Theories of learning: What now?

From Activity Theory to Situated Cognition

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In a recent issue of *Vinculum* (September 2001 pp 8-13), I reported on developments of a socio-cultural theory of learning: **activity theory**. I focused on some of Vygotsky's and his colleagues' contributions to the psychology of learning, and mentioned briefly that there have been other developments in recent times.

One major development of the quiet revolution towards theories that see knowledge as socio-contextual has been the unfolding of theories of **situated cognition**.

As in socio-cultural theories such as Vygotsky's activity theory, knowledge for situation cognitionists is held in the social sphere, by groups of people - but the theory develops this idea further.

With situated cognition, common concepts, patterns of action and interaction, and tools used are not only shared, but are shaped by interaction with the situation and also help to shape the situation. Thus action takes place not merely in or on an environment, but with it. Note that situatedness here is not merely physical. "It is not possible to walk into a situation. Instead, language use and, thus, meaning are situated in interested, intersubjectively negotiated social interaction" (Lave, 1991, p. 67).

Situated cognition is not just one theory, but a growing theoretical movement that had its roots in neo-Marxist theories of practice (e.g. Lave & Wenger, 1991), from philosophical situation theory (Barwise and Perry, 1983), and Deweyian pragmatism (e.g. Schön, 1983).

In fact, situated cognition is not a theory of knowledge or learning as much as a theory of social practice - a theory about the ways that humans interact in social settings, of which learning is only one dimension.

Situated cognition is not a single view, but one that "generates interconnected views of perception, cognition, language, learning, agency, the social world, and their interrelations" (Lave, 1988, p. 66). Clearly it developed out of activity theory, but is still very much "work in progress" (Kirshner and Whitson, 1997, p. 4).

Some key principles of situated cognition

Important features of the theory of situated cognition, that will be considered, successively, include:

- Cognition is situated in communities;
- Community goals;
- Dialectic relationships;
- A mind-body-environment nexus; and
- The tool of language.

• Cognition is situated in communities

It is not often that we think of activity as knowledge, but one key idea of situated cognition is that situated activity is "a distributed form of cognition" (Lave, 1988, p. 1). This means that certain common understandings are played out by groups of people involved in shared practices in particular settings. Whether they be architects, sport participants, principals, teenagers, members of parliament, publishers, or mathematics teachers, there are patterns of activity that need to be learned by neophyte participants if they are to become true and active members of the group.

This idea of knowledge being bound in particular contexts is not difficult to accept. As teachers, for example, we know that many of the tools (including words and patterns of language use, aids to teaching and learning, traditional behaviours and ways of reacting) that are common in classrooms but rarely used elsewhere. We know, too, that the concepts and procedures taught in school mathematics are somewhat different from those that children would meet in non-school contexts and even different from those used by expert mathematicians.

The theory of situated cognition does not say that such transfer is impossible - we all know that that is not the case because we see evidence of successful transfer frequently. It does recognise though that transfer is not a simple process and that the ability of a person to transfer knowledge from one context to another should not be taken for granted. The knowledge must be re-created in each new context by cognitive activity, and perhaps some trial and learning. This has implications for both teachers as well as curriculum developers, so I will return to this point below.

• Community goals

The best known exponents of situated cognition theory, Jean Lave and Etienne Wenger (e.g. 1991) raised the notion of learning as being distributed among co-participants in any social situation. Here the theory differs from constructivism - as do all theories that have been developed in the socio-cultural field - in that knowledge is created by social groups acting together.

Individual "learning" is not separate from participation in social activities or from changes in a social identities.

In relation to mathematics education, there are many relevant communities of practice that have their own typical ways of thinking and working, including, learners, textbook authors and publishers, parents, academics, curriculum developers, and mathematics teachers. Mathematics students need to come to grips with what it is to be a member of a community of learners in a classroom and school, and also what it is to be a mathematician - or at least a school mathematician, for most mathematicians say there is little in common between the way mathematicians work and the way school mathematics works.

The learning of mathematics, like any learning, is a process of socialisation into a community of understanding.

Each context has its mentors and role models, so the notion of apprenticeship has proved useful in the theory of situated cognition. In any community of learners, initially neophytes participate on the periphery but increasingly they take on more dominant roles and participate in ways that shape the setting and its activities (Lave and Wenger, 1991).

