LEARNING IN ACTIVITY

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1. Introduction

In traditional psychology, learning is studied at the level of the individual. This is true of behaviorism, which studies behaviors of individual organisms, and also of cognitivism, which studies mental processes and structures within individuals’ minds. This chapter presents an approach to the study of learning in which the unit of analysis is larger than an individual person—either two or more people, such as a dyad, a group, a classroom, a community, or an individual person working with objects and technological systems. Many learning scientists conduct research at these levels of analysis, and this is part of what distinguishes the field from experimental cognitive psychology, where the usual level of analysis is the individual. We refer to these higher-level learning systems as activity systems because the focus of learning sciences research is often on how people learn by engaging in activities in these systems, such as solving a problem or making or designing something. An activity system can be as large as a classroom of students with a teacher, or as small as a single individual interacting with some text or a programmed computer. Research on activity systems focuses on the ways in which the individual components act and interact with each other, and also focuses on larger contextualizing systems that provide
resources and constraints for those actions and interactions. This definition of activity system is designed to be broad enough to incorporate a range of perspectives that theorize activity systems; these include cultural-historical activity theory (e.g., Engeström, 1987), situated learning (Lave & Wenger, 1991), situated action (Suchman, 1995), distributed cognition (Hutchins & Klauson, 1998), and cultural psychology (Cole, 1996; Rogoff, 2003). We use the term *situative* in this chapter, intending it to refer to the general approach of all these research programs.

In an activity system, regular and recurring patterns of activity are called its *practices*. People who know how to participate in the same shared practices are called a *community of practice*. When individuals want to join a community of practice, at first they do not know how to participate in these shared practices. Consequently, at first they are *peripheral* members of the community, and their learning trajectory gradually leads them toward participating more fully in the community’s practices (Lave & Wenger, 1991).

To illustrate the concept of practices, consider patterns of discourse that occur in school classrooms. Schools are organizations with distinctive practices and for students to learn in the way that is valued by educators, they need to adapt to the practices associated with the activity systems of schools, including participating in classrooms, study groups, and homework.

A type of episode that occurs frequently in school classrooms is labeled IRE or IRF (Initiation, Response, Evaluation or Feedback). The teacher takes the first turn, I, usually asking a question. Then the teacher calls on a student who takes the second turn, R, giving an answer. The teacher takes the third turn, evaluating
the student’s answer, E, sometimes adding additional feedback, providing clarification or elaboration, F (Wells, 1993).

Patterns of turn-taking in brief episodes have been studied intensively by conversation analysts, especially by Schegloff (2007). Schegloff’s analyses focus on adjacency pairs, in which two turns complete a functional unit of conversation. We hypothesize that IRE and IRF units are extensions of a common adjacency pair, QA, a question followed by an answer. In much ordinary discourse, QA functions to provide the questioner with information he or she did not have. In IRE or IRF, the teacher who asks a question knows the answer, and information generated in the exchange is whether or not the answer is known by one or more of the students. IRE and IRF units are common in much school practice (Bellack, Kliebard, Hyman & Smith, 1966; Mehan, 1979; Sinclair & Coulthard, 1975), and occur in the nonschool discourse experience of some young children, but children who participate in different discourse practices at home may be prepared differentially for participation in the discourse practices that they encounter at school.

An important aspect of discourse practices involves how participants are positioned in relation to each other and to the subject-matter being discussed. In IRE and IRF units, the student participant is positioned as someone whose knowledge is being assessed, not as someone who is expected to contribute an idea or information toward progress in understanding an issue in the subject-matter domain. (See Harré & van Langenhove, 1999, and Holland, Lachicotte, Skinner, & Cain, 1998, for discussions of positioning and positional identities.)

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1 Heath (1983) reported that nearly half of the utterances directed toward a two-year-old girl in one family in a 48-hour period, were questions, and of these, 45% were “Q-I questions in which the questioner has the information being requested of the child” (p. 250).
Learning science researcher-designers have developed and studied classroom activities in which students are positioned with different agency than they are when discourse is limited to IRE and IRF interchanges. Engle and Conant (2002) studied interaction of fifth-grade students and their teachers in classroom activities developed in the Fostering Communities of Learners project (Brown & Campione, 1994) as the students worked in groups on projects of writing reports about some endangered species. The analysis focused on the occurrence of an extended debate among the students about how orcas (often called “killer whales”) should be classified, as whales or as dolphins. Engle and Conant hypothesized that conditions for the students’ productive disciplinary engagement included their being positioned with authority and accountability in a practice that encouraged problematizing substantive issues in the discipline and that provided resources that supported the students’ taking, challenging, and supporting positions on these substantive issues. (We discuss another analysis of the data obtained in this classroom setting, by Engle (2006) below.) Learning scientists are working actively with teachers to support them in changing the discourse practices toward positioning with more productive agency. Examples include Mercer (1995), who referred to exploratory talk, Resnick, Michaels, and O’Connor (2010), who referred to Accountable Talk, and Chapin, O’Connor and Anderson (2009), who referred to academically productive talk.

