Draft of LEARNING AS INTERACTION

Kai Hakkarainen
Department of Psychology, University of Helsinki
Kai.hakkarainen@helsinki.fi

Abstract.

The purpose of the study was to examine the role of interaction in human learning and development at multiple levels. Cognitive growth is conceptualized in terms of interaction between cognitions (current and new information, informal and formal knowledge, crystallized and fluid knowledge) within the human mind. Sociocultural theories, further, examine cognition in terms of interaction between mind and cultural knowledge objects and artifacts. Many researchers also argued that an interaction between several agents within social communities is the main mechanism of cognitive growth. Accordingly, learning is conceptualized as a process of participating in social communities rather than one of knowledge acquisition. It is concluded that cognition can neither be reduced to individual mental processes nor social practices, but takes place through dynamic interaction between these two.

Keywords: dynamic cognition, interaction, distributed cognition, sociocultural theory, peripheral participation

1. Introduction

The purpose of the present paper is to examine the role of interaction in human learning and the development of expertise. The paper addresses interactive processes important for human development at multiple levels. In this article, the concept of interaction is loosely used to refer to processes which are dialectical or reciprocal in nature so that the development cannot be explained by referring to a single source or driving force; interaction between several partially independent factors has to be taken into consideration. There are always several mutually dependent factors that jointly control human development and their specific configuration and the interaction between them appear dynamically to change their effects. The following discussion should, however, be taken only as a very tentative effort at conceptualizing the very complex issues involved.

The interactive view of human cognition does not, however, have a very strong background in history of psychology; it has been much more common to construct mechanistic or reductionist explanations of human behavior that are in accordance of unexamined everyday accounts of cognition. The traditional psychometric approach to human intelligent activity, for instance, explained human intelligent activity by relying on individual characteristics. Accordingly, individual mental abilities are assumed to be fixed and genetically determined and used to explain how well an actor succeeds in one or another task (Olson, in press). The problem is that even if these kinds of explanation may help us to make sense of the everyday world, they do
not help us to understand either interactive formation of intellectual achievements or learning difficulties (see Salonen, Olkinuora, & Lehtinen, 1982). A further problem is that these explanations may become self-fulfilling prophetesses and push an agent to lose his or her fait in the ability to handle problem-solving situations altogether.

The cognitive revolution gave a rise to much more complex explanations of human cognition that focused on examining knowledge structures and reasoning that people use to solve problems they encounter. Although cognitive explanations certainly went beyond psychometric ones in terms of describing, modeling, and explaining intelligent activity, there were serious limitations. Many cognitive approaches took a mentalistic view of cognition and focused exclusively on analyzing how an individual agent processes “mental representations”. It was assumed, accordingly, that cognitive scientists do not need to know anything else except formal symbol-manipulation operations to explain human cognition. We do not need to be familiar with the environment an agent lives in or know his or her developmental history, future goals, or the larger sociocultural environment in question (Fodor, 1981, p. 231). It follows that the traditional cognitive view was not fundamentally interactive in nature. The importance of sociocultural environment was acknowledged, it was considered to be a background variable that generally may be left out of analysis, if desired. However, there also emerged certain cognitive theories that represented a dynamic approach to explaining human cognitive growth.

Interactive approaches to examining human cognition are reviewed in the following. Table 1 presents levels of interaction to be discussed that appear to have very important in human learning and the development of expertise.