Lave and Wenger later termed this **"legitimate peripheral participation"** (1991, p. 40). In the apprenticeship model, both the ways in which work is produced and the nature of mastery are shaped by "old timers" through social interaction - including but not restricted to modelling.

> "Apprentices learn to think, argue, act and interact in increasingly knowledgeable ways, with people who do something well, by doing it with them as legitimate peripheral participants" (1988, p. 19).

Their participation becomes more central as their skills and knowledge grow, forming a bridge between the individual and the warranted practices of the community. While "newcomers" have some agency in this process they learn mainly by participation in community activity.

The partial participation by newcomers is by no means 'disconnected' from the practice of interest. Furthermore, it is also a dynamic concept. In this case, peripherality, when it is enabled, suggests an opening, a way of gaining understanding through growing involvement. (Lave and Wenger, 1991, p. 37)

The notion of **cognitive apprenticeship** (Brown, Collins, & Duguid, 1989) is also used in recognition that any social context has a body of ideas-in-action that learners need to come to grips with..

The sequences of interaction that need to be learned are aligned to different group goals. For example, most teachers use a "teacher question / student response / teacher comment" pattern of interaction frequently in their classrooms.

Pause for a moment to list mentally some of the reasons why we use this common tool of the trade. My response here would include:

- leading a discussion of relevant content ideas forward as a logical progression of main ideas;
- assessing what children know and keeping account of growing understandings; and
- controlling behaviour and noise.

But you probably thought of some other equally valid goals.

Students usually participate willingly in this pattern of interaction, and you might want to reflect on how their likely goals might differ from your own. Lave (1988, 1991) articulated a common goal for learners when they wrote that many neophytes in workplaces are likely to be cognisant of distinctions between:

(a) valued knowledge and practices, and

(b) what they themselves know and contribute, and thus to be clear about what needs to be learned and practised.

If the students' goals do not match the teachers' closely, at least with both sides showing an acceptable level of looseness and tolerance, then a less familiar sequence of interactions results. The challenge to the situation (either desirable, like when a student expresses an unexpected insight; or undesirable when a student refuses to respond of gives a very inappropriate response) changes the familiar pattern of interaction. Adrenalin levels rise, other students get involved and their roles change, traditional power relationships are challenged, and interpretations are often afforded a higher level of ambiguity. Such transactions might be effective in that they contribute to the feeling that the classroom participants are making some kind of sense together; but in destructive transactions some participants will be losers-and, in fact, the situation and everyone in it will be affected because future reliance on the tool is never quite so predictable.

• Dialectic relationships

Dialectical (i.e. dual-aspect) relationships exist where what might be thought of as separate components are recognised to be two sides of the same coin - one cannot exist without the other. Situated cognition dissolves (or interconnects) the dualism between what is learned and how it is learned (i.e. knowledge and activity), as well as between knowledge and its uses (knowledge and application). In situated cognition, the activities of people and the environments in which they take place are also viewed as elements in mutually-constructed wholes. Mathematics is typically considered to be decontextualised knowledge - after all that is the power of its processes and its forms of representation - so it is a challenge to consider that understandings of it remain tied to specific contexts and actions.

People participate actively in a social context, with behaviour being shaped by patterns of interaction observed, opportunities afforded by others, dynamics of interchanges, perceptions of a social group's expectations, overt and subtle feedback on contributions, and other evidence of successful participation. While all of this is taking place, however, the people are themselves making a contribution to the social context. They follow and model patterns, or perhaps divert from the norm to the extent that they influence others and hence change future forms of interaction. They give opportunities to others via their own actions, making their own impact on the dynamics of verbal and physical interchanges. They too help develop and convey a social group's expectations, and give various forms of appraisal to others about their contributions.

Thus there is a process of mutual modification between people and their social environments, with both undergoing inseparable change over the course of any period of time - from a short exchange such as a quick interchange in a schoolroom to a year's participation in mathematics lessons.

