Jour. Korean Earth Science Society, v. 27, no. 2, p. 140–148, April 2006

Participation Metaphor for Learning and Its Implication for Science Teaching and Learning

Phil Seok Oh*

Department of Science Education, Ewha Womans University, Seoul 120-750, Korea

Abstract: This is a theoretical study of which the goal is to investigate the meaning of a participation metaphor (PM) for learning and draw its implication for teaching and learning science. The review of relevant literature reveals that the PM is associated with the view of learning as ongoing participation in sociocultural practices within a community, and that cognitive apprenticeship is an instructional model related closely to the PM. It is then suggested that a community of learners should be developed if science teaching and learning are to be implemented in line with the PM. Finally, the present study briefly introduces a high school science club as an exemplar of science learning community, including what should be considered in science education research.

Keywords: participation metaphor, situativity theory, cognitive apprenticeship, learning community

요 약: 이 연구는 학습에 대한 참여 비유(participation metaphor, PM)의 의미를 알아 보고 과학 교수 · 학습에의 시사점을 탐색하기 위한 이론 연구이다. 문헌 고찰을 통하여 참여 비유가 공동체 내에서의 사회 · 문화적 활동에 지속적으로 참여하는 것을 학습으로 보는 관점과 맥을 같이 하며, 인지적 도제(cognitive apprenticeship)가 참여 비유와 밀접하게 관련된 수업 모형이라는 것을 살펴 보았다. 이를 토대로 참여 비유에서 주장하는 것과 같은 과학 교수 · 학습이 실현되기 위해서는 과학 학습자 공동체의 육성이 필요하다는 점을 제안하였다. 마지막으로 과학 학습자 공동체의 한 사례로서 어느 고등학교의 과학 클럽 활동을 간략히 소개하였으며, 앞으로의 과학 교육 연구에서 고려해야 할 점들을 진술하였다.

주요어: 참여 비유, 상황 이론, 인지적 도제, 학습 공동체

Introduction

Sfard (1998) pointed out that today's educational research is caught between two metaphors for learning: *acquisition metaphor* (AM) and *participation metaphor* (PM). The distinction between AM and PM is based on two different ways of conceptualizing learning. The AM views learning as acquisition of knowledge: researchers have employed various terms, such as reception, accumulation, internalization, appropriation, development, or construction, to denote the act of acquiring knowledge. In contrast to the AM, the PM reflects the view of learning as participation in practices within a community. While the AM has been predominant in the field of educational research for a long period of time, the PM has recently emerged by the contribution of authors whose approaches are often called the theory of *situated learning* or the *situativity theory* (e.g., Barab & Duffy, 2000; Brown et al., 1989; Collins et al., 1989; Greeno, 1995; Greeno et al., 1998; Lave & Wenger, 1991).

This study was intended as a theoretical investigation in which the goal was to review the PM and draw its implications for science teaching and learning. In what follows, a comparison between AM and PM is accomplished along with Sfard's insight into the two metaphors for learning. It is then followed by the review of literature concerning the meaning of the PM, which leads to practical implications for designing science learning environments. Lastly, this study introduces briefly a case of science learning community of which the main features meet the characteristics depicted by the PM.

*Corresponding author: philoh@ewha.ac.kr
Tel: 82-2-3277-4479
Fax: 82-2-3277-2684

Two Metaphors for Learning

Sfard (1998) indicated that in the field of educational research, almost every common utterance on learning had been based on the assumption that learning is the acquisition of some forms of knowledge by certain human actions. According to her, this trend was the case to different learning theories, including behaviorism, cognitivism, and even constructivism. In fact, from the behaviorist perspective, learning was equated with acquiring associations between stimuli and responses. It was believed that learning was achieved when an individual demonstrated an observable performance properly following the presentation of a specific environmental stimulus (Ertmer & Newby, 1993). To be different from behaviorism, cognitivism and constructivism put a stress on conceptual development in the learner. Some cognitive theorists argue that the acquisition of concepts and thinking skills is made possible by the operations of the learner's cognitive structure (Ausubel, 1985; Merrill, 1991). Constructivists contend that the learner actively constructs knowledge out of the experiences in which he or she is involved (Driver et al., 1994; Schuh, 2003). Although cognitivism and constructivism employ different terms to explain how people acquire knowledge, both theories falls into the same metaphor for learning, i.e., the AM, since they focus mainly on the action of making a certain sort of knowledge the learner's private property (Sfard, 1998). That is,

