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The Cognitive Apprenticeship Model in Educational Practice

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ABSTRACT

Cognitive apprenticeship is a process by which learners learn from a more experienced person by way of cognitive and metacognitive skills and processes. This chapter explores the elements of cognitive apprenticeship, first offering definitions and a historical context, then moving into a review of research. The research review is organized with a three-part focus: on studies that investigate a holistic approaches to educational applications of the process of cognitive apprenticeship; on studies that investigate portions of the process, such as scaffolding or mentoring; and on studies that investigate cognitive apprenticeship activities within communities of practice. Discussion about the intersection of technology and cognitive apprenticeship research is imbedded within each of the three areas of focus, reflecting the steady increase of systematically designed, computer-mediated instruction that is based in social learning theories, especially cognitive apprenticeship theories. Empirical studies have confirmed much of what theories have suggested: (1) that the cognitive apprenticeship model is an accurate description of how learning occurs, and (2) that the instructional strategies that have been extracted from these observations of everyday life can be designed into more formal learning contexts with positive effect. The chapter concludes with a call for more systematic and integrated program of studies working toward the development of guiding principles to support instructional design, teaching, and learning based on the cognitive apprenticeship model.

KEYWORDS

Apprenticeship: A process through which a more experienced person assists a less experienced one by way of demonstration, support, and examples.

Articulation: In cognitive apprenticeship, verbalizing the results of reflective acts.

Coaching: In cognitive apprenticeship, assisting and supporting learners' cognitive activities.

Cognitive apprenticeship: An apprenticeship process that utilizes cognitive and metacognitve skills and processes to guide learning.

Community of practice: A group of people bound by participation in an activity common to them all; may be formal or informal.

Exploration: In cognitive apprenticeship, forming and testing a personal hypothesis in pursuit of learning.

Modeling: In cognitive apprenticeship, demonstrating thought processes.

Reflection: In cognitive apprenticeship, self-analysis and self-assessment.

Scaffolding: Support that is provided to assist learners in reaching skill levels beyond their current abilities; essential to scaffolding is fading the support inversely to the learners' acquisition of the skill that is being supported.

Situatedness: The context or constellation of influential events and elements that govern and shape human life.

Zone of proximal development (ZPD): A term coined by Vygotsky to describe the space between a learner's current skill level and the next skill level that the learner cannot reach without assistance.

INTRODUCTION

Long before education was a field studied in universities—indeed, long before universities even existed—people were learning via apprenticeship. Most simply put, it is a process through which a more experienced person assists a less experienced one, providing support and examples, so the less experienced person gains new knowledge and skills. Apprenticeship is the process through which a parent may teach a child how to tie her shoes and the process through which a person may learn to become a chef or a tailor. In the first example, one would not expect the child to see a demonstration and be able to tie a shoe with no assistance on the first try. Similarly, it seems logical that a new chef starts out with simpler tasks, such as chopping ingredients or garnishing plates, and works his way up to preparing entire dishes and meals. Often larger skills are broken into smaller ones, and supports are provided so that tasks that are given to the apprenticing learner are within the reach of the learner's current ability level or zone of proximal development (ZPD) (Vygotsky, 1978). Also critical to apprenticeship is that tasks must be representative of authentic skills and not merely classroom-type exercises.

Apprenticeship programs have been formalized in many vocational education programs; for example, to become a journeyman electrician, one must work through various levels of apprenticeship. The educational value of apprenticeship, however, is not limited to the learning psychomotor skills or vocational trades. Apprenticeships can just as readily support cognitive and metacognitive learning processes and may appear in both formal and informal learning environments. This chapter first provides a brief description of concepts related to the cognitive apprenticeship model, followed by a description of the instructional strategies that comprise this model. Finally, it presents a summary of recent research related to the use of cognitive apprenticeship and its component instructional strategies.

COGNITIVE APPRENTICESHIP DEFINED

The concept of a cognitive apprenticeship—defined as "learning through guided experience on cognitive and metacognitive, rather than physical, skills and processes" by Collins et al. (1989, p. 456)—has its roots in social learning theories. One cannot engage in a cognitive apprenticeship alone, but rather it is dependent on expert demonstration (modeling) and guidance (coaching) in the initial phases of learning. Learners are challenged with tasks slightly more difficult than they can accomplish on their own and must rely on assistance from and collaboration with others to achieve these tasks. In other words, learners must work with more experienced others and with time move from a position of observation to one of active practice. The learning tasks in cognitive apprenticeship are holistic in nature (see Chapter 35 on whole-task models in this *Handbook*) and increase in complexity and diversity over time as the learner becomes more experienced. A major advantage of learning by cognitive apprenticeship as opposed to traditional classroom-based methods is the opportunity to see the subtle, tacit elements of expert practice that may not otherwise be explicated in a lecture or knowledge-dissemination format.

