual's culture and background. Teachers and learners come to the learning situation with their own understandings and must find a shared meaning to succeed in the learning activity. This shared understanding, called intersubjectivity, is constantly negotiated in our everyday lives, helping in the process of "bridging between the known and the new in communication" (Rogoff, 1990, p. 72). In Tharp and Gallimore's (1988) four-stage model of progression through the ZPD, intersubjectivity is focused in Stage I. The learner and the assister may not similarly conceive the learning goal and the negotiation will take place at the beginning of this stage.

Matusov (2001), in a review of research on intersubjectivity, notes that having a shared goal is a critical component of the teaching–learning situation. When intersubjectivity is lacking, it can be evident in the form of learning conflict, nonparticipation, or unexpected outcomes. An example of conflict is a situation in which the learner does not know how to complete a desired task and perceives the scaffolding assistance as irrelevant to his or her goal. At this point a negotiation of meaning may take place. Failing that, it is likely that the learner will not complete the task as expected or will follow the assistance that is given but fail to learn because he or she does not understand the purpose of the scaffolded activity.

31.2.2.3 Fading. Fading of scaffolding occurs as the learner gains independence and no longer needs support to complete the desired task. Returning to the construction metaphor, Greenfield (1999) points out that scaffolding would not be used when workers are just a few feet from the ground. To move the learner toward self-sufficiency there must initially be an external (adult) regulation of the learning activity, followed by the learner's (child's) redefinition of the activity, followed by a shifting of responsibility (Diaz, Neal, & Amaya-Williams, 1990). When this shift occurs—in the transition from Stage I to Stage II (per Tharp & Gallimore, 1988)—the assister's lessening of assistance is referred to as fading. Fading is not an abrupt process; it is evidenced by hints and feedback that gradually become less frequent and less detailed (Collins et al., 1989).

How does fading work? Reciprocal teaching (A. L. Brown & Palincsar, 1989; Palincsar & Brown, 1984; Palincsar, Brown, & Campione, 1993; Rosenshine & Meister, 1994) is a method of scaffolding for teaching reading comprehension that provides a clear example of how fading would occur. There are four sequential guided learning strategies that are part of reciprocal teaching; after reading a text, a cooperative learning group gathers with an adult leader and engages in

1. questioning, in which a content-oriented question is asked, opening the dialogue;
2. summarizing, in which the gist of the test is summarized and the group can work toward consensus;
3. clarifying, in which any misunderstandings or disagreements in meaning are addressed; and
4. predicting, in which likely future text content is discussed.

Throughout this process the teacher scaffolds their learning by rephrasing or elaborating on statements and asking questions (Rosenshine & Meister, 1994). As scaffolding is removed, students take greater responsibility over facilitating the reciprocal teaching process, which requires them to be primary instigators in the construction of knowledge; as the teacher ceases to scaffold and hands over responsibility to the learners, fading is taking place.

31.2.3 Modeling Defined

Modeling, a form of demonstration followed by imitation, frequently is used as a way of helping the learner progress through the ZPD (Tharp & Gallimore, 1988). The work of Bandura (1977) showed that modeling is a more efficient way of learning than trial and error. Jonassen (1999) discusses two types of modeling, behavioral and cognitive modeling. The former is one most people are familiar with, as it is arguably the easiest way to teach a psychomotor skill and involves imitation of the demonstrated act. Cognitive modeling, however, is more complex (Tharp & Gallimore, 1988). For example, a teacher might model a decision-making process by talking aloud about the considerations taken and explaining the rationale for the end result. The learner in this case would not be engaged in direct imitation but, rather, use of similar strategies in a related context. Per Tharp and Gallimore (1988), the concept of imitation as mimicry is too simple to be considered modeling. During the learning process, modeled activities are coded through the use of labels or imagery. Using a psychomotor example, dancers often use their hands to mark the presence of particular moves in a choreographed piece as they watch it being demonstrated; these smaller motions help them remember the modeled moves when it is their turn to practice.

Learners may observe the target action (behavioral modeling) or reasoning (cognitive modeling) as presented by an expert or more experienced peer. In fact, peer modeling is an activity in which learners tend to engage even without instructor design or direction, manifest through learners observing and following the strategies used by others who are working on similar tasks nearby (King, 1999). This form of modeling, unintentionally offered, has a major impact on socialization and enculturation of children and adults in new environments (Gallimore & Tharp, 1990). The impact of modeling is strongest when it is an explicit process. Individuals who engage in a process of expert observation, reflection, and practice being more likely to be able to apply the learned knowledge in a different setting than those who receive a passive model (Cooper, 1999).

31.2.4 Mentoring and Coaching Defined

A mentor, by its most basic definition, is one who mediates expert knowledge for novices, helping that which is tacit become more explicit. The two most common uses of the word *mentoring* are to describe (a) a professional development relationship in which a more experienced participant assists a less experienced one in developing a career and (b) a guiding relationship between an adult and a youth focused on helping the youth realize his or her potential and perhaps overcome some barriers or challenges. In both cases it is the mentor who provides advice and support and may serve as a role model. Whereas these examples generally imply long-term relationships, mentoring can be used as an instructional strategy on a smaller scale.

In a phenomenological review of the mentoring literature, Roberts (2000, p. 151) notes that there are eight "attributes" of mentoring that commonly appear.

1. A process form
2. An active relationship
3. A helping process
4. A teaching-learning process
5. Reflective practice
6. A career and personal development process
7. A formalized process
8. A role constructed by or for a mentor

Certainly notions of helping, teaching and learning, and reflection all seem central to mentoring, which is a process that involves relationships. Not mentioned directly, but implied, is the concept of expertise. Mentors are expected to provide expert knowledge to protégés, which involves that they both have said expertise and know how to effectively share it with others (Little, 1990). Mentors may use strategies such as verbal descriptions and diagrams to help concretize or reveal expert knowledge such as why things are done in a certain way and the relationship between parts. However, mentors should not take an overly directive role with mentees; instead they should use strategies like questioning to help mentees articulate their understanding, a process that supports the development of intersubjectivity as well as assessment of progress (Billet, 1994).