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2 These studies, often in the form of design-based development and research (e.g., Schoenfeld, 2006) are often developed and studied in collaboration with practicing teachers.

3 Both are correct, but the students’ sources were inconsistent. Orcas are classified as being in the same phylogenetic family with dolphins, different from whales, but orcas, dolphins, and whales are all included in the phylogenetic order cetaceans, often referred to as the whales. The “big ol’ argument,” as the students referred to it, that extended over twelve weeks of their activity, was sparked when they were on a field trip to Sea World, where a staff person told them that many people think that orcas are whales, but they’re not — they’re dolphins.

4 Accountable Talk is a registered trade mark of the Institute for Learning, University of Pittsburgh. “In the accountable talk form of classroom interaction, the teacher poses a question
In many societies and throughout history, individuals have primarily interacted in activity systems that contained only other members of the same community of practice. In complex modern societies, and specifically in schools, activity systems often include participants who are members of different communities of practice — this can make their participation problematic (see Eckert, 1990), or the resulting diversity can be a source of creative productivity (e.g., Engeström, 2001).

In the remainder of this chapter, we discuss three issues. In Section 2, we present a framework for analyzing the behavior of activity systems and we discuss a hypothesis that changes in one of the components (expansion of the object or subject (that is, the agent) of activity, as understood by the participants) can be a key component of significant learning by the system. In Section 3, we discuss relations between theories at different levels, specifically between theories that focus on learning by individual participants and theories that focus on learning considered as changes in practices of activity systems. In Section 4, we discuss research on understanding and learning concepts, using the situative perspective that focuses on understanding and learning at the level of activity systems.

2. A Framework for Analyzing System-Level Activity and Learning
This chapter considers learning at the activity-system level of analysis. A framework for analyzing the activity of a system was developed by Engeström (1987) building on Vygotsky’s (1987) theorizing. In Engeström’s framework (see Figure 1), the three major components of an activity system are a subject or agent (which can be an individual but also could be a group of people), an object (what the subject works on), and resources, which the subject uses in its effort to transform the object according to a goal. A guiding assumption of this framework is that an activity system has the goal of transforming the object toward a desired outcome. This is particularly true of activity systems that occur in learning environments, because they have the goal of leading learners toward a desired learning outcome.

![Diagram of the activity system](image)

Figure 1. The structure of an activity system (from Engeström, 1987, p. 78).

To illustrate use of this analytical scheme, consider a task analyzed by Hutchins (1995), constructing a fix of the position at sea of a vessel of the U.S. Navy. This task was performed often by a team of ten seamen and officers, at least once per hour when the ship is in the open sea, at least once every 15 min
when the ship was in sight of land, and at least every three minutes when the
ship was operating in restricted waters. The object of the activity was the ship’s
position in the water and its representation on a chart and in the ship’s log. To
take a position fix near land, individuals on the deck sited designated landmarks
using instruments called alidades, which provide numerical measures of the
directions between the ship and the landmarks. These were communicated via a
television line to the room on the ship’s bridge where an officer drew lines,
called Lines of Position, on a chart from each of the landmarks in the directions
reported from the deck. Three Lines of Position were drawn. If they could have
been exactly accurate, they would intersect at a single point on the chart. In
practice, they formed a triangle, and if the triangle was small enough, the
position of the ship, represented on the chart, was judged to be determined
satisfactorily. Finally, the officer drew a line from the determined position in the
direction corresponding to the ship’s current bearing, and of a length
corresponding to the ship’s current speed, to indicate the projected path of the
ship during the next time interval, and another officer recorded the ship’s
position and the time of the fix in the ship’s log.

Using Engeström’s scheme, the subject (or agent) of this activity was the set
of naval personnel assigned as the Sea and Anchor Piloting Detail, and the object
was the ship’s position at the time of the fix and its representation. Before the fix
was taken, the ship lacked such a representation, and as a result of the activity,
one came into being. There were resources used in achieving this, including the
alidades used to site landmarks, the telephone lines used to communicate to the
officer who drew Lines of Position, and the chart itself.
An analysis of learning by an activity system involves identifying a change in the practices of the system and giving an account of how that change was accomplished. In several recent studies, analyses of learning at the level of activity systems have concluded that an important aspect of learning was an expansion of the subject’s understanding of the object. For example, Engeström (2001) found that a group of children's caregivers expanded the object of their activity from discrete single consultations to long-term care relationships involving more cooperation and communication across administrative units.