Instructional Strategies and Models Associated with Cognitive Apprenticeship

Although cognitive apprenticeships readily occur on their own, without intervention, certain instructional strategies are hallmarks of the theory and can be purposely implemented to support learning. Intentional teaching and learning through cognitive apprenticeship require making tacit processes visible to learners so they can observe and then practice them (Collins et al., 1989). The basic model consists of the following strategies:

- *Modeling*—Demonstrating the thinking process
- *Coaching*—Assisting and supporting student cognitive activities as needed (includes scaffolding)
- *Reflection*—Self-analysis and assessment
- *Articulation*—Verbalizing the results of reflection
- *Exploration*—Formation and testing of one's own hypotheses

Note that these strategies refer to the teacher's or expert's actions; the learners in cognitive apprenticeships (CAs) are engaged in acts of observation, practice, and reflection.

Collins and colleagues' (1989) model generally is considered the foundational one, but other slightly different versions have been proposed. Gallimore and Tharp (1990) identified six forms of scaffolded assistance: (1) instructing, (2) questioning, (3) modeling, (4) feeding back, (5) cognitive structuring, and (6) contingency management. Enkenberg (2001) added scaffolding and explanation as key strategies. LeGrand Brandt et al. (1993) presented a sequential model of modeling (both behavioral and cognitive), approximating, fading, self-directed learning, and generalizing. Liu (2005), who used a cognitive apprenticeship approach to support preservice education, offers instructional designers a three-phase Web-based CA model with a dynamic relationship between the initial modeling–observing phase and the second scaffolding–practice phase, which then is followed by the guiding–generalizing phase. The similarities across these models are their reliance on instructional strategies that provide learner guidance and engage learners in different types of practice until the guidance is no longer needed.

Concepts Associated with Cognitive Apprenticeship

Four key concepts commonly discussed in the cognitive apprenticeship literature are (1) situatedness, (2) legitimate peripheral participation, (3) guided participation, and (4) membership in a community of practice.

Situatedness

Situated learning is active learning that takes place via one's participation in an authentic task or setting (Lave and Wenger, 1991). Context, or situatedness, reflects the ways in which cultural, historical, and institutional factors influence the actions of our everyday lives (Brown et al., 1989; Rogoff, 1990; Wertsch, 1998). Learning that occurs within the context of application is considered more likely to result in improved practice; for example, would you prefer to receive medical treatment from someone who has classroom training only or someone who has trained on actual patients in a clinical setting? As Brown et al. (1998, p. 230) indicated, "The central issue in learning is becoming a practitioner, not learning about practice." Current educational systems, particularly universities, have been criticized for separating learning from practice, resulting in an education that does not sufficiently prepare students for job performance (Enkenberg, 2001); in other words, these systems are criticized when they lack situatedness and fail to engage learners in authentic practices with cultural tools and natural performance conditions.

Legitimate Peripheral Participation

In cognitive apprenticeship, a newcomer who primarily observes is considered a legitimate peripheral participant. In essence, this label validates observation as a learning activity. It would be unreasonable to expect a newcomer to be a full participant in an activity. One must learn not only the whole tasks to be accomplished and their assessment criteria but also the smaller tasks that comprise them. An apprentice can gain initial experience through observing a holistic process from the periphery. Once the big picture is understood, participation can shift from peripheral to active, with the learner completing smaller, component parts of the larger task while receiving iterations of feedback from someone who is more experienced. At this point, the learner is no longer a legitimate peripheral participant, but instead is inbound, beginning to identify more with insiders of the community's practice.