Enerson (2001) points out that teacher-centered terms like *sage, actor,* and *pedagogue* have long been used as metaphors for the teacher's role and suggests that *mentor* more appropriately puts the focus on the learner. Essentially, the teaching-learning situation changes from being about teacher performance to being about learner needs. One may act without an audience, but it is not possible to mentor without a mentee. One might evaluate an actor's performance without regard for the audience's reaction, but a mentor cannot effectively be evaluated without consideration of the mentee.

For most people, the term *coach* initially brings to mind sports. Coaching also is commonly heard in reference to technology (people who provide just-in-time, task-based assistance) and business settings (people who are hired to provide guidance on a particular task at the individual or organizational level). Collins et al. (1989) quite simply describe coaching as assistance from a master. In many ways a coach and a mentor do the same thing, and in practice the terms often are used interchangeably, so how do we differentiate them? Parsloe and Wray (2000), who discuss practical applications of coaching and mentoring in the learning process, distinguish coaching from mentoring by suggesting that a mentor is one who provides support of a more general nature in an ongoing capacity and a coach is typically focused on assistance for meeting a particular goal. By this definition, within the context of career development a mentor would help guide the career choices and workplace skills of the mentee, while a coach would be involved in more concrete, goal-oriented tasks such as getting a new job or promotion.

Burton, Brown, and Fischer (1999, p. 149) state that there are four goals for a coach to accomplish:

1. ensure that appropriate subskills are acquired,
2. design appropriate exercises and supply the required technology,
3. demonstrate the student's performance in the interest of highlighting problems, and
4. provide clear explanation and instruction.

Additionally, a coach maintains focus on the goal, determining when learner exploration is fruitless and when a learner is ready to move onward.

Still others rely on a more modest definition of *coach,* considering it a scaffold and believing that coaching is the process of helping a student work through an activity (Guzdial, 1995; Jarvela, 1995). The difference here seems to be in designating coaching as technique—one of many strategies an expert might use to assist someone who is more novice—from coaching as career.

31.3 TYPES OF COGNITIVE APPRENTICESHIP RESEARCH

A constant across research in cognitive apprenticeship is consideration of learning environment and context; in other words, it is an awareness of the situated nature of learning. Roth (2001) suggests that in any instance of educational research an observation must be considered as a result of the interaction of three factors: the activity, the individual, and the community. These elements are interrelated and continuously changing and affecting each other and, thus, the learning that results.

Research interests in cognitive apprenticeship grew throughout the late 1980s and early 1990s, with studies largely focused on children's learning processes (e.g., Palincsar & Brown, 1984; Palincsar et al., 1993; Rogoff, 1990; Rogoff, Mosier, Mistry, & Goncu, 1993). This growth pattern is no surprise, as the roots of the field grew out of renewed interest in Vygotsky's (1977, 1978) work on the social nature of cognitive development in children that came about as part of the constructivist movement. Bonk and Kim (1998), in a review of research, found little research looking at sociocultural theory as it relates to adult learning in formal settings; instead the focus tends to be on K–12 environments. They suggest that more research is needed to determine if adult learners benefit from the same forms of scaffolding as children; if there are differences in needs among young, middle, and adult learners; and how to determine the ZPD in adult learners. Such research conducted in higher education and adult learning settings has grown with advances in technology; educational researches have seized the challenge of determining how technology can help offer learning experiences that use cognitive apprenticeship strategies that are simultaneously more effective than traditional instruction and more efficient than non-computer-based methods.

Research on cognitive apprenticeship has taken various approaches. For organizational purposes, I have divided them into three groups that are representative of the kinds of research that has been done in the last 20 years.

1. **In situ *research.*** This type of research seeks to capture elements of cognitive apprenticeship for the purpose of documenting a learning experience and guiding further work, both in theory and in practice. These studies do not have designed interventions or experimental groups and favor a case study methodology. Also included in this category are evaluations—both formative and summative—of mentoring programs.
2. ***Designed interventions and experimental studies.*** This group includes experimental studies and studies of prescriptive instructional designs. In addition, to determine whether particular interventions are effective, some studies have sought to find out how cognitive apprenticeship-based classroom experiences compare to more traditional ones.
3. ***Research on technology*** and how it might support cognitive apprenticeship. This category of research includes studies of technology used as a teaching enhancement, with participants collocated in a live setting; as a teaching medium, with participants potentially located in different settings and communicating through the computer; and as a teacher, in which learners receive support from the computer.

Each category of cognitive apprenticeship research is discussed separately, although the technology studies certainly do overlap with the other two categories.

31.4 IN SITU STUDIES

In situ studies of cognitive apprenticeship can be important to our understanding of how students best learn. Lave and Wenger (1991) suggest that the analysis of legitimate peripheral participation may uncover aspects of the learning experience that have previously been overlooked. The research done in this area is responsible for the initial theories of cognitive apprenticeship. It has served to develop knowledge bases of expert performance and preliminary recommendations of what methods are likely to work under particular conditions and in particular settings.

31.4.1 Cognitive Apprenticeship in Everyday Practice

In a study of a community of writers at an urban nonprofit organization, Beaufort (2000) explored the roles the writers played and how new writers were integrated into the community following an apprenticeship model. Fifteen roles were observed in this example, ranging from observer, reader/researcher, and clerical assistant on the novice end up to author, inventor, and coach on the expert end. New or less experienced writers learned the process through taking on roles such as the clerical assistant (a role reserved for new members), which allowed for extended observation of the expert writers at work. New employees gained both experience and responsibility as time passed through this model, which exhibited Lave and Wenger's (1991) legitimate peripheral participation. Although the act of learning was not formalized or labeled by participants, and much learning occurred through observation, more experienced employees would serve as mentors and illuminate the tacit components of the writing process as needed. This model of learning worked for most participants, but one employee did not succeed and was let go. The results suggest that learning writing through a social process with authentic tasks is effective, and the researcher states that a similar model may be useful in school settings, where writing has traditionally been an individual, general skills learning activity.