> First, they simply talked about passive reception of knowledge, then about its being actively constructed by the learner; later, they analyzed the ways in which concepts are transferred from a social to an individual plane and internalized by the student; eventually, they envisioned learning as a never-ending, self-regulating process of emergence in a continuing interaction with peers, teachers, and texts. As long as they investigated learning by focusing on … "acquisition of knowledge", however, they implicitly agreed that this process can be conceptualized in terms of the *acquisition metaphor* (p. 6).

In this respect, the dichotomy between so called personal and social constructivism is not meaningful: both schools of constructivism address the knowledge-acquisition process with varying emphases on the role of an individual learner and social interactions among people. Sfard (1998) pointed out, "The individual/social dichotomy does not imply a controversy as to the definition of learning, but rather rests on differing visions of the mechanism of learning" (p. 7).

While the AM addresses learning with a focus on the learner's acquisition of knowledge, the PM conceptualizes it in the context of a community of practice. Communities are everywhere and people live as members of a number of them. But, in the perspective of the PM, a community is different from a group of interest or a geologically separated locality in the sense that it involves practices socially shared by members (Smith, 2003). Practices refer to "regular patterns of activity in a community" (Greeno et al., 1998, p. 6). They have been formed as a cultural heritage in a community of practitioners and maintained so consistently that the community can pursue its own enterprise over time. For instance, Bereiter (1994) portrayed the practices of the scientific community as progressive discourse, which consists of four moral commitments: mutual understanding, empirical testability, expansion of the collectively valid knowledge, and openness. These commitments distinguish science from other disciplines and make it appear the existence of scientific methods.

With shifting a focus to communities rather than individuals, the PM conceives of learning as a process of becoming a member of a certain community (Sfard, 1998). Being a member of a community entails participating in practices of that community, and therefore, participation in practices of a community involves learning inevitably. This does not mean, however, that participation in social activities is merely a condition for acquiring knowledge, but rather, in the PM's framework, participation in social practices is the learning process itself. According to Sfard (1998), the PM makes salient the dialectic nature of learning interactions in which an individual and community affect and inform each other. When the learners participate in practices of a community, they contribute to functioning and growing of the community and the community allows the learners to develop their identities to relation to the greater whole. From this point of view, the goal of learning for individual learners is to improve their participatory abilities in order to contribute more effectively to community building (Greeno et al., 1998; Lave, 1991, 1996; Sfard, 1998).

Although Sfard (1998) clearly distinguish the two metaphors for learning, she cautioned carefully that it was not desirable but even dangerous to choose one metaphor since neither metaphor alone could deal properly with the complexity of learning. Rather, educators should take account of the AM and PM inter-complementarily because "the act of acquisition is often tantamount to the act of becoming a participant, and if so, one can find it difficult to consider AM and PM separately, let alone as mutually exclusive" (p. 6). Nevertheless, considering that the AM has been prominent in the field of educational research for several decades, it is now necessary to examine the PM as a new view of learning. Based on this need of a study, from the below, the meanings and implications of the PM are explored in more detailed manner through the review of literature which addresses learning from the PM's perspective.

Participation Metaphor (PM)

Learning as an ongoing participatory process

The view of the proponents of the PM is often called the theory of *situated learning* or the *situativity theory*. The basic idea of this school of learning theory is that all learning takes place in some situation and the situation in turn affects the nature of learning. However, the term 'situated' at times leads into the misunderstanding that "there are some kinds of cognition that are situated and some that are not" (Greeno, 1995, p. 68). But, the situatedness is a common characteristic of learning, and the difference between learning in different settings is how it is situated (Greeno, 1995; Greeno et al., 1998). From the PM's perspective, learning is situated in a socio-cultural system, i.e., a community of practice, where the individual learners interact with the system as well as with other members. This point of view is different from those of behaviorists and cognitivists in that it conceives learning in the relationship between individuals and larger environments, rather than dealing with the environments merely as factors influencing the behaviors and thinking processes of individual agents (Ertmer & Newby, 1993; Greeno et al., 1996).