At least since the provocative theorizing of Bateson (1972), the idea of shifts between qualitatively different levels or types of learning has influenced researchers. The idea of shifts implies the possibility of a radical expansion of the scope and impact of learning in an activity system. In the situative perspective, such expansive potential or expansivity is an important quality of learning in activity. This idea provides hypotheses about a distinction made by theorists of organizational learning, notably by Argyris and Schön (1978) as the distinction between “single-loop learning” and “double-loop learning”. Single-loop learning is generally simpler than double-loop learning. In single-loop learning, a modification of practice can be accomplished by adding to or altering some aspect of activity without changing underlying understanding of the agency of participants, the goals of the activity or the uses of resources that can be relevant for achieving the system’s goals. Double-loop learning involves a change in the participants’ understanding of some fundamental aspect of the activity. Double-loop learning can bring about a radical expansion of the scope and impact of activity in a system. Such expansive potential or expansivity is an important quality of learning in activity.
The notion of expansion was theoretically elaborated by Engeström (1987), and the theory of expansive learning has generated a line of studies reviewed by Engeström and Sannino (2010). This line of research is designed to analyze situations when the conception of the object of learning is itself changed during the activity. An example would be the expansion of the object of a health care activity from a discrete single consultation to a long-term care relationship involving various caregivers (Engeström, 2001). This example illustrates the multi-dimensionality of expansion, minimally including a temporal and a socio-spatial dimension (Engeström, Puonti & Seppänen, 2003). The learning challenge for the participants is to acquire mastery of work on the expanded object, while designing and implementing the necessary changes in the activity system. Another example would be the shift in organization of classroom discourse, which we mentioned in Section 1. A limited version of the object of classroom instruction is for students to acquire routine knowledge and procedural skill, so they can perform well on tests in which they need to recite accurately or apply procedures correctly. A more expansive understanding of the objective of instruction is for students to understand concepts and principles of a domain and develop productive habits of mind that support productive and generative use of concepts and principles. Learning scientists are engaged in research and development that investigate conditions in which this more expansive object of learning can be enacted.

Another aspect of activity that can be involved in double-loop learning is the role of the subject (or, alternatively, the agency of the participants). An example is provided by Ginnett’s (1993) early study of airline crews at work. Ginnett had the opportunity to observe and compare the performance of two kinds of captains:
those assessed by check airmen as being exceedingly good at creating highly efficient teams (HI-E captains) and those who received low ratings on this same ability (LO-E captains). The performance Ginnett observed was a formal crew briefing before the first leg of a new crew complement, conducted in the terminal 1 hour before departure. The most interesting finding had to do with how the captains talked about the crew boundaries. The HI-E captains worked to expand the team boundaries. They included in “we” the total flight crew, as opposed to some of the LO-E captains who only included the cockpit crew and referred to flight attendants as “you.” The HI-E captains also tried to include gate personnel, maintenance, air traffic controllers, in some cases even the passengers as part of the group – not as outsiders (Ginnett, 1993, p. 87).

Ginnett also found that the best captains kept “elaborating and expanding” the routines of the crew (Ginnett, 1993, pp. 96–97). In Ginnett’s data, such expansive moves were initiated by skilled captains who had the courage to deviate from the routine by “disavowing perfection”: “They make a statement suggesting they don’t know something about a particular issue even though the information is often quite readily available. (...) They are open about dealing with their own vulnerabilities” (Ginnett, 1993, p. 90).

In another example, Engle (2006) hypothesized that expansive framing of interactions (as opposed to restrictive framing) during learning plays an important role in the results of learning being productive, that is, in its resulting in transfer. Expansive framing includes an expansive understanding of the object of learning and an understanding of agency that includes learners actively participating in the construction of their knowing and understanding of the
subject matter. The idea of expansive framing was developed further and evaluated further empirically by Engle, Nguyen, and Mendelson (2011). According to these authors, “contexts are framed expansively as opportunities for students to actively contribute to larger conversations that extend across times, places, people, and activities” (Engle, Nguyen and Mendelson, 2011, p. 605). The boundaries of expansive learning contexts are framed as being wide-ranging and permeable, increasing the number of contexts that can become linked with them.

These ideas of contextual expansion of learning are well in line with key tenets of the theory of expansive learning. The learning of new skills and concepts may be radically enhanced when those skills and concepts are not handled as isolated actions of answering “what?” and “how?” questions but are instead embedded in envisioning and constructing the structure and future of the entire activity system, that is, answering “why?” and “where to?” questions. This aspect of expansion might be characterized as contextualizing or anchoring upward (Engeström, 1990, p. 194).