Similar to analysis of legitimate peripheral participation, analysis of expert performance can be used to help determine ways in which novice performance may be supported. For example, the process of *in situ* knowledge construction by a competitive table tennis player was documented through the player's reflective commentary on watching a videotape of a recent match (Sève, Saury, Thereau, & Durand, 2002). The player was able to articulate the underlying thought behind his actions during the game, demonstrating points at which he was learning about his opponent's game and strategies and integrating that knowledge with his knowledge about the game in general as well as his past experiences competing against this opponent. The knowledge generated by this study—and in-depth exploration of situated actions—can be used to build a model of expert actions within table tennis. Such models are useful for teachers and coaches to draw on and use to support their students.

31.4.2 *In Situ* Studies of Scaffolding

Focusing more directly on techniques used in a formal learning situation, Roehler and Cantlon (1997) examined the use of scaffolds in two social constructivist classrooms, exploring the types and characteristics of scaffolding in learning conversations taking place during elementary-school language instruction. Two constructivist classrooms were observed in this study, including an English as a second language (ESL) class. An analysis of lesson transcripts from the ESL classroom resulted in five types of scaffolding that were commonly used.

1. Offering explanation
2. Inviting student participation
3. Verifying and clarifying student understanding
4. Modeling desired behaviors
5. Inviting students to contribute clues

Over time, students took more responsibility for learning in this environment and the amount of scaffolding used by the instructor lessened.

Savery (1998) noted that instructors in a business writing course made use of all six of Gallimore and Tharp's (1990) forms of scaffolded assistance (instructing, questioning, modeling, feeding back, cognitive structuring, and contingency management), although each occurred in different amounts based on student need. Instructing, questioning, modeling, and cognitive structuring were part of the teachers' interaction with the students. Feedback occurred through grades and comments on assignments. Finally, contingency management was largely unspoken, although it had been designed into the course itself that students would face repercussions for unproductive behavior. Also using Gallimore and Tharp's framework, Sugar and Bonk (1998) found, in their analysis of electronic mentoring in an adventure learning program for middle- and high-school students, that 75% of the mentors' time was spent engaged in questioning, feedback, and cognitive structuring. Contingency management and task structuring (as per Tharp, 1993) were minimally used and modeling did not occur at all. Sugar and Bonk hypothesized that had the mentors engaged in modeling there might have been more student interactions. This hypothesis is consistent with the findings of Dennen (2001), in which modeling was the most effective way to generate desired student performance across classes in an on-line forum.

31.4.3 Scaffolding, Modeling, and Reflection in the Classroom

Scaffolded learning and modeling followed by learner reflection have been suggested as a way to help learners achieve what they would not be able to do on their own and then to make sense of and to internalize the experience. As mentioned earlier, a learner working within her ZPD initially requires assistance but then takes responsibility for the task and internalizes it (Tharp & Gallimore, 1988); reflection would occur as the learner comes to understand her activities. Reflection as a learning activity has become in vogue during recent years, but best practices in scaffolding reflection still remain to be determined.

Bean and Patel Stevens (2002) looked at how scaffolding affected the reflection process for teacher education students enrolled in university-level courses. A group of preservice teachers was divided into five groups of five students each and asked to participate in a bulletin board discussion base on instructor prompts. Their instructor provided scaffolding in the form of modeling and suggesting response types. A group of inservice teachers was also studied. They were asked to keep weekly journals relating concepts from their assigned readings to their own classroom experiences. Analyzed using constant comparative and critical discourse methods, a purposive sample of work completed by each group yielded similar results. The students' written work followed the models given as a scaffold but did not extend in any substantial way beyond the scaffold. The students stated their personal beliefs related to teaching and learning and integrated reading concepts, as they had been asked and supported to do, but they did not reach the point of addressing issues related teaching and learning in the larger arena of critical discourse. Interestingly, preservice teachers avoided mention of local contexts, keeping their comments focused on their personal belief systems, whereas inservice teachers tended to discuss their localized situations at length without really commenting on institutional and societal levels. The authors conclude that whereas scaffolding had a clear effect, it did not help achieve all of the instructional goals, but they are not sure whether this is inherent in scaffolding or indicative of a scaffold that did not fully meet the learners' needs.

Parker and Hess (2001) used modeling followed by reflection to prepare student teachers for leading discussions in their classroom. They hypothesized that by experiencing a well-designed class discussion and engaging in reflection on the activity, learners would be able to adapt and use the same methods with another group of learners. Whereas the scaffolding in this instance resulted in productive in-class discussion for the learners (student teachers), it did not in turn teach them how to lead discussion themselves. Thus, modeling and reflection were effective methods of addressing course content, but simply engaging in and using the methods was not enough to prepare the learners in turn to serve as instructors using those same methods. One suggested reason for the ineffectiveness was that the class discussions that the learners engaged in were exemplars in terms of process, resulting in a seamless focus on the content being discussed, with little to no emphasis on the method itself. In other words, learners saw and succeeded in using the model of how to participate in discussion—which was what they were asked to do—but because their attention had not been called to it and they were not asked to engage in the practice of it, they did not pick up on the instructor's modeling of how to lead discussion.

Another way in which students may need scaffolding assistance is task structuring (Tharp, 1993), which may include activities such as "chunking, sequencing, detailing, reviewing, or any other means to structure the task and its components so as to fit it into the learner's zone of proximal development" (Sugar & Bonk, 1998, p. 142). Dennen (2000), in a qualitative study of students engaged in month-long computer-mediated collaborative problem-based learning scenarios, found that scaffolds in the form of chunking and sequencing helped motivate students and enabled them to focus more on the content-based learning goals than on project management elements of the assignment.