### Table 1. A Summary of Levels of Interaction Analyzed

<table>
<thead>
<tr>
<th>TYPE OF INTERACTION</th>
<th>CENTRAL INTERACTIVE PROCESSES</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Within mind</strong></td>
<td>- An interaction between existing and new knowledge that leads to abductive inferences for explaining unexpected phenomena</td>
<td>- Creating new meanings and ideas through abduction and further articulation of unspcific meanings</td>
</tr>
<tr>
<td></td>
<td>- An interaction between informal (tacit) and formal (explicit) knowledge</td>
<td>- Transforming formal knowledge to informal one and explicating the informal through reflection</td>
</tr>
<tr>
<td></td>
<td>- Interactive process that transforms fluid knowledge (new problem situations) to crystallized knowledge (automated routines)</td>
<td>- Facilitating dynamic expertise by releasing cognitive resources and engaging in progressive problem solving</td>
</tr>
<tr>
<td><strong>Between minds and artifacts</strong></td>
<td>- Processes of externalization and internalization</td>
<td>- Extending cognitive resources by using cognitive artifacts as tools of thinking</td>
</tr>
<tr>
<td></td>
<td>- Using external representations to aid thinking</td>
<td>- Providing cultural resources for individual thinking</td>
</tr>
<tr>
<td></td>
<td>- Relying on various cognitive tools</td>
<td></td>
</tr>
<tr>
<td><strong>Between minds</strong></td>
<td>- Engaging in constructive interaction with the fellow inquirers</td>
<td>- Looking at one’s own cognitions from the viewpoint of the others</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Capitalizing on cognitive diversity in development of new ideas</td>
</tr>
<tr>
<td><strong>Within and between communities</strong></td>
<td>- Participating in communities of practices</td>
<td>- Transforming structures, roles, and practices of participation and opening up one’s zone of proximal develop-</td>
</tr>
</tbody>
</table>
In the following sections I will review research reports that focus on dynamic interaction a) within the human mind; b) between minds and external artifacts; c) between several minds; and, finally, d) within and between social communities. After examining theories that attempt to dynamically explain human cognitive growth and change, I will move to analyze approaches that take some sort of sociocultural approach to explaining human cognition. Characteristic of these theories is to extend the scope of inquiry also to consider external artifacts and tools that human beings use to extend their cognitive resources as well as examine cognition as a process of participating in a social community rather than merely as individual mental activity.

2. The Role of Interaction in the Growth of Human Cognition

Dynamic Interaction Between Existing and New Cognitions

There is a cognitive tradition that I call “dynamic cognition” that has focused on analyzing and modeling human cognitive growth and cognitive change rather than just studying and describing isolated cognitive functions. Some aspects of cognitive research on expertise and conceptual change that I regard as representing this ‘interactive’ tradition are reviewed in the following.

Psychological and educational research has examined human learning as a process of developing expertise. In the cognitive sciences, the concept of expertise refers to a well-organized body of accessible and useful domain-specific knowledge which an agent draws upon and adds to, in effectively solving complex problems (Glaser & Chi, 1988). The ability to solve complex problems relies on domain-specific knowledge that allows identification of promising solutions among an infinite number of other alternatives. Results of expert-novice comparisons indicate that differences in perceptions, knowledge and knowledge organization are the basic sources of experts’ capabilities rather than differences in reasoning skills (Glaser & Chi, 1988). Having relevant knowledge and understanding rather than general intellectual abilities determine how well an individual is able to solve problems in semantically complex domains.

The cognitive concept of expertise does not necessarily entail a special social status as a recognized expert; an actor may be an expert in his or her community even if he or she does not have a very high formal status (see Stein, 1997, on expertise as a social role in a community). Even a child may be regarded as “expert” insofar he or she has a rich body of accessible and usable domain knowledge (Hatano & Inagaki 1992; Olson & Bruner 1996). So there is a plausible basis for the metaphor of student-as-expert; we have made the assumption that an ordinary student can, to a significant extent, adopt some essential features of an expert role, specifically, taking on challenging learning goals and adopting practices that facilitate cognitive growth (Scardamalia & Bereiter 1994; Cognition and Technology Group at Vanderbilt 1997).

Expert studies indicate that human cognition relies on a vast dynamic knowledge base that help persons to cope with their limited reasoning capacity. As a consequence, learning appears to involve interaction between old and new cognitions; human agents are always interpreting new phenomena in terms of earlier cognitions. Encountering some surprising phenomenon that does
not fit in with our preconceptions and expectations gives rise to an abductive process through which new concepts and conceptions are generated (Peirce, 1957; McDermott, 1990; Thagard, 1988). Abduction is a well-educated guess that, if it would be true, would explain the surprising phenomenon, and it has a central role in human cognitive activity. An agent’s knowledge structures determine his or her epistemic horizon in a sense that only those phenomena that are in accordance with the knowledge structures are perceived and processed. Questions that arise from an interaction between existing and new knowledge may engage agents in a process of knowledge-seeking inquiry that fosters epistemic change within and among themselves (Hakkarainen & Sintonen, in press; Lonka, Hakkarainen, & Sintonen, 2000). By engaging in the abductive processes, the agents may push themselves (and each other) to go beyond their current levels of understanding.