In recent studies of learning, the notion of “learning object” has been systematically used by Marton and his colleagues (e.g., Marton & Tsui, 2004; Marton & Pang, 2006). Marton distinguishes between three aspects of the learning object, namely the (a) instructor’s intended object of learning, (b) the enacted object of learning which “defines what it is possible to learn in the actual setting” (Marton & Tsui, 2004, p. 4), and (c) the eventual outcome as the student’s lived object of learning (Figure 2).
Marton’s conceptualization reveals that there may be serious discrepancies or mismatches between the three perspectives on the object of learning. Especially for studies of learning in activity systems, Marton’s conceptualization is also problematic. The intended object is depicted as a monopoly of the instructor. However, also learners have intentions. Their life interests and work concerns may become intended learning objects that may more or less openly compete or clash with the intended object of the instructor. This is the issue of learners’ agency emphasized in studies of expansive learning (e.g., Sannino, 2008; Engeström, 2011). It calls for an extended version of Marton’s conceptualization (Figure 3).
Expansive learning understood as expansion of the object or the subject (agent), or both, of an activity is typically a lengthy process that calls for longitudinal research designs. To facilitate and compress processes of expansive learning in activity systems, formative intervention methods such as the Change Laboratory (Engeström, 2011; Virkkunen & Newnham, in press) have been developed. A Change Laboratory typically consists of about ten weekly sessions in which practitioners of an activity system (or multiple collaborating activity systems) analyze developmental contradictions in their activity, design a new object and a corresponding new pattern for their activity, and take steps toward implementation of the new design. The relatively compact format of the Change Laboratory allows for effective data collection and detailed analysis of steps and interactions in an expansive learning process. Recent analyses have focused on discursive manifestations of contradictions (Engeström & Sannino, 2011) and
cycles of learning actions (Engeström, Rantavuori & Kerosuo, 2013) in Change Laboratory interventions.

Expansive learning entails debates and negotiation between different perspectives on the learning object. In Change Laboratory interventions, this is typically manifested in the form of deviations from the initial plans and intentions of the interventionists, as the participants take over and redirect the course of learning by means of articulating novel versions of the object (Engeström & Sannino, 2012; Engeström, Rantavuori & Kerosuo, 2013).

These sequences resemble the processes described by Gutiérrez and her co-authors (Gutiérrez, Rymes & Larson, 1995; Gutiérrez, Baguedano-López & Tejeda, 1999; Gutiérrez, 2008). Gutiérrez and her colleagues analyzed how the gap between the instructor’s object or authoritative “script” and the learners’ object or “counter-script” led to collisions and conflicts. Occasionally the parties found common ground on which they could build an expanded hybrid object for meaningful negotiated learning. Gutiérrez and her colleagues characterize these events as emergence of “third spaces” in the teaching-learning process.

The expanded hybrid object may emerge by means of fairly straightforward mapping of the learner’s object of vital interest onto the instructor’s intended object. An example is shown in the Brazilian film City of Men (2007). A teacher in the primary school of a favela tries to teach the students the history of Napoleonic wars but faces mainly indifference, resistance and disturbance. As the conflict is aggravated and a field trip promised to the students is about to be canceled, a boy suddenly comes up with his own account of the unfolding of the Napoleonic wars, explaining them in some detail in terms of the gang wars in the favelas. This depiction of recruiting a perspective of a
learner illustrates an important general idea that Luis Moll and his colleagues refer to as Funds of Knowledge (González, Moll, & Amanti, 2005), in which perspectives and knowledge that is held in a community are recruited to diversify and authenticate the contents of school instruction.

In Change Laboratory interventions, an expanded object of learning is more commonly worked out by means of inventing a novel idea or model that deviates from both the intended object of the interventionist and from the initial interests of the practitioner-learners. Such a novel idea is often suggested by one or a few learners in opposition to both the interventionist and some of the other learners and it may take repeated efforts to gain reception and support from them (Engeström, Pasanen, Toiviainen & Haavisto, 2005; Engeström, Rantavuori & Kerosuo, 2013; Sannino, 2008).

3. Patterns of Explanation Involving Activity-System-Level Phenomena and Concepts

In traditional cognitive psychology, studies of learning focus on knowledge or changes in knowledge and capabilities of an individual person. With laboratory methods, the individual learner is intentionally removed from the usual contexts of learning. If other people, materials, and practices are considered or theorized by cognitive psychologists, they are considered to be a context for what that individual does and learns. This is in contrast to the situative perspective we present in this chapter. However, the cognitive perspective and the situative perspective are not incompatible; rather, we argue that analyses of learning and cognition that focus on individuals and analyses that focus on activity systems are complementary. In Mitchell’s (2003) integrative pluralism, alternative
explanations can be developed that attribute causal functions to different aspects of complex processes that occur in the domain and that can contribute to understanding by identifying multiple factors that operate. A common way for alternative theories to be complementary is for them to pursue explanations of the same phenomena at different levels of analysis, and this is the relationship that holds between analyses of learning by individuals (associated with cognitive psychology) and learning by and in activity systems (associated with the situative approach we describe in this chapter).

A focus on activity systems can provide three different forms of explanation of how learning happens, two of which involve integrative links between individual and activity-system levels of theorizing:

1. An individual learns by participating in an activity system, and that individual’s learning is explained by properties and processes within the activity system. One might call this a “top down” explanation, because learning of one component of the activity system—one participant—is explained by the activity system.