Although the PM has both psychological and anthropological origins (Barab & Duffy, 2000), the recent development of the PM rests heavily on the contribution of social anthropologists with strong interest in human development and learning. Among them, Lave (1991, 1996; Lave & Wenger, 1991) conceptualized learning from her studies on social practices in such diverse contexts as lives of midwives, tailors, meat-cutter, and alcoholics. When situated in a community, learning is not a matter of a person's internalizing knowledge but becomes a matter of the learner's transforming his or her participation in social practices of the community. Lave and Wenger (1991) used the words 'legitimate peripheral participation' as a descriptor of a newcomer's engagement in community practices which involves learning.

> Learners inevitably participate in communities of practitioners and ··· the mastery of knowledge and skill requires newcomers to move toward full participation in the socio-cultural practices of a community. "Legitimate peripheral participation" provides a way to speak about the relations

between newcomers and old-timers, and about activities, identities, artifacts, and communities of knowledge and practice. It concerns the process by which newcomers become part of a community of practice (p. 29).

The engagement in sociocultural practices gradually leads the participants to become more centrally involved in the community. The peripheral participation opens "a way of gaining access to sources for understanding through growing involvement" (p. 37) and enables newcomers to be a full participant who, with better knowledge and skills, can contribute to the reproduction and transformation of the community. From the perspective of the PM, this ongoing participatory process accompanying with the development of the participant's identity entails learning invariably. In the process of increasing participation, the motivation to learning is to become a full participant in sociocultural practices and the goal of learning involves nurturing the community. In short, learning "is an aspect of changing participation in changing communities of practice" (Lave, 1996, p. 150).

When conceptualizing learning in relation to a community, it is important to note that "the form that the legitimacy of participant takes is … not only a crucial condition for learning, but a constitutive element of its contents" (Lave & Wenger, 1991, p. 35). Of course, it is through the engagement in social activities that learners gain new knowledge. But, the knowledge acquired includes the cultural-historical heritage of the community, such as joint goals, shared experiences, socially negotiated norms, how to do something, and value systems (Barab & Duffy, 2000; Lave, 1996). Gaining such knowledge contributes to the development of an identity as a member of the community as well as the individuals' intellectual growth. Consequently, "developing an identity as a member of a community and becoming knowledgeably skillful are part of the same process, with the former motivating, shaping, and giving meaning to the latter, which it subsumes" (Lave, 1991, p. 65). Thus, when learning is defined as an increasing participatory process with a community context, the participation in social practices is not merely a condition for learning, but rather the learning process itself.

Apprenticeship as an instructional model

Learning, when conceived of as the ongoing participatory process in sociocultural practices, is structured in apprentice-like forms (Lave, 1991, 1996; Lave & Wenger, 1991; Rogoff, 1990). Apprenticeship has been studied by anthropologists and socio-cultural theorists regarding human development and it has resurged as a valuable educational practice. Several authors contributed to the development of apprenticeship as an instructional model, and their model is often called *cognitive apprenticeship* (Barab & Hay, 2001; Brown et al., 1989; Collins et al., 1989; Roth & Bowen, 1995).