In the process of articulating explanations, an agent is engaging in a process of explicating the meaning of his or her concepts. The meaning of his or her concepts is continuously growing so that a concept’s meaning is something virtual; it is related to previous and following conceptions (Peirce, 1991). A concept is translated into more determinate and articulated form through the process of using concepts. Accordingly, thinking and action are interwoven in the process of meaning change (see also Minsky, 1975; Thagard, 1988). Thus, a concept’s meaning does not only represent what is actually thought, but also new meanings emerging from a connection with subsequent thoughts (Rosenthal, 1990, p. 205). Weak conceptual change refers to gradual meaning change in the basis of existing conceptual structures. Radical or strong conceptual change entails formation of new core concepts, explanatory principles and ontological assumptions (Carey 1986; see also Vosniadou & Brewer, 1987; Chi, 1992). In the educational context, conceptual change can be seen as a process in which the meaning of an agent’s spontaneous concepts change to correspond to well-defined and articulated scientific concepts. This allows new ways of problem solving as well as solution of new problems with a familiar structure.

**Interaction between Tacit and Explicit Knowledge**

Formal education produces only general epistemic conditions for development of expertise; yet genuine expertise develops through a very long process of solving problems in one’s domain (as a rule of thumb, it requires 10 years of practice). During this time, formal knowledge transmitted through education undergoes profound changes and becomes transformed into informal or tacit knowledge (Polanyi, 1966) that appears to explain experts’ exceptional performance (Bereiter & Scardamalia, 1993). It is typical for novices to have a large body of formal knowledge but few or no skills in applying this knowledge to solve problems. Experts, in contrast, may not, any more, remember as much formal knowledge as novices; however, they are able to apply their knowledge to solve problems effectively in their domain. Informal and tacit knowledge used by experts encapsulates theoretical knowledge organized around problems and cases as well as formal scientific knowledge, the combination of which appear to promote effectiveness and flexibility in problem solving (Bereiter, 1992).

Consequently, a significant proportion of expert knowledge is tacit in nature; thus experts may know more than they are able to tell (Polanyi, 1966). According to Nonaka and Takeuchi (1995), the key to understanding human knowledge is the interaction between tacit knowledge and explicit knowledge. Through using metaphors and analogies, various personal hunches and
insights may be explicated and further elaborated and new ideas and innovations created. Explication transforms tacit knowledge towards explicit knowledge that can be reflected on and shared between inquirers. Although tacit knowledge certainly does have these innovative potentials, it is important to remember that it is highly automatic and requires little or no time or thought. Thus tacit knowledge may involve long-term and overlearned practices which escape conscious control and may lead to mindless routines and reduction of cognitive flexibility (Feltovitch, Spiro, & Coulson, 1997).

Interaction Between Crystallized and Fluid Cognition

In order to explain the development of expertise, it is important to make a distinction between crystallized and fluid competence. (Bereiter & Scardamalia, 1993). The former represents partially automated patterns of problem solving developed in practical experience. The latter refers to processes of deriving knowledge and skills needed for solving new problems, from the expert’s knowledge base. Beginning to work in a new domain of knowledge or learning to solve new kinds of problems is initially very difficult because the agent does not have routine solutions to problems (see Bereiter, in preparation). However, gradually an agent learns solutions for typical problems and situations encountered in activity and develops corresponding knowledge structures and practices. As a consequence of forming routines, work gradually becomes easier and easier. The new skills become gradually crystallized so that many cognitive resources are released. This process of releasing intellectual resources through an interaction between fluid and crystallized competence is an essential aspect of the development of expertise.