Critical to success in scaffolding is shared understanding. In a descriptive study of learner interactions in a "model culture" environment called Fifth Dimension, Kaptelinin and Cole (2001) found three phases of intersubjectivity that affect the ability to communicate productively in this social learning context. The first phase precedes intersubjectivity and involves the coordination of individuals' goals. The premise here is that the participants need to have a sense of their own goals before anything else can take place. This individually focused phase is followed by a phase in which a group identity emerges (intersubjectivity), which in turn is followed by a third and final phase in which the group experience is translated back to the individual (postintersubjectivity). As a result of this analysis, the researchers suggest that consideration be given to fostering these phases when designing instruction. Savery (1998), in the above-mentioned study of collaborative computer-based writing in a business course, also argues that the successful teams were developing intersubjectivity. In this instance it took the form of learning about each others' interests and preferences through the process of working together, which in turn helped them work more productively.

31.4.4 Scaffolding in One-on-One Learning Situations

In a qualitative study examining the effects of electronic peer mentoring in a university physical therapy class, it was found that both mentors and mentees learned through the process of reflection and articulation (Hayward et al., 2001). Protégés benefited from the mentors' stories and experiences, which made the learning more concrete and authentic, whereas mentors reinforced concepts already learned by connecting theory to practice and perhaps doing a bit of new research in order to address mentees' questions effectively. The technology, although initially considered a barrier to students who chose the field of physical therapy in part out of a desire for face-to-face interactions, did not inhibit the usefulness of the mentoring activity and these peers did engage in computer-mediated social exchanges much as one would anticipate in a face-to-face meeting.

Mentor teaching strategies were studied as well, with integrative teaching being the most popular. In this strategy, the mentor combines theory and practice in their explanation to the mentee. Hayward et al. (2001) found that most mentors provided far more information than the mentees had requested. About one-third of the mentors used a strategy called *expert push,* in which a mentor did not directly answer the mentee's question but instead returned questions that would hopefully help him find the right answer.

Peers also may serve as mentors to each other, with learners in some instances identifying on their own both their knowledge gap (given their learning goals) and peers who can help them attain their learning goals. Engaging in study groups and asking for peer assistance is a common practice in many educational settings, as students realize that their peers can often supply the learning assistance that they need. Loong (1998) studied the peer apprenticeship that developed between two students engaged in a computer-mediated mathematical task. Initially the students had different approaches and worked rather independently, with one student focused on mathematical rules and the other focused more on concepts. Over time, however, the rule-focused student noticed that the concept-focused student's expertise was needed, and he assigned himself to this peer in an apprentice role.

In a case study of teacher educators (university faculty) who received technology coaching from preservice teachers, coaching was found to be a mutually beneficial activity (Matthew, Callaway, Letendre, Kimbell-Lopez, & Stephens, 2002). The faculty learned new technology skills while the student coaches gained teaching experience. Coaching was found to be a particularly appropriate teaching and learning method for this audience because they tend to have just-in-time technology learning needs and are unlikely to engage in formal learning opportunities to learn new technology skills. Additionally, it was deemed more relevant for the teacher-educators to learn under authentic, situated conditions.

Expert tutors both teach and motivate well, as evidenced by the effects on their tutees and high scores on independent measures (Lepper, Drake, & O'Donnell-Johnson, 1997). Some of the scaffolding methods used by the expert tutors, as observed in 30- to 60-min math sessions with students who have a history of academic difficulties, included their selection of the problem to work through, problem presentation (which includes motivational elements), and encouragement of the learner to solve the problem independently, although subtle intervention or debugging strategies may be used as needed.

31.4.5 *In Situ* Practices and Effects of Mentoring Programs

Traditional programs pair up mentors and mentees, often considering personal preferences and interests in the process. Programs may have guidelines for the pairs to follow, training for the mentors, and/or points at which their progress is reported or evaluated. It is these programs that tend to be researched, as we seek to find out what types of interactions occur, which ones are effective, and how the participants perceive the usefulness of the relationship. Evaluations also tend to be conducted on funded mentoring programs to determine whether or not the funding is well spent or the program is meeting its goals. Not all mentoring occurs within a program, but studies on informal mentoring practices are less common. Many mentor–protégé pairs develop informally; not only would locating such pairs and determining how representative they are be difficult, but also identifying the participants of informal mentoring would affect the very nature of their interaction by making them consider labels and roles for their intuitive relationship. A third area of potential study is technology-mediated mentoring, which is discussed later.

The results of a review of 10 evaluations of youth mentoring programs (Jekielek, Moore, Hair, & Scarupa, 2002) found that their impacts fell into multiple areas, including academic achievement (in terms of attendance, attitudes, and continuing education, although not necessarily grades), health and safety (in terms of preventing and reducing negative behaviors), and social and emotional development. Productive mentoring practices were found to be structure, regular meetings, mentor training and preparation, and a focus on the mentees' needs rather than the mentors' expectations.

Lucas .(2001) studied an after-school mentoring program for sixth-grade students. Mentors were college undergraduates who were enrolled in a for-credit course. This mentoring program, called Project Mentor, was voluntary and extracurricular for the mentee participants but promised them support for academic achievement. Lucas suggests based on her research that there is true interdependence between the role of mentor and that of mentee. She found that the relationship between mentor and mentee is heavily based on individual factors including personal preferences, prior experiences, and goals and expectations; essentially, the nature of the experience transcends any traditional definition or training that may take place and is heavily shaped by the individuals who are involved in it. Lucas also found a much greater desire to engage in mentor–mentee interaction when it was focused around an activity that the mentee could not successfully complete alone. She also found that successfully collaborating on such activities generally created a closer relationship between the mentoring pair.

Langer (2001), in his study of the nature of mandatory mentoring at SUNY Empire State College (ESC), found a gap between his results and the predominant views in the theoretical literature about mentoring. Whereas the literature base tends to place a heavy emphasis on the close interpersonal relationships developed between mentors and mentees, Langer observed a process that was focused almost exclusively on goal attainment. This is not to say that faculty mentors and their students at ESC never develop close relationships but that the task focus and school-year time frame relegate the development of a social bond to a secondary status. What Langer and ESC are referring to as mentoring might better fit the definition of coaching, which is more task-focused than relationship-focused.