Guided Participation

Guided participation is the social element of cognitive apprenticeship. Often the guidance is provided tacitly, as one naturally participates in everyday life (Rogoff, 1990); there is an inherently situated component to guided participation. Guided participation, to be successful, must take place within a learner's zone of proximal development (ZPD). The ZPD, as originally defined by Vygotsky (1978), is a dynamic region that is just beyond the learner's current ability level; the ZPD of a learner gaining new skills and understanding moves with that learner's 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. Tharp and Gallimore (1988) used a four-stage model to describe the dynamic and recursive process through which learners work within their ZPDs and come to internalize knowledge, only to begin again with newly defined ZPDs. Rogoff (1990, p. 16) noted that cultural learning and development, in addition to individual cognitive development, occur as 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.

This observation again stresses the situated nature and social interconnectedness of learning through cognitive apprenticeship.

Community of Practice

Although learning organizations and institutions have sought to implement elements of cognitive apprenticeships in formal learning situations, cognitive apprenticeships often naturally occur within a community of practice (CoP). A community of practice is a group of people—either formally or informally bound—who engage in and identify themselves with a common practice. Examples of a CoP might be educators within a given school district or members of a professional organization for clarinetists. What brings these people together as a CoP are three critical elements:

- *Mutual engagement*—A shared task or interest and a resulting identity
- *Joint enterprise*—A common set of community standards and expectations
- *Shared repertoire*—A common vocabulary that differentiates the CoP from others

Wenger (1998) suggested the following trajectories as a model of how membership within a community of practice occurs:

- *Peripheral*—One who may not become an insider to the community but who nevertheless takes part in community events (e.g., parents who volunteer in the classroom)
- *Inbound*—A person who is becoming a fully participating member of the community (e.g., a student teacher or brand new teacher)
- *Insider*—A person who has become a fully participating member of a community (e.g., a teacher)
- *Boundary*—A person who is not a fully participating member of the community but who participates by bringing a different set of skills or services to the community (e.g., a technology specialist)
- *Outbound*—A person who is preparing to leave the community (e.g., a teacher who is moving to an administrative position or preparing to retire)

Although one may enter a community on one trajectory point and move to other points (e.g., inbound to insider and eventually to outbound), such a path is not mandated. Learning need not occur through the interactions of participants on different levels of the trajectory; for example, teacher professional development may occur through peer reciprocal teaching (Glazer and Hannafin, 2006). Movement through the trajectories is fluid in many contexts, although some communities may have formal levels of membership that are aligned with these labels. The utility of the labels is that they support understanding of the different ways in which people might participate in a CoP or a cognitive apprenticeship.

RESEARCH ON COGNITIVE APPRENTICESHIP

The body of research on cognitive apprenticeship has been growing steadily and in many ways overlaps with research on other constructivist learning theories and methods. For this chapter, we sought to include recent reports of empirical research on cognitive apprenticeship. Theoretical works or ones merely describing instructional projects, software, or elements of practice have not been included here. We have separated the research into studies focusing on (1) the whole CA model as enacted in instructional settings, (2) individual instructional strategies associated with CA (mentoring, scaffolding), and (3) cognitive apprenticeship within communities of practice. We note, however, that this separation is somewhat artificial given the interrelatedness of concepts and strategies. Additionally, we have limited this review to studies with a primary focus on *cognitive* apprenticeship and related strategies. Studies on trade and vocational apprenticeships were not included because they tend to focus on issues other than cognitive problem-solving skills. Similarly, studies that merely mention instructional strategies related to CA but do not focus explicitly on how those strategies relate to CA were not included. In excluding such studies, this chapter is not an exhaustive one, but it is representative of the types of research being done.

Studying the Enactment of Cognitive Apprenticeship

Studies examining cognitive apprenticeship have researched both the parts and the whole. The parts are generally understood to be the instructional phases outlined by Collins et al. (1989), whereas the whole consists of the process of these events occurring at a specific time and place with unique individuals co-constructing the series of apprenticeship moments. These studies attempt to identify the critical elements of the CA episodes across settings and with varied populations. Cognitive apprenticeship is especially appealing to designers of Web-based learning environments who are embracing a more constructivist approach to learning and instruction. Similarly, CA has begun to find a home in both K–12 education and teacher education programs, both of which have been researched contexts.