Just as traditional apprenticeship is defined by a certain relationship between master (or mentor) and apprentice (or mentee), the cognitive apprenticeship model portray the instructional process based on the mutual relationship between teacher and students in shared problem-solving or task-completion situations. Collins and his colleagues (Brown et al., 1989; Collins et al., 1989) refer to cognitive apprenticeship as the learning-through-guided-experience on cognitive and metacognitive skills and processes that experts use to handle complex tasks. This instructional model has a series of teaching and learning strategies that includes the teacher modeling, students practicing under the teacher coaching, and students performing the task with independent competence. Cognitive apprenticeship begins with the teacher modeling of solving a problem or carrying out a task. What is modeled by the teacher is what students should be able to reproduce as a result of learning. In cognitive apprenticeship, however, this learning goal is not achieved by simply mimicking someone else's performance: it is accomplished through ongoing social practices where the learner is allowed to participate peripherally in and take increasing ownership for completing a task. While students attempt to carry out the target task, the teacher assumes the role of coaching so that the learners can bring their performance closer to that of experts. The content of the coaching may vary, being contingent on the level of student performance: it "may serve to direct students' attention to a previously unnoticed aspect of the task or simply to remind the student of some aspect of the task that is known but has been temporarily overlooked" (Collins et al., 1989, p. 481). Thus, in cognitive apprenticeship, the teacher does not govern the whole process of learning, but rather instructional decisions are made through the teacher's pedagogical response to the current level of student knowledge and skills. Moreover, students are given opportunities to articulate and reflect their own strategies and develops new ones for themselves (Brown et al., 1989; Collins et al., 1989). The instructional intention embedded in the cognitive apprenticeship model is for students to have autonomy for their own performance. Therefore, the teacher coaching becomes less until the learner solve the problem with greater competence or perform the task independently.

The entire process of cognitive apprenticeship described so far is very similar to that of 'scaffolding' which can be comprised of sequential teaching and learning practices as follows (c.f., Maybin et al., 1992; Oh, 2005; Scott, 1998):

- *Teacher and students building a contextual basis*: the teacher tunes into a student's present state of ability and understanding and establishes a shared goal of solving a problem or completing a task
- *Joint problem solving or task completion*: the student attempts to solving the problem or completing the task under the situated help by the teacher. The teacher gradually withdrawals his or her assistance with the student taking more ownership and responsibility.
- *Students demonstrating independent competence*: the student solves the problem or performs the task with independent competence.

Just as scaffolding is considered as a desirable form of educational interaction between educational grown-ups and educational growing-ups, cognitive apprenticeship has been paid attention as an effective model of teaching and learning (Barab & Hay, 2001; Brown et al., 1989; Collins et al., 1989; Roth & Bowen, 1995).

Implication for Science Teaching and Learning

Developing a community of learners

As implied by the discussion thus far, if educators are to implement their work in line with the PM, they should develop a learning environment in ways that allow learners for ongoing participation in social practices with continuously improved knowledge and skills. In this setting, cognitive apprenticeship can be used as a promising model for teaching and learning some subject. Many authors recognize such an environment and call it as a *community of learners* or *learning community* (Barab & Duffy, 2000; Bielaczyc & Collins, 1989; Brown & Campione, 1998; Crawford et al., 1999; Rogoff, 1994; Sfard, 1998).

A community of learners has such common characteristics as (a) diversity of expertise among its members, who are valued for their contributions and given support to develop; (b) a shared objective of continually advancing the collective knowledge and skills; (c) an emphasis on learning how to learn; and, (d) mechanisms for sharing what is learned and for recruiting members of the community. (Bielaczyc & Collins, 1989, p. 272; see also Barab & Duffy, 2000; Rogoff, 1994). These features are far away from those of the traditional classroom which focus mainly on students acquiring the same set of information at the same rate by following the same procedures. In fact, while learning in a community context, the participants assume asymmetric roles with the primary goal being to construct, maintain, and nurture their community (Bielaczyc & Collins, 1989; Rogoff, 1994). A learners' community also "go[es] beyond the simple coming together for a particular moment in response to a specific need" (Barab & Duffy, 2000, p. 37). That is, it has a reproduction cycle through which newcomers are continuously engaged in mature practices with mentors and, as a result, become more knowledgeable and capable experts.

As for the subject matter science, a learning community is built on the principles as follows (Crawford et al., 1999, pp. 703-704; see also Roth & Bowen, 1995):

- *Authentic task*: instruction is situated in tasks that are related closely to students' own interests and similar to activities of scientists in practices.
- *Interdependency in small group work*: members cooperate with each other and draw on the expertise of more capable others.
- *Public sharing and negotiation of understanding*: students and teachers publicly share ideas and negotiate understanding of substantive science content.
- *Collaboration with experts*: students collaborate with experts outside the school.
- *Shared responsibility*: responsibility for learning and teaching is shared, and the roles of the teacher and students are considered equally important.