Billet (2000) studied the learning process of mentees in a formal workplace mentoring program over a 6-month period. This prolonged engagement allowed him to identify learning sources and strategies that were influential on the mentees' development. Mentors were trained in workshops that introduced guided learning strategies such as questioning, modeling, and coaching and helped them to identify ways that these strategies might be used in their workplace. Engagement in everyday work was found to have the greatest influence on mentee development, supporting the concept of situated cognition, and Billet suggests that the guided learning strategies were used to enhance this engagement. A specific analysis of guided learning strategies showed that the ones that were used most frequently, such as questioning, modeling, and coaching, were perceived as the most useful. Less-used strategies, such as diagrams and analogies, were less valued by the mentees; mentors reported greater challenges finding ways to draw upon and use these strategies spontaneously with their mentees.

Young and Perrewé (2000) looked at career and social support factors and their effects on participant perceptions of the success of a mentoring relationship, finding that mentors' expectations generally were met when a protégé was involved in career support behavior. Conversely, protégés tended to measure the success of their mentoring relationship in terms of the amount of social support they received. Young and Perrewé hypothesize that this difference in perception may be due to the mentors' established status, which may have them focused on successes directly related to the mentoring goal (career enhancement), whereas their more novice protégés may not yet be able to predict the impact of particular career-related behaviors but will look for encouragement and friendship as indicators that they are performing as expected.

Although none of the results presented in this section are generalizable, given the methodologies used, they are nonetheless quite valuable to the field. They confirm theoretical principles and strategies and represent what is possible in everyday educational settings with regular teachers and students.

31.5 DESIGNED INTERVENTIONS AND EXPERIMENTAL STUDIES

An organized program of experimental studies is much needed at this point in the development of cognitive apprenticeship theory and practice. The various theories of how cognitive apprenticeship works and the results from *in situ* research both need to be studied with rigor in the interest of attaining generalizability. Small pockets of experimental studies have been conducted to date, but many of these studies occur in isolation rather than in a related series.

31.5.1 Effectiveness of Cognitive Apprenticeship

To gain support for a paradigm shift regarding methods of learning and instruction, it is necessary to demonstrate the effectiveness of cognitive apprenticeship. Hendricks (2001) conducted an experimental study to determine whether situated instruction was more likely to result in transferable knowledge than traditional instruction. The content area was causality, with a learning goal focused on students being able to determine whether or not a cause–effect relationship was present in particular research studies. The control group received "abstract instruction" in the form of a lecture and practice activity, whereas the treatment group's "situated instruction" followed the instructional model set forth by J. S. Brown et al. (1989), beginning with discussion, then modeling, and, finally, coaching and scaffolding to assist the learners in applying the knowledge. Scaffolding was faded and control ceded to individual students as they demonstrated the ability to identify causality, and, finally, students were asked to reflect aloud, articulating what they had learned. The results demonstrated that students in the treatment group outperformed the control group on a posttest administered at the end of the instruction, but there was no significant difference in performance on a far-transfer task 2 weeks later. However, the results still show that the differences in instruction had some effect. Whereas only two students successfully completed the transfer task, both had been in the treatment group and both indicated that they had already applied the learned information at home. Additionally, students in the situated group had a more favorable reaction to the instruction than those who received the lecture and practice intervention. Hendricks suggests that although these results counter claims that situated learning is more likely to result in knowledge that is transferable to real life, they may simply be indicative of how challenging it is to produce far transfer given any kind of instruction and may be affected by the use of a fabricated situation to measure transfer.

The use of expert concept map structures as a form of scaffolding has been demonstrated to be effective. Chang, Sung, and Chen (2001) studied the impact of three variations of a concept mapping activity on student learning in a biology class. In one treatment, called "construct by self," students had access to a computer-based concept mapping tool that had hints built into the system; the hints compared the learner's concept map with that of an expert. In the other treatment, called "construct on scaffold," students were given a blank outline of an expert's concept map to fill in using the same computer-based tool. The control group was asked to create a pencil-and-paper concept map with no form of assistance. Results of a posttest showed that there was no significant difference in terms of performance of the students in the control group and the construct-by-self treatment group. The construct-on-scaffold treatment group, however, had a higher level of mastery. A postsurvey of student impressions of concept mapping showed that students using the computer-based tool in either treatment group preferred concept mapping as a learning activity much more than those using pencil and paper in the control group. The researchers theorize that the students in the construct-on-scaffold group learned more because the expert's outline helped reduce their cognitive load while keeping them focused on the material that was relevant to learning biology.

Coltman, Petyaeva, and Anghileri (2002) conducted a study of the impact of adult support in a discovery learning process for young children. In the study, children were given building blocks and were asked to complete abstract tasks related to three-dimensional shapes, such as recognizing size and shape equivalence in different formations of building blocks. All subjects were pretested to ensure novice status in this area. Learners in the control group were to complete the tasks unaided; those in the treatment group were offered graded levels of support. There were four support levels, starting with contextualization of the task, followed by guided reflection, modeling, and, finally, direct demonstration. In practice, the second level (reflection) was sufficient scaffolding for 28% of the students in the study, and the remaining 72% performed the task correctly when modeling was offered; the fourth available support, demonstration, was not used with any subject. A posttest 3 days after the task intervention was used to measure learning gains. Children in the treatment group outperformed those in the control group, with respective posttest task completion rates of 90.7% and 33.3%, respectively. This study suggests that discovery alone is not sufficient to ensure that learning will take place and demonstrates the value of scaffolding—particularly in the form of modeling—in the learning process of children.

In a study of mathematics learning in peer groups, Webb, Troper, and Fall (1995) found that the level of help students received (ranging from none to receiving just the right answer to various levels of explanation of the concepts) is a predictor of student engagement in constructive activity, which in turn is a predictor of student achievement. Students who received no help or who were told the right answer tended to avoid engagement with the learning exercise, whereas those who received explanations engaged in activities like reworking a problem. Essentially, these results support using level-appropriate explanations to scaffold mathematics instruction, as they foster a learning climate that may lead to greater student achievement. Similarly, King (1994) found that when students are guided by both lesson-based questions and questions that cue and connect prior knowledge with the present lesson, they perform better than students who have only the lesson-based questions. These results suggest that providing students with help oriented toward making connections with material and conceptual support rather than answers is a useful form of scaffolding.