2. The activity system as a whole learns, and that learning is explained in terms of mental representations and behaviors of the participating individuals. This would be a “bottom up” explanation, sometimes referred to as a reductionist, individualist, or mechanist explanation.

3. The activity system as a whole can be said to “learn”—when practices evolve, or interactional routines change, over time. A third type of explanation explains learning of the activity system in terms of properties and processes of the activity system. This would be a horizontal form of explanation, because the cause and the effect are both at the same level of analysis.
Traditional cognitive psychology focuses on a fourth form of explanation: explaining how an individual learns in terms of properties, processes, and behaviors of that individual. This form of explanation is horizontal and generally neglects the role of activity systems, shared social practices, and context in learning.

**Pattern 1: Individual Learning Phenomena Explained by System-Level Hypotheses.** In one pattern, the phenomenon to be explained is learning by one or more individuals, and the explanatory concepts and variables are properties of activities in multiperson activity systems. In other words, changes in individual cognition are explained in terms of concepts and hypotheses about activity in a larger system (Figure 4).

![Diagram](image)

**Figure 4. Individual learning phenomena explained by system-level hypotheses**

One example is a study of teaching and learning a concept of place value, by Bowers, Cobb, and McClain (1999). The teacher (McClain, a co-author) led her
third-grade class in activities of representing, calculating, and reasoning about quantities that included diagrams that distinguished single objects, groups of ten, and groups of one hundred. Individual students were interviewed before and after this instruction, and they gained in their conceptual understanding of the quantitative meanings of numerical symbols and operations. The desired learning outcome was attained, and it was causally explained in terms of properties of the activity system—the activities and practices associated with the teacher’s lesson plan.

In another example, by Moss and Case (1999), fourth-grade students participated in classroom activities—collective practices—designed to advance their understanding of concepts and representations of rational numbers. Moss and Case found that the activities they had designed were effective; the individual students in the classroom attained the desired individual learning goals, and the learning was again explained as a causal outcome of participation in the collective practices.

In these classroom examples, the independent variables—the phenomena to be explained—were learning outcomes at the individual level of analysis: changes in the answers given by individual students to questions posed by interviewers, or performances on tests. These learning outcomes were explained as due to the activities that the students had participated in. The activities included using and discussing representations of objects with quantitative properties; these objects were interpreted as referents of numerical symbols that were used to pose problems involving arithmetic operations. Referring back to Figure 1, in these classroom activities, the objects were students’ knowledge and understanding of meanings of numerical expressions, which can support
their success in answering questions about quantitative properties of pictorial or spatial embodiments, and answers were found by reasoning about quantities with numerical representations. As a result of participating in these practices, individual students came to interpret numerical symbols as referring to quantities and their reasoning was more successful.

The investigators explained these findings by arguing that students learned about properties of quantities by participating in these instructional activities. Bowers et al. (1999) also characterized an aspect of the classroom participation structure that they hypothesized to be relevant to students’ learning. Bowers et al. discussed norms of interaction, including general social norms (e.g., attending to others’ solutions and explanations) and socio-mathematical norms (e.g., using quantitative terms in explanations), and reported that the teacher and students attended to the establishment of these norms. In Figure 1, these norms function as rules of practice that constrain the classroom’s discourse activity. (These rules also function as resources, which facilitate participation shaping ways in which members of the system interact with each other as they collaborate in activity.) The norms also relate to the way in which responsibility for different aspects of activity are distributed among the participants (the division of labor), by expecting students to develop meaningful explanations of their work, not just procedures that result in correct answers.

Engle (2006) also documented conceptual learning by individual students that resulted from their participation in an activity system. Engle studied fifth-grade students who worked in groups to write reports about endangered species. The students’ explanations and evaluations of habitats were more advanced after they participated in an activity in which they were asked to discuss habitats for
species different from those they studied in their projects. This enhanced learning was demonstrated in interviews with individual students, and also in evaluations by the group. Engle (2006) also examined records of students’ interactions with their teacher during the students’ work on their report, and found that the teacher frequently framed students’ contributions in ways that attributed authorship to a student rather than to the source; the teacher attributed generality to the source and to the information that the student contributed. Engle referred to this pattern of interaction as expansive framing, and subsequently conducted another empirical study and found that when a tutor (Engle) used expansive framing, students were able to transfer their learning to new contexts more successfully than students in a control condition (Engle, Nguyen & Mendelson, 2011). Like the classroom examples by Bowers et al. (1999) and by Moss and Case (1999), we propose that the instructional activities in Engle’s studies involve changes in the object of activity (see Figure 1). In other words, the content of the knowledge to be learned was not presented as static facts, to be memorized; rather, it was transformed into a different category—one of active engagement with material and knowledge building. The students’ activity could have been presented as constructing text only to satisfy the requirements of an assignment; instead, the teacher framed students’ contributions as having significance for broader audiences and for events on a broad time scale. And this resulted in deeper conceptual learning and greater transfer.