Cognitive research on the mechanisms of dynamic development of expertise has identified progressive problem solving as a basic mechanism of cognitive growth (Bereiter & Scardamalia, 1993). A characteristic of such activity is to undertake more and more challenging problems and to work at the edge of one’s competence. The kind of expertise involves in progressive problem solving may be called dynamic expertise. Although progressive problem solving may make a problem more difficult to solve, it substantially facilitates learning and knowledge advancement. Further, through working at the edge of his or her competence, an expert’s cognitive system maximally adapts to the information-processing requirements or other constraints of the task environment, leading to profound changes in functioning of the agent’s cognitive system (Ericsson & Kintch, 1995). In light of such findings, progressive problem solving is often regarded also as the basic mechanism underlying the development and growth of human intelligence (Perkins, 1995). Thus, an interaction between current level of accomplishment (crystallized skills) and the edge of one’s competence (the zone of proximal development, Vygotsky, 1978) characterizes the development of expertise.

The above discussion indicates that human learning and cognitive growth may be conceptualized by referring to several interactive processes, such as an interaction between existing and emerging conceptions, tacit and explicit knowledge, or fluid and crystallized competence. Even if these interactive processes represent fundamental mechanisms of cognitive growth, there are certain limitations. An obvious weakness is that these mechanisms cannot be explained and understood by looking only at mental processes within the human mind. What is needed is an extended framework that helps one to examine dynamic cognition in the frames of cultural historical environment and social community.
3. Interaction Between Mind and Cognitive Artifacts

Expanding Intelligence Through Distributing Cognitive Processing Load

In explaining human intelligent activity, cognitive theories increasingly emphasize the socially distributed (or shared) nature of cognition (cf., Engeström, 1992; Hutchins, 1995; Oatley, 1991; Perkins, 1993; Salomon, 1993, Salomon, Perkins, & Globerson, 1991). Distributed cognition refers to a process in which cognitive resources are shared socially in order to extend individual cognitive resources or to accomplish something that an individual agent could not achieve alone. Human cognitive achievements are based on a process in which an agent’s cognitive processes and the objects and constraints of the world interactively and reciprocally affect each other. Cognitive processes can be distributed between humans and machines (physically distributed cognition, Norman, 1993; Perkins, 1993) or between cognitive agents (socially distributed cognition). Typical of distributed cognitive systems is to represent knowledge in an easily accessible form, support effective memory retrieval, organize and structure human activity in the environment, and provide constructive arenas for building of new ideas.

The cognitive significance of distributed cognition is based on a fact that human beings have only limited cognitive resources such as time, memory, or computational power (Cherniak, 1986). Norman (1993, p. 43) argued that human cognitive resources are highly overestimated; without external aids humans have only a limited memory and reasoning capacity. Higher cognitive accomplishments presuppose that an agent uses the external world and his or her fellow inquirers as sources of knowledge, organizers of activity, and in general as extensions of his or her cognition. By using socioculturally developed cognitive tools, external representations, and other artifacts, we are able to reduce the cognitive processing load and take on more complicated problems to solve than would otherwise be possible (Pea, 1993).

Consider how difficult is would be to estimate time without a clock, speed without a speedometer, or location without a map. Clocks, speedometers, calculators, drawings and maps are examples of artifacts that humans use for coping with and overcoming limitations in our cognitive capacities. Such tools developed in the course of cultural history that support our intelligent activity are called cognitive tools. One may say that these artifacts embody human intelligence in that, by using them, we are able to carry out more difficult tasks than would otherwise be possible. Using cognitive tools radically changes relations between an agent and the environment because he or she is relying on an abstract representation (e.g., map) of the environment rather than acting by relying on direct feedback from it (Olson, 1994). An important aspect of the development of our civilization has been to deliberately build, develop, and transmit cognitive tools.