31.5.1.1 Research on Intersubjectivity. Mutual understanding is a key part of being able to communicate clearly and to ensure that learning goals have been met, but exactly how this understanding is developed remains somewhat of a puzzle. Illustrating this challenge is a study conducted by Hallam and Hazel (1998) in which postgraduate students with similar backgrounds were paired. Each person individually read a text and then discussed it with his or her partner. The results showed that the individuals were likely to have differences in understanding and interpretation of the passages read, particularly in parts that were connected to areas in which they had prior knowledge or experience, although the participants generally expected their partners to have a common understanding. Given the frequency with which students are asked to read passages and then participate in class discussions, the lack of mutually agreed-on interpretations of readings is particularly problematic.

Jarvela (1995) studied the relevance of social interactions between students and teachers based on a cognitive apprenticeship model used in a technologically rich environment. Jarvela was interested in the key parts of shared cognition in learning interactions and in how much the expert should be controlling the interaction. Specifically, Jarvela studied the work of seventh-grade boys using a Legologo environment to determine if modeling, scaffolding, and reflection fostered appropriate task involvement; whether cognitive apprenticeship fostered worthwhile social interactions for teachers and learners; and how the technology affected the learning interactions. Findings indicated that a reciprocal understanding of the task at hand was important; if teacher and student did not conceive of the task similarly, scaffolding and modeling might fail. Learners who did not share their teachers' understanding tended to be frustrated when modeling occurred and when reflection was required; indeed, it was found that teacher modeling did not create reciprocal understanding. In this study, the technology was found to be of assistance to the learning process because it fostered reflection activities and thus made students' thought processes more visible to the teacher.

As shown through the studies by Jarvela (1995) and Hallam and Hazel (1998), much remains to be known about how intersubjectivity can be efficiently developed in a classroom environment with multiple participants. Although the consequences of our failure to do so seem to highlight its importance very effectively, and we have been able to document when it does and does not occur, we do not yet know how to develop and support intersubjectivity efficiently among participants in a learning situation.

31.5.2 Studies of Reciprocal Teaching

Reciprocal teaching, described earlier, is one of the first-studied methods of scaffolded instruction, and research has looked at the method itself as well as a variation that involves direct instruction on the method followed by a reciprocal teaching episode. Studies of reciprocal teaching have proven it to be a successful technique for improving reading comprehension (A. L. Brown & Palincsar, 1989; Palincsar & Brown, 1984; Palincsar et al., 1993; Rosenshine & Meister, 1994). For example, results from Greenway's (2002) quasi-experimental study, albeit limited by the lack of a control group, indicated that students' reading comprehension scores and self-confidence both improved due to the reciprocal teaching intervention. Another study of reciprocal teaching (Brand-Gruwel, Aarnoutse, & Van Den Bos, 1998) looked at its effects on students with both reading comprehension and decoding problems (as opposed to students with only comprehension problems, as studied by Palincsar and Brown, 1984). Participants came from both regular and special schools. The study provided instruction and practice on the four reciprocal teaching strategies—questioning, summarizing, clarifying, and predicting—in alternating reading and listening activities. Student skills were measured using a pretest, a posttest, and a retention test. Results indicated a clear effect on student performance shortly following the intervention, but long-term performance differences between the control and the treatment group were not statistically significant. Also, there were no significant differences in performance related to school type (regular or special).

Related to reciprocal teaching, particularly the concept of shifting responsibility for process from teacher to learner, Chou, Lin, and Chan (2002) created a computer-based reciprocal tutoring system (RTS) that contains a virtual tutor and tutee. This tutor is programmed to trace a human tutee's actions and to scaffold his or her learning process through timely guidance. When the roles are reversed, with the human playing tutor and the RTS playing tutee, the human learner will observe the computer attempt to solve a problem (programmed to have difficulties) and will be required to diagnose any problems that arise. The human tutor's actions are monitored by the system and feedback is provided in the instance of an incorrect diagnosis.

31.6 TECHNOLOGY STUDIES

Up to this point, cognitive apprenticeship has been discussed as an activity engaged in by human participants, which is appropriate given the dynamic nature of the ZPD. However, computer use in conjunction with scaffolding, mentoring, and coaching of various kinds is being explored. In some instances the computer is being used as a medium through which scaffolding is provided; I refer to this as *computer-mediated* cognitive apprenticeship. Finally, there are researchers and developers who believe in the promise of what is called "software-realized scaffolding" (Guzdial, 1995; Shabo, Guzdial, & Stasko, 1997), in which the ability to scaffold is built into a software program and enacted by the computer in response to a user's actions; I refer to this as *computer-based* cognitive apprenticeship.

31.6.1 Computer-Mediated Cognitive Apprenticeship

Interest in computer-mediated cognitive apprenticeship has grown with the Web-based education trend of the last decade. As learning experiences move to an on-line environment, educators and researchers have sought to determine what constitutes worthwhile computer-mediated interactions between teachers and learners. Learner-centered strategies, including mentoring and scaffolding collaboration, have been hailed as the solution (Bonk & Dennen, 1999), moving away from information transmission models of learning, which tend to result in static content and flat interactions in an on-line environment. Oliver and Herrington (2000) state that coaching and scaffolding are essential to achieve deep levels of asynchronous discussion. McLoughlin (2002) theorizes about how scaffolding might be used in distance learning situations, noting that in such settings "the metaphor of scaffolding is appealing in principle, yet elusive and problematic." Why is scaffolding in an on-line environment so challenging? In part because it brings into question whether or not traditional roles of teacher and learner will be relied on.

McLoughlin suggests a variety of technology interventions that rely on scaffolding, including computer-supported intentional learning environments (CSILEs), which are collaborative learning spaces in which the teacher is a facilitator and the student is tasked with communicating and creating knowledge objects (e.g., Scardamalia & Bereiter, 1994); intelligent tutoring systems (ITSs), which help break down and manage specific tasks; and goal-based scenarios (GBSs), which engage students in authentic tasks and provide computer-based resources and scaffolding in the form of task assistance and hints as needed (e.g., Schank, Berman, & McPherson, 1999). Whereas the latter two fall under the category of computer-based learning experiences, CSILE would be considered a computer-mediated form of cognitive apprenticeship.