The research we have reviewed in this section demonstrates that activity systems and their practices are not independent from the individual-level learning that participants undergo; for example, as Engle et al. (2011) showed,
differences between positioning students in expansive framing vs. bounded framing can result in differences in transfer that is assessed at the level of individuals. To develop a complete explanation of learning in activity, we need to include descriptions of aspects of participation in activity systems and also descriptions of the learning outcomes of individuals.

*Pattern 2. Explaining changes in activity systems in terms of the individual participants in the system.*

In this explanatory pattern, “learning” refers to a change over time in the activity system as a whole; for example, patterns of participation in joint activity may change (Rogoff, 1990), or the sequences of an interactional routine may evolve. In Pattern 2, changes in activity systems are explained in terms of how actions and interactions of components of the system result in the learning and cognitive performance of the system.

In an example of Pattern 2, Hutchins and Klausen (1998) used the concept of *distributed cognition* to explain the process whereby an airplane crew successfully made a case that supported their request to be cleared to change the altitude of their flight. The crew’s explanation of the need to change altitude depended on knowledge that no single member of the crew possessed, so their success depended on coordinating and combining their individual knowledge into a coherent argument. Distributed cognition has also been documented by Hutchins (1995b), who analyzed how the crew members of an airplane cockpit, supported by material resources, remembered to change the settings of flaps and slats during the plane’s descent toward landing. Hutchins (1993; 1995a) also analyzed conditions of participation by members of the navigation team of a naval ship, focusing on the opportunities that participation afforded for junior
members to learn the capabilities that would be needed as they advanced in rank
and to master the responsibilities for performing more complex tasks in the
team’s activity. Hutchins documented that the success of the learning
environment provided by that activity system resulted from an aspect of their
working arrangement in which the more junior members had access to the
information that was communicated and what was done with that information
by more advanced members of the team.

In this pattern of explanation changes in an activity system using hypotheses
about individual components, integration can be advanced by constructing
explanations of events at the level of activity systems that characterize
mechanisms at the level of individual learning and cognition that in turn explain
phenomena at the level of activity systems.5

Figure 5. Explaining changes in activity systems in terms of the individual
participants in the system

5 We adopt a concept of mechanism that has been developed by Machamer, Darden, and
Craver(2000). A mechanistic explanation hypothesizes a set of entities that behave in a way that
produces a functional result in a system.
This was exemplified in an analysis by van de Sande and Greeno (2012), who reported cases in which participants in problem-solving discourse succeeded in reaching mutual understanding after there was a lack of understanding by at least one of them. van de Sande and Greeno accounted for these cases by hypothesizing a kind of mechanism in which constituent entities were the components of activity systems, and these individuals (persons, and in one case, an interactive computer program) constructed contributions to their common ground (Clark & Schaefer, 1989) that resulted in their achieving sufficient alignment in their framings to support their continuing to work jointly on the problem.

**Pattern 3: Activity-System-Level Phenomena Explained by Hypotheses of activity-system properties.**

Nersessian et al. (2003) studied a biomedical engineering lab, where the main project was to discover a way to synthesize artificial blood vessels that could function in human bodies. They referred to the lab as a *distributed cognitive system*. They defined learning at the level of this activity system: learning was defined as a change in the capabilities of the entire lab to conduct research and develop artificial systems. Components of this system-level learning included modifications in the material devices that the researchers developed and used, as well as changes in individual researcher’s understanding of the functioning and history of these synthetic devices. They documented a learning trajectory that involved modifications of devices along with changes in a researcher’s knowing and understanding. Nersessian et al. referred to this trajectory as the development of a *cognitive partnership*. The explanatory concepts that Nersessian et al. proposed are to consider the lab as a *problem*...
space, and to consider problem solving as *distributed model-based reasoning*, in which researchers and devices combine in a complex socio-technical system that collectively increases its capabilities. Nersessian et al. explicitly contrasted these concepts with traditionally individualist cognitive psychological notions. For example, the idea of a “problem space” was originally proposed as a type of mental representation (Newell and Simon, 1972) and the idea of reasoning by representing a process with a mental model was likewise originally hypothesized to be an internal cognitive process (by Johnson-Laird, 1983, and others).

![Diagram](image)

Figure 6. Activity-system-level phenomena explained by hypotheses of activity-system properties

The research we have reviewed in this section demonstrates the value of explanations at the activity-system level of analysis, particularly when the phenomenon to be explained is transformation, change, and learning that occurs
in the activity system as a whole, rather than the learning of any one participant only.