According to Roth and Bowen (1995), a community of science learners can be structured in term of cognitive apprenticeship. Especially, they emphasize that in the cognitive apprenticeship model, learning reside not in the master-apprentice relationship but in the organism of the community. This notion implies properly that the development of a learning community and the cognitive apprenticeship model have to come together into play to make learning meaningful.

A case of science learning community

Although a science learning community may be realized by a classroom environment where students work on socially organized disciplinary practices (Roth & Bowen, 1995) or attend, as apprentices, in real scientists' research programs (Barab & Hay, 2001; Richmond & Kurth, 1999), this present study found an extracurricular activity (i.e., club activity in schools) as a possible site for building a community of science learners. The author of this study has been conducting participant observation in a science club named BS (initial used to keep it anonymous) in a high school located in a mid-sized city, Korea. Although the participant observation research is just in the beginning stage, it seems appropriate to introduce at least briefly some features of BS here when the PM and its implications are discussed.

There are two main reasons for the author recognizing the BS club as a case of science learning community. One is that the typical features of science classrooms are far from those of a learners' community described previously. It has been reported repeatedly that students in science classrooms are mostly engaged in rote learning which emphasizes on acquiring discrete bodies of information and retrieving them in a test. Even in a laboratory setting, the learners follow predetermined procedures and attempt to verify theories presented in preceding lessons, rather than inquiring into authentic problems from their own interest (Moscovici & Nelson, 1998; Son, 2002; Tobin, 1987). Therefore, the traditional science classroom was hardly expected to provide an exemplar as a science learning community.

The other reason for the introduction of the BS club as a model of science learning community was that it had a long history of development as compared with regular classes in schools. BS was founded in 1999 with a few teachers and students in pursuit of providing students with science learning opportunities beyond regular classrooms.

The past several years have witnessed the growth of the club, which, at the present of 2006, has 25 students from the 10th to 12th grade as its members. Two teachers in the high school - biology and earth science teachers are now supervising the club. Such a history does not imply that the BS club is an already well - established learners' community. However, it is reasonable to believe that BS has more potential of growing into a sustainable community of science learners.

Based on these reasons, some features of the BS club are presented in terms of the principles of a learning community and those of cognitive apprenticeship. First of all, the BS students are engaged sustainedly in authentic science tasks, which is one of the major characteristics of a learning community. According to Crawford et al. (1999), 'authentic' means being relevant to students and similar to activities of professional scientists. The authentic tasks on which the BS students have worked include observing celestial objects such as the sun, stars, and nebulae by using telescopes in the school. Notably, this task is not like a one-shot school event that is usually organized for a special day and in which students deal with hands-on materials without minds-on inquiry. BS members observe the sun and make photos periodically in order that they can find some patterns in the shape and movement of the sunspots. This sun-observing activity is a year-long project, even including vacation time, and each student in BS takes turns during the day and year for observing the sun, making photos, and keeping journals.

Second, the members of the BS club participate in socially organized activities and have ownership and responsibility for their shared tasks. These features allow all the participants in BS to cooperate with one another and learn from each other's expertise. Such various programs as in-school science seminars, geological field trips, collecting insect samples, and providing social and educational service in science festivals in local areas take place within the science club throughout a year. Therefore, it is neither possible nor desirable that all the BS members do the same job even in a single event. Actually, BS students function differently to complete a shared task, and their roles change with the change of the club activity. For each member to take his or her own role, the supervising teachers judiciously divide a task into subordinate ones and assign them to different students. Science seminars are an example. For a science seminar, BS members investigate, individually or in small groups, some subjects under a bigger topic which is relevant to their ongoing project. Then, the students share what they have learned with other members through presentation and discussion. This investigation-and-sharing activity is not like the traditional laboratory in schools where every small group conducts the same experiment and report similar results. Especially, since the general topic can be understood best only when all the sub-topics are integrated into a whole, each student is highly responsible for studying his or her own topic and make the finding available to others. Such responsibility is considered, when it is repeatedly given to students on different occasions, as an essential component for the learners to develop themselves with more knowledgeable and skillful identities.