Cognitive Apprenticeship in Multimedia Environments

One dominant belief is that multimedia and Web-based environments can be programmed to support cognitive apprenticeship processes. Many such environments focus on one or two strategies related to cognitive apprenticeship and are discussed later in this chapter, but a few look at how to address the entire CA model. Wang and Bonk (2005) proposed using the CA model as the basis for constructing a groupware environment. Seel and Schenk (2003) used a CA model that sequences activities in the same order as Collins et al. (1989), with an interest in developing a multimedia-based system to support model-based learning. Their formative evaluation of five replication studies showed that CA may be effective as a guide for the design of multimedia learning environments, with scaffolding being the weakest spot. Their findings substantiated earlier studies on integrating CA and multimedia (Casey, 1996) on computer-based coaching (Lajoie and Lesgold, 1989). Generally, addressing individual learner needs in a programmed environment has proven challenging to do but promising for supporting learning; thus, researchers and developers continue to work on ways of implementing elements of cognitive apprenticeship in multimedia environments.

Cognitive Apprenticeship in Higher Education

Many of the studies of cognitive apprenticeship in higher education are focused on teacher education programs. Two studies in particular exemplify the types of research being conducted on CA in the field of teacher education: de Jager et al. (2002) and Liu (2005) each looked at CA and teacher training. In the first, participants were trained in CA and in the second participants were trained using a CA approach.

Targeting the instructional design behavior of middle grade in-service teachers, de Jager and colleagues (2002) showed that, simply put, teacher training results in a change in teacher teaching behaviors. Specifically, their study offered teachers training in a CA approach or a directed instruction approach to reading comprehension then compared their behaviors with a control group of teachers who used the established curricular approach. Both experimental groups showed a change in teaching behaviors, according to their treatment group; however, the authors concluded that changing to a CA instructional approach is no more or less difficult than changing to a direct instruction approach. Because both approaches were founded in constructivist theory, the authors further concluded that their study shows that it is possible to "translate new theoretical insights in learning and instruction into regular school practices" (de Jager et al., 2002, p. 841).

Cognitive apprenticeship environments also may be used to help train preservice teachers. Liu (2005) studied the effects of a Web-based CA learning environment in preservice teaching education. Compared with a traditional classroom approach, the Web-based CA approach resulted in better performance and attitudes toward instructional planning.

Others have looked at using the CA model in fields such as instructional technology (Darabi, 2005), nursing (Cope et al., 2000), chemistry (Stewart and Lagowski, 2003), and engineering. Also studied is how CA impacts higher education teaching practices in general. Hendricks (2001) conducted an experimental study to determine whether CA was more likely to result in transferable knowledge than traditional instruction and found that the treatment group had greater post-test gains but did not perform significantly better on a transfer activity two weeks later.

Cognitive Apprenticeship in K–12 Education

Teachers are being trained in and via CA learning environments and are conversely creating CA learning environments for their students. How do the students perceive these environments and do they benefit from them? Tsai (2005) developed and validated a questionnaire that was then used to determine student attitudes toward a computer-based science instruction; one of the scales asked about cognitive apprenticeship. Among other things, students who took the survey indicated that they preferred learning environments that connected concepts and reality. Considering student epistemological beliefs and learning preferences, Tsai pointed out, can be a useful and fundamental step when designing an instructional environment for a specific group of learners. Teong (2003) did not use information about learners' preferences in the intervention for his study; instead, the study examined the effect of metacognitive training using a word-problem-solving strategy, CRIME, on the experimental group's work with a CA-based instructional software, WordMath. The experimental group, which received metacognitive training, outperformed the other students in word-problem-solving skills in terms of both timing and quality of decisions.

RESEARCH ON MENTORING

The word *mentoring* often brings to mind formal programs in which a more experienced practitioner is paired with a less experienced one to provide guidance in a new career or environment. Mentoring programs and tips on how to create and engage in them are fairly common, with published empirical reviews of them being much less common. The study of such programs and their effectiveness may well occur more often than is published, via internal or informal evaluations. Additionally, studies have been conducted to examine different mentoring practices or strategies as well as the use of technologies to support mentoring.

Formal Mentoring Programs

The results of a review of ten evaluations of youth mentoring programs (Jekielek et al., 2002) found that their impact was felt in 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, and mentee participants were volunteers who were promised support for academic achievement. Lucas 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.

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. Although the literature base tends to place a heavy emphasis on the close interpersonal relationships developed between mentors and mentees, Langer in contrast observed a process that was almost exclusively focused on goal attainment. 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 six-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 in which 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. Questioning, modeling, and coaching were perceived as most useful. Less used strategies, such as diagrams and analogies, were less valued.

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 (mentee) 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 hypothesized 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), while 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.