4. Learning concepts in activity

Much learning sciences research has emphasized the importance of deeper conceptual understanding, as opposed to a form of learning that results only in memorization of disconnected facts (Sawyer introduction, this volume). Experimental cognitive psychologists have mainly limited their studies of learning concepts to the task of learning rules for classifying stimuli. In this section we present a broader view, in which we consider concepts as resources that participants in activity systems use as they communicate about significant aspects of their activity. In this view, we assume that “concepts and their meanings develop and evolve in settings of practice and are maintained in practices because they are useful in conducting the community's activities” (Hall and Greeno 2008, p. 213). In particular, with “functional concepts” (Greeno, 2012)—those that are shaped and used as integral resources in the daily practices of collectives as individuals—a situative approach is valuable.

To illustrate the distinction between formal and functional concepts, consider the example of instruction of the concept of place value in addition and subtraction by Bowers et al. (1999), which we discussed in Section 2. The concept of place value is defined formally, with values of digits in different places equal to multiples of powers of ten, and rules for carrying or borrowing that can be applied without reference to quantities that the numerals refer to. In the Candy Factory microworld that Bowers developed and McClain used in her teaching, objects were shown called pieces, rolls (containing 10 pieces) and
boxes (square displays containing 100 pieces or 10 rolls), and operations of packing (pieces to rolls or rolls to boxes) and unpacking (boxes to rolls or rolls to pieces). The computer program supported activities in which students reasoned functionally about manufacturing or taking away quantities of candy and, in parallel, they reasoned formally about adding or subtracting numbers, represented by numerals, and McClain’s teaching emphasized coordination of these two uses of the concept of place value, with apparent success for the students’ understanding.

Functional concepts, and functional uses of concepts, such as the functional reasoning about place value in Bowers et al.’s (1999) study, provide common ground (Clark & Schaefer, 1989) or anchors (Hutchins, 2005) that help communities communicate more smoothly and efficiently. To perform this role, a functional concept must be shared by many people. And because they are embedded in shared situated activity, functional concepts are often distributed across people as well as tools and artifacts that are used in the activity.

Functional concepts have some flexibility or “play” (Derrida, 19**; Löwy, 1992): they change over time as they are used, contested and debated in practice.

In a system’s activity, for example, in working on understanding and solving a problem, the concepts that are known by the participants function as resources. In Engeström’s framework (Figure 1) concepts are among the tools that the subject can draw on in the activity of working to transform the object according to the system’s goal. It can be productive to consider a conceptual domain metaphorically as a space, and learning its concepts as becoming able to move around in the space, recognizing conceptual resources that can be used productively in activity. Considering a domain of concepts as analogous to an
environment supports the general situative idea that reasoning and problem solving are carried out by systems, which comprise an individual person or persons interacting with other systems that provide resources for the person’s or persons’ activity.

This idea also fits with Davydov’s (1990) version of becoming adept at ascending to the concrete, where the conceptual field may have numerous conceptual germ cells that are interrelated, and someone, or a group, is adept at recognizing the potential utility of these conceptual resources. Greeno (1991) and Schoenfeld (1998) proposed that a conceptual domain, such as mathematics, may be thought of metaphorically as a physical environment. Schoenfeld’s particularly apt version considered knowing and understanding mathematics as analogous to an expert cook’s knowing and understanding the properties of ingredients that can be used to contribute to the flavor and texture of a dish that he or she is deciding to prepare, along with the cook’s knowledge of procedures that are performed in its preparation. Greeno pointed out that learning to move around in an environment is much more effective when one does it with the help of others who are already familiar with the environment.

Adrian Cussins’ theory of cognitive trails (Cussins, 1992; 1993) is a philosophical theory of embodied cognition where the basic metaphor is that of a person moving in a territory. The key concepts are perspective-dependence (PD) and stabilization. Imagine a person standing somewhere in the middle of a city. The person’s ability to find his or her way to any desired location regardless of the person’s initial position is called perspective-independence. In such case, the PD ratio is high - close to 1. The PD ratio is close to zero when the person is completely unable to find his or her way to any desired location in the territory.
People learn to move around in a territory by moving around in the territory. In so doing, they make cognitive trails. According to Cussins, trails are in the environment, but they are also cognitive objects; they are experiential but also relatively durable environmental markings (Cussins, 1992, p. 673-674).

As multiple trails are marked, some trails intersect. Intersections are landmarks. A territory is structured by means of a network of landmarks. Such structuring means increasing the PD ratio. Along with the PD ratio, there is another dimension that characterizes the development of cognitive trails, namely stabilization. Stabilization may also be characterized as blackboxing, as it draws a demarcation line around a phenomenon that is in flux (Cussins, 1992, p. 677). An important way in which stabilization is achieved is by naming, that is, imposing a linguistic structure on experiential structure (Cussins, 1992, p. 679-680). In Figure 7, the point of maximum generality is depicted with the help of an oval. This is where concepts emerge.
Figure 7. Generality as high PD ratio and high stabilization (Cussins, 1992, p. 683)

Cussins depicts cognition as "appropriate spiraling" in the two-dimensional terrain depicted in Figure 3. He calls this movement “virtuous representational activity” (Cussins, 1993, p. 249-250).