Third, the instructional process of the BS club has resemblance to cognitive apprenticeship in that young learners grow into senior members with better competence and the seniors offer mentorship for the juniors. When first joining BS, students learn by taking small parts of projects in the club and by performing what is explained and modeled by the teachers as well as higher graders. But, as they become more knowledgeable and skillful, the students have to assume greater roles in the club. In fact, the supervising teachers increasingly assign more ownership and responsibility so that the students can organize and run their own activities. Furthermore, old members of BS often visit the club to play the role of mentors for the learning of younger students. Many of BS graduators are now attending colleges with majoring in various fields of science (e.g., geology, biology, ecology) and technology (e.g., environmental engineering, mechanical engineering). When coming back for BS activities, these 'old-timers' tell their experiences with BS to new members, coach them to use skills and techniques associated with the current project, and provide scientific information of some subjects related to their majors. One example was observed when BS visited a geological museum during the summer camp 2005. While the teachers of the club stepped aside all the time long, a geology-majoring BS graduator explained high school members what the exhibits represented and responded with answers to their questions. Thus, the student-student mentoring system enables cognitive apprenticeship to be adapted in the instructional process of BS. That is, younger graders learn first by peripheral participation in science activities, then grow intellectually with greater knowledge and skills, and finally become able to teach new members as mentors. This mechanism is also believed to contribute significantly to sustaining and developing the science club for many years.

Concluding Remark

Nowadays science education researchers inquire into educational practices not only in classrooms but also beyond school walls (e.g., research laboratories, museums, Web-based virtual environments) for the purpose of finding and suggesting effective models for science instruction. The present study has shown that the PM, which is associated with the view of learning as the ongoing participatory process in community contexts and the cognitive apprenticeship model for instruction, can provides practical insight to identify exemplary practices in the diverse learning settings. In order to discover useful models for science instruction, however, qualitative research methods, such as participant observation and ethnographical writing, should be applied in intensive and extended manners. It is also necessary for the researchers to develop sound theoretical bases with which he or she can interpret educational and scientific meanings from a variety of people's activities.

References

Ausubel, D., 1985, Learning as constructing meaning. In Entwistle, N. (ed.), New directions in educational psychology: Learning and teaching. The Falmer Press, London, UK, 71-82.

Barab, S. A. and Duffy, T. M., 2000, From practice fields to communities of practice. In Jonassen, D. H. and Land, S. M. (eds.), Theoretical foundations of learning environments. Lawrence Erlbaum Associates, Mahwah, NJ, 25-56.

Barab, S. A. and Hay, K. E., 2001, Doing science at the elbows of experts: Issues related to the science apprenticeship camp. Journal of Research in Science Teaching, 38(1), 70-102.

Bereiter, C., 1994, Implications of postmodernism for science, or science as progressive discourse. Educational Psychologist, 29(1), 3-12.

Bielaczyc, K. and Collins, A., 1999, Learning communities in classrooms: A reconceptualization of educational practice. In Reigeluth, C. M. (ed.), Instructional design theories and models: Volume II: A new paradigm of instructional theory. Lawrence Erlbaum Associate, Mahwah, NJ, 269-292.

Brown, A. L. and Campione, J. C., 1998, Designing a community of young learners: Theoretical and practical lessons. In Lambert, N. M. and McCombs, B. L. (eds.), How students learn: Reforming schools through learner-centered education. American Psychological Association, Washington, DC, 153-186.

Brown, J. S., Collins, A., and Duguid, P., 1989, Situated cognition and the culture of learning. Educational Researcher, 18(1), 32-42.

Collins, A., Brown, J. S., and Newman, S. E., 1989, Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In Resnick, L. B., (ed.), Knowing, learning, and instruction: Essays in honor of Robert Glaser. Lawrence Erlbaum Associate, Hillside, NJ, 453-494.