Bonnett et al. (2006) studied 20 mentor–protégé pairings of research scientists and university-level biology students who used an electronic mentoring program. The more effective pairs were found to have been more prolific and structured in their posting and to have focused more on topics than relationship management issues.

Hudson et al. (2005) created and validated an instrument based on the literature in primary science teaching by selecting five factors that seemed related to mentoring effectiveness (personal attributes, system requirements, pedagogical knowledge, modeling, and feedback). This instrument, called Mentoring for Effective Primary Science Teaching (MEPST), is intended to assess mentee perceptions of their mentors for their intern or practicum experiences.

The Internet has encouraged the exploration of mentoring in environments where mentors and learners are not colocated. A series of studies investigated the effects of online mentoring of preservice 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 et al., 2000, 2001a,b). Post-class surveys and interviews indicated that the students valued the mentoring they received and felt that the computer-mediated forum was an appropriate outlet. 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.

Mentoring Strategies

Integrative teaching is one mentor strategy that may be used. 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. A common strategy, used by one third of the mentors, was *expert push*, in which a mentor did not directly answer the mentee's question but instead returned questions intended to help the mentee find the correct answer.

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). Mentees benefited from the mentors' stories and experiences which made the learning more concrete and authentic, and the mentors reinforced concepts already learned by connecting theory to practice. Also studying mentoring in a university setting, Beck (2004) found that linking a writing course to an engineering department's course could help students better learn how to write lab reports. In this instance, the writing instructor provided mentorship that carried over to the engineering curriculum.

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.

Pear and Crone-Todd (2002) examined ways of using computers to provide feedback to college-level students in a manner consistent with the tenets of social constructivism in a course that used a teaching system referred to as 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 on 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.

RESEARCH ON SCAFFOLDING

Research on scaffolding has focused on how much is needed, what type is needed, and how to best provide it to both individuals and groups. The term *scaffold* appears in many studies, but it is not always well applied. Pea (2004) argued that the term has become a bit overused, to the point where it has lost its true meaning and significance. He traces the term back to its origins, first published in an article by Wood et al. (1976), which rather tightly tied it back to the concept of zone of proximal development. A scaffold was intended to be a tool to help children do something they could not do without assistance. Within this concept is the notion that the scaffold, when no longer needed (the ZPD has shifted with learning), could be faded. Pea (2004) rightly noted that in much of the published research we have shifted from discussing *scaffold with fading* to a different interpretation: *scaffold for performance*. In particular, Pea raised the issue that many so-called software-based scaffolds really are intended as performance supports that may never be removed from the learner; however, it is possible that some of the so-called scaffold-for-performance studies represent situations in which fading might be possible but was outside the scope of the study.

Good descriptions of fading can be found in the literature on reciprocal teaching (Brown and Palincsar, 1989; Palincsar and Brown, 1984; Palincsar et al., 1993; Rosenshine and Meister, 1994). Fading was studied explicitly by Roehler and Cantlon (1997). They 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. Over time, students took more responsibility for learning in this environment, and the amount of scaffolding used by the instructor faded. Bean and Patel Stevens (2002) obtained somewhat contradictory results. In their study of how scaffolding affects the reflection process for teacher education students, they found that students' written work followed the models given as a scaffold but did not extend in any substantial way beyond the scaffold. The authors concluded that, although scaffolding had a clear effect, it did not help achieve all of the instructional goals; this finding may represent an inherent issue with scaffolding (particularly a scaffold for performance), or it may be indicative of a scaffold that did not fully meet the learners' needs.

Distributed Scaffolding and ZPD

A big challenge for classroom teachers is having to teach learners who all have different zones of proximal development. Within a class, the ZPD for many students may be similar, but there likely are some students whose zone is quite different. Some researchers have begun to examine how scaffolding can be flexibly designed to meet the needs of diverse students, recognizing that scaffolding should provide that extra support learners need to successfully complete a just out-of-reach task.

Savery (1998) found evidence that learners do not all need the same amount of scaffolding. He noted that instructors in a business writing course made use of all six of Gallimore and Tharp's (1990) forms of scaffolded assistance, 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. Feeding back 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.

Puntambekar and Kolodner (2005) studied students learning science by design. They used a design diary with learners as a scaffold for their design-related activities. Their findings showed that one form of scaffolding may not be sufficient to meet all learners' needs at all times, and thus recommended the concept of distributed scaffolding. The basic concept behind distributed scaffolding is that offering more support and more types of it results in a greater chance of effectively scaffolding the learning process for each student in a meaningful way.