In communities and workplaces, cognitive trails are typically made in multi-party encounters, discussions and debates. The trails become manifest when there are attempts at stabilization and generalization. In other words, collectively and discursively produced cognitive trails are identifiable by attempts at articulation of explicit ideas or concepts, typically in the form of proposals or definitions.

The anthropologist Tim Ingold (2007) makes a distinction between two modes of movement, namely wayfaring and transport. Wayfaring is the
fundamental mode by which humans inhabit the earth. The lines of wayfaring are typically winding and irregular, yet comprehensively entangled into a close-knit tissue. They have no ultimate destination with which they are seeking to link up. The lines of transport, on the other hand, are typically straight and regular, and intersect only at nodal points of power (Ingold, 2007, p. 81).

Ingold associates the rise of transport with the emergence of capitalist modernity. Wayfaring thus represents the pre-modern, and also the true essence of being human. In this sense, while powerful, Ingold’s account is a dichotomous simplification of history.

In the accounts of Cussins and Ingold, the maker of the cognitive trails, or the wayfarer, is tacitly depicted as an individual moving in relatively pristine space. What is missing in these theories is interaction between wayfarers’ trails and already existing stable lines of transport vested with power. The Cussins-Ingold line of analysis needs to be complemented with the notion of encounters between the old and the new.

The findings of a study by Wagner (2006) are consistent with both diSessa’s idea of knowledge in pieces (see diSessa, this volume) and with the idea that conceptual learning is primarily a process of expansive learning. Wagner interviewed a college student who was taking a statistics course, repeatedly assessing her understanding of the conceptual relation between the size of a sample and properties of the probability distribution of sample means. Wagner found that over time, the student applied the concept of a distribution of sample means in more situations. Wagner interpreted this finding as an example of the idea that learners increasingly learn to respond to features of situations that afford use of a concept, which diSessa and his associates call read-out strategies.
This is consistent with the general idea of expansive learning, as the range of situations in which a concept can be applied expands as the individual learns.

Wagner argued that abstractness is not the key to understanding transfer, but rather that knowledge supporting transfer must somehow account for contextual differences across activities. According to Wagner, in his case study transfer was not supported primarily by the subject’s ability to state her rule in general terms; “rather it was by an expansive set of underlying, context-dependent knowledge resources and coordination knowledge that permitted her to understand how her rule could be recognized as useful and sensibly applied in varying circumstances” (p. 10). Here expansion refers to the range of situations or contexts: “The span of situations to which her rule applied was expanding.” (p. 46) Our interpretation of Wagner’s findings also comports with the idea of learning in a conceptual domain as a process of coming to know where to find and how to use resources in a metaphorically spatial environment.

5. Conclusions

Our chapter attempts to show that the situative perspective on learning in activity is facing new challenges and possibilities that require continuous development of the theoretical and methodological repertoire of the researchers. We have tried to demonstrate that analyzing learning in and by activity systems can significantly enrich our understanding of human learning processes. An activity system as we have characterized it is a more specific and analytical lens than the rather global notion of “organization” used in studies of organizational learning. It offers a way to examine learning beyond the individual without losing sight of the learners as individual subjects.
Our focus on activity systems allowed us to identify three patterns of explanation of learning that occurs through participation in activity systems, two of which contribute to integration between individual-level and activity-system-level learning. Each one of these three patterns is an important extension to the perspective of traditional cognitive psychology. Together the three patterns represent a demanding challenge for learning scientists. It is important that studies of learning in activity are explicit about their choice of the pattern. The most demanding task will be to conduct studies that bring together the three patterns and provide complementary lenses on multi-level learning processes.

We have argued that focusing on expansion of the object of the activity can offer a powerful way to conceptualize learning across the levels of the three patterns. The expansivity of learning is still a relatively poorly understood potential that requires further research. We pointed out two aspects of expansivity, one focused on the object and the other one focused on the context of learning and the ways in which members of the activity system, especially students, participate in the learning process. Exploration of the relationship between these two is a promising avenue for future research.

Situative perspectives on learning have sometimes been understood as rejection of the importance of conceptual learning. We find this reading mistaken and argue that concepts are foundational for in-depth learning of any domain. But concepts are not merely verbal or symbolic labels or definitions. In particular functional concepts embedded in the practices of an activity system are also distributed among material artifacts and embodied enactments of the participants. We suggest that for the study of the learning of concepts in activity, the metaphor of movement in space may be productive. This is another new
challenge for research in the learning sciences, and ideas suggested by philosophers and anthropologists such as Cussins and Ingold should be carefully examined as potential resources for the endeavor.

REFERENCES