Crawford, B. A., Krajcik, J. S., and Marx, R. W., 1999, Elements of a community of learners in a middle school science classroom. Science Education, 83, 701-723.

Driver, R., Asoko, H., Leach, J., Mortimer, E., and Scott, P., 1994, Constructing scientific knowledge in the classroom. Educational Researcher, 23, 5-12.

Ertmer, P. A. and Newby, T. J., 1993, Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. Performance

Improvement Quarterly, 6(4), 50-72.

Greeno, J. G., 1995, Understanding concepts in activity. In Weaver, C. A. III, Mannes, S., and Fletcher, C. R. (eds.), Discourse comprehension: Essays in honor of Walter Kintsch. Lawrence Erlbaun Associates, Hillsdale, NJ, 65-95.

Greeno, J. G., Collins, A. M., and Resnick, L. B., 1996, Cognition and learning. In Berliner, D. C. and Calfee, R. C. (eds.), Handbook of educational psychology. Macmillan Library Reference, New York, 15-46.

Greeno, J. G. and the Middle School Mathematics Through Applications Project Group, 1998, The situativity of knowing, learning, and research. American Psychologist, 53(1), 5-26.

Lave, J., 1991, Situating learning in communities of practice. In Resnick, L. B., Levine, J. M., and Teasley, S. D. (eds.), Perspectives on socially shared cognition. American Psychological Association, Washington, DC, 63-82.

Lave, J., 1996, Teaching, as learning, in practice. Mind, Culture, and Activity, 3(3), 149-164.

Lave, J. and Wenger, E., 1991, Situated learning: Legitimate peripheral participation. Cambridge University Press, Cambridge, UK, 138 p.

Maybin, J., Mercer, N., and Strierer, B., 1992, "Scaffolding" learning in the classroom. In Norman, K. (ed.), Thinking voices: The work of the National Oracy Project. Hodder & Stoughton, London, UK, 186-195.

Merrill, M. D., 1991, Constructivism and instructional design. Educational Technology, 31(5), 45-53.

Moscovici, H. and Nelson, T. H., 1998, Shifting from activity mania to inquiry. Science and Children, 35(4), 14-17, 40.

Oh, P. S., 2005, Discursive roles of the teacher during class sessions for students presenting their science investigations. International Journal of Science Education, 27(15), 1825-1851.

Richmond, G. and Kurth, L. A., 1999, Moving from outside to inside: High school students' use of apprenticeships as vehicles for entering the culture and practice of science. Journal of Research in Science Teaching, 36(6), 677-697.

Rogoff, B., 1990, Apprenticeship in thinking: Cognition development in social context. Oxford University Press, Oxford, UK, 242 p.

Rogoff, B., 1994, Developing understanding of the idea of communities of learners. Mind, Culture, and Activity, 1(4), 209-229.

Roth, W.-M. and Bowen, G. M., 1995, Knowing and interacting: A study of culture, practices, and resources in a grade 8 open-inquiry science classroom guided by a cognitive apprenticeship metaphor. Cognition and Instruction, 13(1), 73-128.

Schuh, K. L., 2003, Knowledge construction in the learner-centered classroom. Journal of Educational Psychology, 95(2), 426-442.

Scott, P., 1998, Teacher talk and meaning making in science classrooms: A Vygotskian analysis and review. Studies in Science Education, 32, 45-80.

Sfard, A., 1998, On two metaphors for learning and the dangers of choosing just one. Educational Researcher, 27(2), 4-13.

Smith, M. K., 2003, Communities of practice, the encyclopedia of informal education. Retrieved from http://www.infed.org/biblio/communities_of_practice.

Son, M., 2002, Understandings and misunderstandings of practical knowledge as school knowledge: A reconsideration of demonstration of lessons in science classrooms. The Journal of Curriculum Studies, 20(3), 243-269.

Tobin, K., 1987, Forces which shape the implemented curriculum in high school science and mathematics. Teaching and Teacher Education, 3(4), 287-298.

Manuscript received: 13 January 2006
Revised Manuscript received: 17 February 2006
Manuscript accepted: 27 March 2006