Both historically and cognitively most important has been development of tools for externalizing one’s psychological processes, and creation of representations which have made epistemic achievements possible that were otherwise completely unattainable (Goody, 1977; Norman, 1993; Olson 1994; Vygotsky, 1978). Karl Popper (1972) distinguished between physical reality (World 1), the mental world (World 2), and the world of cultural knowledge (World 3). Externalization is a process of transferring knowledge from Popper’s (1972) World 2 (subjective knowledge) to World 3 (objective, cultural knowledge). The most important tools of externali-
ization are writing and visualization. Writing forces an agent to derive certain conclusions from his or her beliefs and theories and thereby articulate them more thoroughly (Goody, 1977; Olson, 1994). Through externalization of conceptions, otherwise implicit meanings can be explicated and information represented in a more abstract and decontextualized form. Further, externalization requires an agent to explicate connections between his or her conceptions, and thereby connect pieces of information from several points of view (cf. Minsky, 1975). This makes inconsistencies and illogicalities salient for an agent, and establishes a cognitive need to construct more advanced conceptions. Further, writing enables one to represent conceptual information visually, thereby facilitating explication of the inner relations of the phenomenon being explained (cf. Pea, 1993). Through scientific visualization, the advantages of the powerful human visual system can be used to facilitate conceptual understanding (Latour, 1988).

**From Learning to Knowledge Building**

The idea that human mind may be explained in terms of interaction with objects in the world is taken very far in Carl Bereiter’s theory of knowledge building. He argued that current practices of learning and instruction are based on an assumption that the human mind is a kind of container or archive, and learning is the accumulation of knowledge into the mind. The problem of the mind-as-a-container metaphor is that it allows one to distinguish only mental states (World 2) and physical reality (World 1). What is missing is Popper’s (1972) World 3 that contains human thoughts and ideas that the culture preserves and carries on. According to the traditional view, knowledge is simply transmitted or conveyed to a student’s head from the teacher’s mind or books. Further, the modern constructivist conception of learning, that emphasizes the learner’s active role in the learning process, is also, in essence, based on the mind-as-a-container metaphor by assuming that the knowledge is created by the mind itself. In the background of Bereiter’s theory is the connectionist theory of mind that would allow conceptualization of the mind as an interaction with objects in the world – without assuming the representational level at all.

Bereiter (in press) has analyzed practices of working with knowledge in school and in science. He pointed out that knowledge is produced at school mainly as a mean for carrying out learning tasks and assessing results of learning. Such activities are focused only on making changes in an agent’s mental state, i.e., oriented towards Popper’s (1972) World 2 of subjective knowledge. However, knowledge production has a substantially different role in scientific research communities. It is characteristic of research laboratories to produce knowledge objects, such as theories or designs that have a permanent value and occupy Popper’s World 3. Bereiter calls these objects conceptual artifacts. These knowledge objects can be shared, articulated, and extended by relying on the cognitive resources of the whole community. He conceptualizes knowledge work as work that is focused on conceptual artifacts and adds to their value. Knowledge organizations and scientific research communities produce new knowledge and understanding through criticizing, extending, elaborating, and transforming knowledge objects. Communal and individual knowledge advancement are reciprocally dependent on each other; through working to advance their communal knowledge, individual agents engage in activities that tend to facilitate dynamic changes in the meaning of their conceptions.

Relying of Bereiter’s knowledge-building model, some educational researchers have designed networked environments for computer-supported collaborative learning. These environments,
such as CSILE (Computer-supported Intentional Learning environment, Scardamalia, Bereiter, & Lamon, 1994) or Future Learning Environment (Muukkonen, Lakkala, Hakkarainen, 1999) facilitate practices of working transformatively with knowledge by providing students with an environment for working together with knowledge objects. Students are guided to create World 3 objects by constructing their own research questions, intuitive theories or designs. A learning environment’s public database creates a sort of plane of objective knowledge, Popper’s World 3, for a classroom, a plane in which students can jointly work to advance their communal knowledge. Students may be engaged with productive working with knowledge objects in the same way as the scientific community is engaged with theory improvement (Hakkarainen, Lonka, & Lipponen, 1999).