31.6.1.1 Computer-Mediated Scaffolding. Oshima and Oshima (2001) studied ways to improve learning for novices through the use of discourse scaffolding. Two groups of learners were studied in successive years, the first with a comprehension-oriented learning objective and the second with a synthesis-oriented one. The learners used the WebCSILE (Computer-Supported Intentional Learning Environment) tool to support their interactions. The second group had the addition of learning supports in the form of a schedule discussion and a page providing tips for writing ideas. These scaffolds were developed based on the feedback from the first group. Statistically, these two groups used the tool in similar ways, generating and reading about the same number of messages. A comparative analysis of the resulting discourse shows that whereas students in the first group discussed contents at the metacognitive level, those in the second group did not, and the quality of writing did not improve in the second group. This was surprising to the researchers, who surmised that this may have been because the scaffolding alone was not sufficient to promote greater knowledge advancement and, in fact, may in some ways have limited the interactions that took place. Learners in the second group used the provided scaffolding as a directive for what to do and followed its suggestions quite literally, like a task list. More extensive and tailored instructor intervention is planned for future studies.

Pear and Crone-Todd (2002) examined ways of using computers to provide feedback to students in a manner consistent with the tenets of social constructivism. The setting for this study is a college-level course, which used a teaching system called a computer-aided personalized system of instruction (CAPSI). Drawing on the concept of scaffolding, course material was arranged in manageable units. A peer-tutor model was developed in which more advanced learners provided feedback to their classmates in an open-ended question practice test environment. Although the findings of this study show that the method works to help ensure that students receive a high amount of feedback while keeping the process manageable for instructors, it neglects to comment on the impact of this intervention on the learning process for either the students who received the feedback or the peer tutors who provided it.

Guzdial and Turns (2000) recommend the use of anchors, or topics that students wish to discuss to stimulate interest and motivation. Using the Collaborative and Multimedia Interactive Learning Environment (CaMILE), a discussion tool, students identify a note type they wish to use, which essentially labels the nature of their contribution and gives them a sentence prompt. For example, if students choose a New Idea note, they may be given the prompt "I propose. . . . " In CaMILE, Web pages are linked from notes and used as anchors to begin particular discussion threads. Guzdial and Turns compared the use of CaMILE to support anchored discussion with the use of a newsgroup tool lacking its management, facilitation, and anchoring features, hypothesizing that the anchored threads would be more effective (defined as having broad participation and being on-topic) than the unanchored ones. In an initial study, which looked at participation across multiple classes, findings indicated that discussion threads in CaMILE were longer than those in the newsgroup, with low variability of length in the newsgroups but high variability in CaMILE. There was no significant difference between the two tools in terms of the number of active participants. A second study focused on discussion within a single class. Findings in this study indicated that the students who used CaMILE participated more extensively than their newsgroup counterparts and that teacher participation was greater in number of messages but far less in percentage of messages.

31.6.1.2 Computer-Mediated Mentoring. The advent of the Internet has encouraged the exploration of mentoring in environments where mentors and learners are not collocated. Bonk and his colleagues at Indiana University investigated the effects of on-line mentoring of pre-service teachers in a project called Conference on the Web (COW), which spanned multiple years and involved collaborations from faculty and preservice teachers at other schools and universities internationally (Bonk, Angeli, Malikowski, & Supplee, 2001; Bonk, Daytner, Daytner, Dennen, & Malikowski, 2001; Bonk, Hara, Dennen, Malikowski, & Supplee, 2000). Students in the COW environment were asked to post case-based reflections based on observations in their early teaching experiences and connect these observations to theory learned in their teacher preparation classes. Mentors, in the form of peers, graduate students, university faculty, and in-service teachers, provided case posters with feedback on their ideas. Postclass surveys and interviews indicated that the students valued the mentoring they received and felt that the computer-mediated forum was an appropriate outlet. Indeed, this forum allowed communication among parties who would otherwise not meet. The quality of student reflection was not as high as it might be, and further work is needed to develop better scaffolding and mentoring strategies for use in online environments.

Russell and Cohen (1997) shared their experiences and reflections as participants in a reflective colleague relationship over e-mail. This relationship was similar to what others would call mentoring or coaching, although the authors chose a different term to help indicate the peer nature of their interaction, using Schon's (1983) description of reflective practitioners as those who articulate their thoughts and experiences, reflect on them, and then discuss these reflections with critical friends. In particular, Russell and Cohen explored the impact that e-mail had as a medium, finding that the asynchronous technology provided two important advantages to this mentorlike relationship: (a) It allowed them to complete the articulation and reflection process without any interjections or distractions, and (b) it resulted in a written archive of the reflection that could be used later for further reflection. They also commented on how the process of being reflective colleagues helped them both grow, whether they were playing the role of the reflector or the role of the critical friend.

31.6.2 Computer-Based Cognitive Apprenticeship

Davis and Linn (2000) and Davis (2003) studied the use of prompts to scaffold the reflection process for middle-school science students working within a computer-based system called Knowledge Integration Environment (KIE) developed by Bell, Davis, and Linn (1995). This system supports the scientific process by prompting students through related activities, such as identifying the needed evidence to support claims and determining whether presented evidence is adequate.

Davis and Linn found in two related studies that reflective prompts in KIE promoted knowledge integration in students working on science projects. Students in Study 1 were assigned to two conditions, those receiving activity prompts and those receiving both activity prompts and reflective self-monitoring prompts. In Study 2, three conditions were used: (a) belief prompts, which were unlikely to impact work on the project (control group); (b) activity prompts; and (c) self-monitoring prompts. They found that the self-monitoring prompts, which encouraged and scaffolded reflective behavior, had the greatest impact on knowledge integration as evidenced by performance on student projects. Davis and Linn suggest that the reflective articulation that is involved in responding to self-monitoring prompts helps students better self-assess their understanding and thus engages them in knowledge integration.