Building on this idea that scaffolds need not be limited to one kind per instructional intervention, Tabak (2004) discussed how distributed scaffolding can be synergistic in nature; for example, students might use software programs with built-in scaffolds but also rely on just-in-time scaffolding from their instructors. The two forms of scaffolds together are a more powerful learning support than either on its own.

Teacher-Provided Scaffolding Strategies

Discourse-based scaffolding is one form of coaching that teachers tend to implicitly rely on in classroom settings as they respond to learning needs. To study discourse-based scaffolding, researchers typically examine the interactions that occur between teachers and learners and how they support the learning process on different types of projects. Teacher scaffolding may seem like a silent activity and thus not be immediately observed, but it is a constant for good teachers (Masters and Yelland, 2002). Through quiet monitoring, teachers are able to enter a group and ask questions or propose options at just the right time and withdraw such supports when they are no longer needed.

Determining student needs is a driving force for this research. Rasku-Puttonen et al. (2003) found that students need extensive scaffolding when working on long-term problem-based learning activities, as well as ample opportunity for reflection. Teacher flexibility in response to learner self-regulation also was considered important. Tabak and Baumgartner (2004) examined differences in the effectiveness of teacher modeling dependent on whether the teacher and students have a symmetric (*partnerlike*) or asymmetric (*mentorlike*) relationship. Symmetric and asymmetric relationships result in different discourse structures and impact mastery of cultural tools. They recommend a partner role for teachers helping to develop students identified as people who can work with scientific concepts. Meyer and Turner (2002) found that nonscaffolding classroom discourse (e.g., direct instruction or focus on objectives questions) is not as effective as scaffolded discourse at helping students become self-regulated math learners.

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 and Bonk, 1998, p. 142). Supporting this theory, Dennen (2000) found that scaffolds in the form of chunking and sequencing tasks helped motivate students and enabled them to focus more on the content-based learning goals than on project management elements of the assignment. Although this study looked at a one-time project and thus fading did not occur, in the context of a larger classroom effort one might fade such scaffolds during successive projects.

Scaffolding is not limited to classroom situations; early interactions with one's parents ideally provide scaffolding as a child is guided through new experiences (Rogoff, 1990). Neitzel and Stright (2003) studied how mothers scaffolded their preschool children's performance on problem-solving tasks and then measured the children's self-regulatory abilities in the kindergarten classroom. They found that more highly educated mothers were more likely to scaffold their children's work and engage children in metacognitive discourse, and in turn these behaviors resulted in children who exhibited higher rates of task persistence and behavior control in the classroom.

Software-Based Scaffolding

Software-based scaffolding has been a developing topic of interest as educational software becomes increasingly sophisticated. Reiser (2004) suggests that software-based scaffolding serves two major purposes. First, it can be used to help provide structure to the learning task, guiding them through the major stages or tasks and prompting them at appropriate times. Second, it can be used to create a problem space in which learners must explore the content. These two types of scaffolds may work harmoniously or may conflict with each other. Software-based scaffolds must be designed in consideration of various tradeoffs such as level of generality, learner control, and learner choice, with an attempt to support learners without stifling or overdirecting them.

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 of 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 inline with the goals designed into the system.

Picking up on this issue of metacognitive development, Graesser et al. (2005) designed computer-based learning environments to support inquiry and metacognition. They have been able to develop pedagogical agents that both model self-explanation and coach students in metacognitive strategies, demonstrating that the computer is a viable tool for supporting development of deeper levels of metacognitive thinking and when explanatory reasoning is involved. Land and Zembal-Saul (2003) similarly found that software-based scaffolds are a useful support to articulation and reflection processes.

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 known as the Knowledge Integration Environment (KIE), developed by Bell et al. (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 (2000) found in two related studies that reflective prompts in KIE promoted knowledge integration in students working on science projects. They suggested 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 asking students to share their thoughts at that point in the activity or directed prompts. Learners who received 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 prescripted and programmed into the KIE, were too limiting or narrow for these learners or did not challenge them enough. It will thus be interesting to see the results of recent research interests in scripting for online discourse (Choi et al., 2005; Jonassen and Remidez, 2005; Makitalo et al., 2005). Also, computers are unable to adjust to learners' unique needs in as subtle and personalized of a manner as a teacher might, making it difficult for a program to sufficiently and consistently identify each learner's zone of proximal development (Ainsworth et al., 1998). This research also indirectly supports the calls of Tabak (2004) and Puntambekar and Kolodner (2005) for the use of distributed scaffolding.