4. Development of Expertise through Social Participation

Extending Cognitive Resources Through Social Interaction

In the background of theories concerning socially distributed cognition are observations according to which many cognitive problems, which cannot be solved individually, can be addressed only by combining limited knowledge and skills of several agents (Hatano & Inagaki, 1992; Hutchins, 1995; Miyake, 1986). A fundamental source of advancement of inquiry is social communication and, in the context of science, scientific argumentation. Through social interaction, contradictions, inconsistencies and limitations of an agent’s explanations become available because the process forces an agent to perceive his or her conceptualizations from different points of view. Limited cognitive resources can be overcome by distributing the cognitive load to several agents, each of whom is equipped with restricted power of cognition.

Miyake (1986) and Hutchins (1995) have argued that social interaction provides new cognitive resources for human cognitive accomplishment. According to Miyake’s analysis, understanding is iterative in nature, i.e., it emerges through a series of attempts to explain and understand processes and mechanisms being investigated. In a shared problem-solving process, agents who have partial but different information about the problem in question appear collectively both to improve their understanding through social interaction (see also Oatley, 1991). The cognitive value of social interaction appears to be based on a fact that human beings cannot keep more than one complex hypothesis activated at a time. Although an agent may not have an easily accessible cognitive mechanism for testing his or her hypothesis, this testing process occurs naturally with pairs of agents working together. The founders of PDP program realized that socially distributed cognitive systems function parallelly in a way that goes beyond possibilities of an individual:

One of the great joys of science lies in the moment of shared discovery. One person’s half-baked suggestion resonates in the mind of another and suddenly takes a definite shape. An insightful critique of one way of thinking about a problem leads to another, better understanding. An incomprehensible simulation result suddenly makes sense as two people try to understand it together (Rumelhart, McClelland, and the PDP Research Group, 1986, ix)
Further, there is a growing body of evidence that cognitive diversity and distribution of expertise promote knowledge advancement and cognitive growth. Distribution of cognitive efforts allows the community to be more flexible and achieve better results than otherwise would be possible. Moreover, studies of Hutchins (1995) and Dunbar (1995) have revealed that groups which consist of members having different but partially overlapping expertise were more effective and innovative than groups with homogeneous expertise. The Fostering Communities of Learning approach, developed by Brown and Campione (1994), is a pedagogical model that is designed to take advantage of the distributed expertise and cognitive diversity characteristic of communities of scientific practice. Conceptual advancement is facilitated by cultivating each student’s own expertise. Students engage in a self-regulated and collaborative inquiry being, as a group, responsible for the task. Social support for deepening inquiry could provide overlapping zones of proximal development (Vygotsky, 1978) in which students can operate at the edge of their competence.

**From Acquisition to Participation Metaphor of Learning**

Sfard (1998 see also Salomon & Perkins, 1998; Hakkarainen, 2000) distinguished between two metaphors of learning, i.e., the acquisition metaphor and participation metaphor. The former represents a traditional view according to which learning is mainly a process of acquiring desired pieces of knowledge. The acquisition view may emphasize transmission of knowledge from experts to learners (traditional pedagogy) or acquisition of knowledge by learners themselves (child-centered pedagogy). The participation metaphor, in contrast, considers learning as an interactive process of participating in various cultural practices and shared learning activities, a process that structures and shapes cognitive activity in many ways. Accordingly, learning is seen as a process of becoming a member of community and acquiring the skills to communicate and act according to its socially negotiated norms (Lave & Wenger, 1991).

In the background of the participation metaphor are Vygotskian (1978) and neo-Vygotskian theories according to which human mind is constituted through sociocultural activity. Vygotsky argued that an interaction between less and more able members of a community fosters conceptual growth through internalization of cultural-historically formed conceptual tools. Following this approach, Barbara Rogoff (1990) argued that understanding is dialogical in nature; it takes place between people rather than within people. She considered learning as a process that transforms structures of participation in sociocultural activities, enabling understanding and changing the participants’ roles and responsibilities. Students learn through participating in a community as they collaborate with other children and adults in carrying out culturally meaningful activities. Interaction between peers representing different levels of conceptual understanding enables each participant to achieve new competencies or skills within his or her zone of proximal development. On this view, cognitive growth is inherently relational and thus human minds are co-constructed – rather than constructed -- in the process of participating in social communities.