In Davis' 2003 study, students working in pairs received either generic prompts, basically asking students to share their thoughts at that point in the activity, or directed prompts. Directed prompts took one of three forms: Thinking Ahead prompts, which pushed learners to think about task structuring and information needs; Checking Our Understanding prompts, which asked learners to identify current knowledge gaps; and Thinking Back prompts, which asked learners to think about what they might do differently next time. She found that the learners who receive the generic prompts were more likely to develop a coherent understanding of the overall project in which they were participating than those who received the more heavily scaffolded or controlled direct prompts. Learner autonomy was also a factor, with autonomous learners demonstrating the greatest comprehension benefits from the generic prompts. It is possible that the directed prompts, which were programmed into the KIE, were too limiting or narrow for these learners or did not challenge them enough. It is also possible that the learners' understanding of the material was different from that expected and thus the prompts were not fully relevant to their thought processes.

This study demonstrates one of the challenges of providing computer-based scaffolding; it is difficult to meet learners' needs with respect to providing instruction within the learner's ZPD that is relevant to the learner's current understanding without human diagnosis and intervention. Whereas computers can be programmed to understand and react to different input patterns, they lack the ability to make the subtle judgments that human teachers do and to identify accurately and consistently each learner's ZPD (Ainsworth, Wood, & O'Malley, 1998).

Can computers actually respond to learner input at an appropriate level to provide cognitive support? Hague and Benest (1996) suggest that computers can provide "over-the-shoulder" guidance to students, essentially playing the role of a coach. Based on the premise that information and problems should be presented to learners in a scaffolded manner, graded by difficulty, and within the ZPD, they discuss the challenge of programming a computer-aided learning system to diagnose correctly the student's learning difficulty based on an incorrect response. Their solution is to build hot spots or hyperlinks into the material so students can access clues as needed. These clues will assist the students but will not supply them with the correct answer. Their system has not yet been tested in classrooms for practical *in situ* effectiveness but, nonetheless, is indicative of directions being explored.

Shabo et al. (1997) designed scaffolding into *Graphica,* a computer-based environment focused on graphics learning. Graphica provides scaffolds that are built into learning exercises in the form of resources (hints, descriptions of expert processes), coaching (computer-based critiques of student work that are available on demand), and articulation (a newsgroup; the one form of human–human interaction built into the program). In a formative evaluation of Graphica, they found that many students were unsure how to use its various components to support their learning processes. The practice exercises and visualization components were popular, but scaffolds such as the expert analyses and hints were not heavily used. The challenge for users of Graphica and similar programs is that they must have sufficient metacognitive development to identify their own learning needs, and their learning goals must be in-line with the goals designed into the system.

31.7 LOOKING TO THE FUTURE: RESEARCH AND PRACTICE

The most essential statement that can be made with reference to research in cognitive apprenticeship is, quite simply, "We need more." The present body of research, with exceptions in a few key areas such as reciprocal teaching, is largely scattered across personal interest areas rather than focused on a program of research that will lead to greater generalizability of results and the development of prescriptive knowledge to guide practitioners. *In situ* and experimental research studies should be designed to work together, complementing each other in the knowledge production process. Although individual studies of unique or proprietary programs and software are interesting and have some value, there is a greater need for results that clearly demonstrate (a) whether or not (and under what conditions) cognitive apprenticeship is preferable to traditional instruction and (b) how to implement and support a cognitive apprenticeship model of learning through scaffolding, mentoring, and coaching activities. All of this work needs to be done within the context of what is reasonably operational within today's standard educational contexts. Research on cognitive apprenticeship has already demonstrated its great potential as a method of facilitating learning; now we need to determine whether it is suitable, practical, and efficient as well.

There are some definite challenges to implementing cognitive apprenticeship methods on a grand scale in K–12 education given the reality of today's classrooms. Large class size limits the teacher's ability to interact with and assess individual student's needs. Diverse cultural and communication styles can further inhibit teacher ability to meet many students' needs in a cognitive apprenticeship. Curricular and time pressures tend to favor the use of other, seemingly more efficient teaching methods. Dominant and required methods of assessment do not always align with and measure the learning outcomes. State-mandated learning goals may leave little room for development and negotiation of students' personal learning goals. Teachers need methods, templates, and tools to help simplify and support the process as well as the backing of other stakeholders such as administrators and parents.

Hogan and Pressley (1997) suggest that whole-class scaffolding is possible though reaction to and elaboration on student comments in a class discussion. The teacher can use discussion as a way of prompting student thinking, focusing the direction of the discussion. Such strategies involve requesting explanation, elaboration, clarification, and extension of student contributions. A range of instructional goals and philosophies can be addressed through this method, which balances student-centeredness with subject-centeredness. Conceptually, this idea sounds good. However, what remains is to prove the practical soundness of this idea and generate empirical-based prescriptions for putting it into practice.

In higher education, the focus of cognitive apprenticeships likely will continue in the same vein as for the last 5 years, with mentoring programs (both live and on-line), scaffolded on-line discussion and reflection activities, and computer-based tools to support self-study. Research in on-line learning in general has been robust, including the study of closely related learning methods such as problem-based learning. Technology seems to hold great promise and interest as both a mediator of and a provider of scaffolding, modeling, mentoring, and coaching. Whereas proprietary programs are essential to furthering knowledge and capabilities in this area, the next steps in research should focus on developing and researching techniques that will work with the commercial programs that educational institutions have already invested in rather heavily, in terms of both adoption and training.

In closing, although the historical roots of cognitive apprenticeship in education are clear, the future is not. It seems likely that corporate and continuing education will continue to use methods of cognitive apprenticeship, which are appropriately focused on moving one's ability from novice-level to expert-level skills. It is also probable that distance learning initiatives will continue to embrace methods such as mentoring and components of scaffolding such as modeling and task structuring that have already proven to be useful in managing the learning process. However, whether cognitive apprenticeship will be widely adopted in K–12 education and on face-to-face college campuses in the current climate of high-stakes standardized testing—performance on which is likely better supported through other instructional methods—remains unknown.

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