Scaffolding and Computer-Supported Collaborative Learning

Scaffolding might be provided by human interactants mediated by computers. This form of scaffolding differs from software-based supports in that a live person uses computer-based tools to assist another's performance. Learner-centered strategies are important here (Bonk and Dennen, 2007), as we move from information transmission models of learning which traditionally involve flat interactions with static content in an online environment. Scaffolding has been considered essential to the development of deep asynchronous discussion (Oliver and Herrington, 2000); however, in an online context the metaphor of scaffolding is not only appealing but also elusive and problematic (McLoughlin, 2002). Why is scaffolding in an online environment so challenging? In part because it raises the question of whether or not traditional roles of teacher and learner will be relied upon. McLoughlin suggested 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 (Scardamalia and 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 (Schank et al., 1999). Other recent studies building on the CSILE foundation have looked at how Knowledge Forum, a program that offers knowledge-building scaffolds, impacts student learning (Bereiter and Scardamalia, 2003; Lax et al., 2004; Nason and Woodruff, 2003; Oshima et al., 2003). Studies in this area often use a design-based research method (see Chapter 54 in this *Handbook*).

Oshima and Oshima (2001) studied ways to improve learning for novices through the use of discourse scaffolding; specifically, the WebCSILE tool was used to support their interactions. A comparative analysis of two groups' discourse showed that, although students with a comprehension-oriented objective discussed content at the metacognitive level, those with a synthesis-oriented one did not. Further, the quality of writing did not improve in the group that also had a page of writing tips and a schedule as additional support. The researchers felt that the support in fact may have in some ways 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.

Guzdial and Turns (2000) recommend the use of *anchors*, or topics that students wish to discuss to stimulate interest and motivation. Using a Collaborative and Multimedia Interactive Learning Environment (CaMILE), they compared anchored discussion to the use of a newsgroup tool lacking CaMILE's 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. No significant difference were observed 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 the number of messages but less in the percentage of messages.

RESEARCH ON COMMUNITY OF PRACTICE

Cognitive apprenticeships are a natural occurrence within communities of practice, and the CoP model, as pioneered by Etienne Wenger (Wenger, 1998; Wenger et al., 2002), has been promoted as a way to support professional learning during the last decade. This movement toward thinking about professions as communities of practice has very much paralleled the rethinking of organizational knowledge and development of knowledge management strategies. Of particular interest to many researchers has been the experience of new employees as they get socialized into an organization. In other words, are new employees learning and assimilating by observing the practices of their more experienced peers? This research on people on peripheral and inbound trajectories helps examine how prior learning and initial learning within an organization tend to shape one's experience and overall path within a community.

Cognitive Apprenticeship and Newcomer Adjustment

Socialization was found to be important to newcomer adjustment by Kammeyer-Mueller and Wanberg (2003). This study, situated within the organizational development discourse on proximal and distal indicators of newcomer adjustment, collected data from newcomers at seven different organizations four times during a 12-month period. In addition to socialization, both pre-entry knowledge and proactive personality were shown to be related to positive adjustment.

Also concerned with this critical point in one's membership in a community of practice, Klein et al. (2006) examined the impact of socialization experiences occurring prior to and immediately upon the hiring on 194 new employees at an educational institution. They found that two factors—realism of pre-entry knowledge and agent helpfulness—had a positive impact on job outcomes as measured through role clarity, satisfaction, and commitment to the organization.

Slaughter and Zickar (2006) found that role understanding, as indicated by the two variables of role conflict and role ambiguity, impacts how newcomers become involved in organizational activities. They concluded that the behavior of community insiders influences the attitudes of the newcomers, thus it matters with whom one interacts upon entry into a community. Their study was conducted within a university department, and they also found that graduate student activities or lack thereof in a department also may be indicative of different community alignments; in other words, some students may engage in activities that would show their commitment to their anticipated career more so than to their department, knowing that commitment to the department will not necessarily have career rewards.

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. The results suggest that learning writing through a social process with authentic tasks is effective, and the researcher stated that a similar model may be useful in school settings, where writing has traditionally been an individual, general-skills learning activity.