**Developing Competencies Through Participating in Communities in Practices**

The participation metaphor indicates that the development of expertise is not only related to the nature of an individual’s knowledge structures but also to that person’s access to relevant for-
mal and informal cultural knowledge through participating in an expert community or network (Ericsson & Charness, 1994; Lave & Wenger, 1991; Wenger, 1998). Lave and Wenger (1991) proposed that expertise and competencies are mediated through closely functioning, unofficial ‘communities of practice’. These are groups of persons with particular skills or expertise who interact formally within an organization or informally--but routinely--in a type of network for shared pragmatic or knowledge-related goals. A community of practice is built around a shared enterprise or project that members of the community agree on and for which they jointly take responsibility. Everyone belongs to several communities of practice at home, school, workplaces or in hobby circles, but individuals seldom become aware of the existence of these informal communities – that do not have official memberships or standard patterns of participation.

Wenger (1998) emphasized that the developmental history of communities of practice continuously produces discontinuity and boundaries that become apparent when a person tries to move from one community to another. When one is interacting with members of another expert community, one often meets limits of his or her competence and understanding, for instance, dealing with lawyers, medical doctors or tax authorities. As a consequence of these discontinuities, persons sometimes face obstacles to learning that appear to be insurmountable. Critical in overcoming this kind of problem is obtaining in one way or another, access to an expert culture in which there has accumulated a great deal of knowledge about the domain in question. In many cases, however, an actor does not have connections or information that would help him or her to cross the boundary between two communities of practice (Engeström, Engeström, & Kärkkäinen, 1995). As a consequence, boundary crossing is likely to be both intellectually and emotionally very demanding.

If boundaries between communities of practices make learning and understanding difficult, we may argue that, correspondingly, people can learn almost anything when they get support needed in crossing boundaries. Connections created by participation rather than fixed individual characteristics help persons to overcome learning difficulties and deeply understand the things being studied. Through boundary crossing, many problems that appear hopelessly complicated become relatively simple. In order to achieve exceptional competence, one does not need an exceptional mind or intelligence but sustained interaction - relying on intensive participation - with cultural knowledge resources (Ericsson & Charness, 1994; Hakkarainen, Lonka, & Lipponen, 1999).

Peripheral Participation in Expert Communities

The development of expertise is facilitated through socialization to cultures of expertise that is called legitimate peripheral participation (Lave & Wenger, 1991; Wenger, 1997). It is essential to create social structures that enable learners – whether they are studying at school or participating in working life – to participate in various communities of practices from the very beginning of learning. Peripheral participation is a process during which novices gradually adopt experts’ silent knowledge, culture of activity, and grow up to be members of that expert culture through participating in experts’ practices without being responsible of the whole process. Belonging to a community and taking part in its activities provide significant resources for learning and intellectual development (Wenger, 1998). The more deeply we learn things the more we can participate in communities with which we are identifying.
The focus in peripheral participation is on learning mental processes and collaborative activities in which experts are engaged during complex problem solving rather than just to gain practical skills. Therefore, this kind of process is called “cognitive apprenticeship” to separate it from more traditional forms of apprenticeship (Collins, Brown, & Newman, 1989). All higher level cognitive processes are learned through this kind of cognitive apprenticeship whether one is talking about technical practice (e.g., craft, many industrial professions), arts (e.g., music and visual arts), kinesthetic-motor (e.g., ballet) or scientific (e.g., graduate school) skills. Participation in these processes may require very long formal education, but formal studies do not produce expertise, which can only develop through sustained participation in problem-solving practices of an expert community.