Research on Identity Development

Identity development—whether or not one immediately relates to a particular community of practice—also has been of interest to researchers. Identity issues were raised by Klein and colleagues (2006), as those who more readily understood the organization and were better able to identify their own role within it; however, communities of practice do not inherently transmit a sense of identity to those who are peripheral or on an inbound path. Davis (2006) found that the professional relationships one builds with others in the CoP and particularly with those in a supervisory capacity will impact trajectory and identity development among occupational therapists. Cope et al. (2000)

found that the nursing community of practice readily accepted student members into the community, but their professional acceptance was dependent on displayed competence. Thus, it seems that identity and acceptance are related, but other factors may be involved in becoming a successful practicing member of a profession.

Varelas et al. (2005) studied the relationship between identifying oneself as a scientist and as a science teacher in a population of new teachers. They found that these new teachers were identifying as scientists when engaging students in science learning activities and that they were drawing upon instructional strategies, such as mentoring, modeling, and articulation, that are part of the cognitive apprenticeship model. As time passed, these teachers identified more as science teachers and tried to create a community of scientists in their classrooms.

Research on Community Interactions

Communities of practice also are often mentioned in relation to teachers and their professional development. New teachers tend to learn much from their interactions with more experienced teachers, including how to engage in teaching-related discourse (Smith, 2005); however, Smith found that, despite learning taking place, relationships between parties on different trajectories may not always be tension-free because of different personal needs and objectives.

Distributed scaffolding (also discussed in the Scaffolding Research section) is one way of addressing the different needs of a group of learners, but one also might bring the learners together as a community with a common goal, all working jointly within a ZPD. Goos et al. (2002) looked at how a collaborative ZPD might be developed among learners working on inquiry-based projects in a math community. They coded learners' interactions as reading, understanding, analysis, exploration, planning, implementation, or verification (for examples of the coding scheme, see Artzt and Armour-Thomas, 1992; Schoenfeld, 1992), as well as by metacognitive act. Their findings indicate that the social interactions of learners working together can lead to a collaborative ZPD.

Research on communities of practice need not be limited to work or school settings. Merriam et al. (2003) studied how informal learning takes place via social interactions in a community of practicing witches. Through talking to representatives of different covens, they found that membership in these groups very much fit Wenger's (1998) community of practice trajectory and that both formal and informal situated learning was prevalent.

SUMMARY OF COGNITIVE APPRENTICESHIP RESEARCH

As can be seen in this review of theory and research on the cognitive apprenticeship model, the professional dialog spans diverse fields of study, learner groups, and settings. Empirical studies have confirmed much of what theories have suggested: (1) that the cognitive apprenticeship model is an accurate description of how learning occurs naturally as part of everyday life and social interactions, and (2) that the instructional strategies that have been extracted from these observations of everyday life can be designed into more formal learning contexts with positive effect. On the whole, however, the research is still fragmented, with bits and pieces situated in different subfields of educational research (e.g., teacher education, multimedia-based education, adult education). Although many of the studies point back to Collins et al. (1989) as a framework, few refer to each other. In part this may be due to the recency of this work and publication cycles.

FUTURE STEPS IN RESEARCH AND PRACTICE

Two areas in which future research on cognitive apprenticeships may be particularly valuable are the design of communities of practice and technology-based learning programs. The growing popularity of situated learning and the desire to create learning communities to support professional development and organizational knowledge management have spurred the intentional design of communities of practice. Questions remain about how these communities are best designed and implemented or if they even can be purposely created as opposed to naturally evolved.

The potential impact of computer technologies on cognitive apprenticeships has been explored with two main purposes in mind: using computers to provide learning support and using computers to support learning-focused discourse. In the case of the former, the challenges to researchers and developers are twofold: (1) to develop guiding principles of providing computer-supported cognitive apprenticeships that will work across proprietary software products, and (2) to develop programs that are sufficiently able to address learners' individual needs and provide appropriate supports at the right moments. In the latter example, the literature on distance learning and online discourse, although not explicitly focused on cognitive apprenticeship, may provide a good start for examining how to engage in modeling and coaching and how to encourage articulation, reflection, and exploration in computer-mediated learning environments.

Finally, as research on the cognitive apprenticeship model matures, it would be helpful to see a more systematic and integrated program of studies working toward the development of guiding principles to support instructional design, teaching, and learning based on this model.

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* Indicates a core reference.