Figure 3 schematically depicts various aspects of growing up to an expert culture through peripheral participation. An important aspect of the process is the model provided by more experienced members and gradual participation in more and more demanding activities. It follows from the limited knowledge and skills of a novice that he or she needs a great deal of support and guidance in the beginning of the process. For the beginner, practically all situations are problem-solving tasks solving for which an expert’s support is needed. It is relatively easy, however, gradually to learn to understand complex phenomena when an agent is continuously receiving support that is adjusted to the level of his or her competence. “Scaffolding” means that the adult or tutor is controlling some elements of task in order to make solving of the problem possible for the novice (compare adults supporting a child so that he or she may practice swimming or riding bicycle) (Wood, Bruner, & Ross, 1976). An essential aspect of scaffolding is to adjust the amount of support to the learner’s needs; provide more help when needed but gradually decrease help as the learner’s skills are developing.

Figure 1. Growing up to an expert community

Structuring patterns of participation in a way that facilitates progressive problem solving may facilitate organizational intelligence. Bereiter (in press) argued that a community that sets up gradually tightening requirements for actors and provides support for higher-level accomplishments when needed, facilitates dynamic development of one’s expertise. Further, building bridges between learning and expert communities throughout educational system appears to be an important resource of facilitating the development of expertise. From cognitive research on
educational practices have arisen various forms of student-expert partnership for building connections between schools and varied kinds of expert cultures and communities (Cohen, 1997; The Cognition and Technology Group at Vanderbilt, 1997). A integration with an expert culture appears to help young students to understand experts’ ways of solving problems and to approach tasks in their domain, adopt their tacit knowledge, and, generally, learn to understand how experts think.

Discussion

The present paper examined learning as an interactive process. The problem was addressed at multiple levels from interactive models used to characterize human cognitive growth, to socioculturally oriented theories that examine learning as a process of participation in social communities. The traditional cognitive theories considered the importance of getting feedback from the environment for adjusting and fine-tuning one’s mental representations. It was assumed, however, that human mind is autonomous and could be analyzed in isolation from its social and cultural environment. The sociocultural theories, in contrast, indicated that the interactive relations between an actor and the cultural environment in which he or she is embedded shape, modify and even constitute the mind. Cognitive science is likely to be facing a paradigm shift in which the socially and culturally distributed nature of the mind is acknowledged.

From the viewpoint of sociocultural theories, we may argue that all intelligence is artificial intelligence (Michael Cole). In other words, intelligence does not come from the depth of an individual mind but emerges in a process of participating in and interacting with cultural-historically developed cognitive tools and artifacts and social community. While acknowledging the sociocultural foundations of human mind, however, we do well to take a dialectical view that acknowledges the social aspect of mind without reducing cognitive phenomena to sociological ones. Cognitive theories that focus on explaining dynamic changes in human cognitive activity cannot be adequate without referring to changed individual cognitions. According to a dynamic interaction view, individual and distributed cognitions are in interaction, co-evolve, and reciprocally affect each other. Salomon (1993; Salomon et. al., 1991) have argued that distributed cognitive processes produce “cognitive residues” by enhancing an agent’s cognitive competencies which affect subsequent distributed activities. When a person is moving from one community to another, he or she is, in many cases, taking along a great deal of knowledge and competence to new communities. However, in order to transform these knowledge structures into workable actions, a person needs to adapt to local conditions and situations so that the environment of activity enters the picture again. Perhaps we might say that cognition is stretched out between the actor and his or her environment (Salomon, 1997).

A methodological implication of the interactive approach is that cognitive theorists should not exclusively focus on studying cognition as an individual mental process. We should develop methods that characterize relations between actors rather than represent their individual attributes. Palonen and Hakkarainen’s (1999) study indicated that the methods of social network analysis, for instance, appeared to supply useful tools for assessing sociocognitive structures of participation in computer-supported learning, an approach with several advantages over one focusing only an individual student's activities. Studying the relations among participants of networked learning, helps one to better understand and explain collaborative processes that affect the individual students: An important challenge of cognitive research is to develop computer tools that will help people to collaborate and build knowledge together (see Lehtinen,
Researchers working in the area of AI in education, for instance, are developing **collaborative assistants** that help people to share knowledge and experiences (Watt, 1999; Coleman, 1999).

**References**


Hakkarainen, K. & Sintonen, M. (accepted for publication) Interrogative approach on inquiry and computer-supported collaborative learning. Science & Education.