According to the theory of **constructivism**, an individual learns by accommodating new knowledge into an established conceptual framework, and that activity might involve adaptation of the framework so that the new ideas fit more comfortably (following Piaget's sense of "accommodation"). In **situated cognition**, the process of adaptation is more dynamic, involving mutual modification rather than a matching process. It is recognised that negotiation and adaptation of the group's ideas will take place as interaction in the social context proceeds. Thus the theory has been called "interactivist", "relational", and "dialectical".

However, it is worth noting that those social contexts are composed of individuals whose reflexive interactions define the contexts, so these "cannot be understood without knowing the characteristics of the component individuals and how these characteristics govern the social processes that influence development" (Brownell and Carriger's, 1991, p. 366). The context where one becomes a successful learner, though, is generally shaped only marginally by the activity of any particular learner.

In theories of situated cognition, learning is not a separate activity, but "an integral part of generative social practice in the lived-in world" (Lave and Wenger, 1991, p. 35).

The development of knowledge and social interactivity are interdependent and indivisible. Thus the learning of mathematics depends on opportunities for social interaction within the contexts of the everyday experiences that entail the use of mathematics, including but not limited to schooling.

• **A mind-body-environment nexus**

Many theories of learning attend to relationships between **"mind"** and **"body"**. Situated cognition is no exception, with its third dialectic factor being the social **"situation"**. The mind is a product of the interaction between individuals and their environments.

Perception cannot be removed from **action**, because every perception involves observation and analysis. This internal activity shapes individuals' reactions - with even a decision not to react being one form of reaction. Thus perception and action and environmental change arise together, trialectically forming each other.

Much of this happens at an unconscious level, so when a need for problem-solving arises it usually does where the pattern of activity is varied. The situation in which the blockage (the recognition that a problem has been encountered) occurs then forms the practical context for thinking. Thus cognition is situated in an activity and in a specific context, and both forming and testing proposed solutions involve practical action in that context. (An even stronger mind-body dualism, in the theory **enactivism**, will be the subject of a further article in this series of *Vinculum* articles on current learning theories.)

The work of Anna Sfard should be of interest to mathematics teachers here. Sfard (1991, 1994, 1998) saw development of understanding in mathematics as involving a "grasping the essence" through two quite different activities: acquisition and participation. Through these activities, understandings become **reified** (that is, experience is transformed into something like an object, it is thing-ified) over time as idiosyncratic, relational images that arise from particular sets of cumulative experiences. The act of creating these abstract entities involves transformation from an operational to a structural mode of thinking.

One key pedagogical implication of this is that operational forms generally precede **structural forms** – understanding at a higher (structural) level is creativity activity. (In similar vein, Gray and Tall devised the term "procept" to indicate the constructive linking of process and concept, as an anticipation of the fully developed "process" and "related "concept": 1994. The way that an operational form may precede a more abstract conceptual or structural form can also be seen in Piaget's classic account of "concrete" operations, where a learner is able to handle a task, but only by directly working with concrete manipulable objects to aid the mental abstracting and processing.) An implication of this is that operational activities should be ordered in ways that facilitate children's development of bigger and more abstract ideas.

Another important aspect is that this process of "grasping the essence" is not necessarily a slow, steady or predictable one - Sfard wrote about the phenomenon of sudden illuminations (as in the classic Gestalt "Aha!"moment of insight, or Archimedes' famous "Eureka!" moment) that also enable further related concepts to be illuminated. A vital aspect of Sfard's work has been identification of conceptual **"objects"** and temporary barriers to mathematical understanding that Secondary students must overcome. In Sfard's work, "objects", are abstract but meaningful ideas such negative or directed numbers. They are "reified" from learning experiences. Some are very complex ideas, such as $\sqrt{-1}$ (the square root of negative one). Similarly **"barriers"** are conceptions that learners have developed that prevent them from imagining the "objects". Temporary barriers to understanding of these two particular abstractions might be that negative numbers get smaller and smaller as one counts -1, -2, -3, etc. (in fact, they do get "smaller" in one sense, while their absolute magnitude increases - the increasing "smallness" is quite different from the approach towards zero as we count down a sequence of proper fractions; 1/2, 1/3, 1/4, ...); and a belief that square numbers are always positive (true in simple experience, but not assumed in the abstract).

> "The techniques for adding, subtracting, multiplying and dividing of signed numbers may be not very difficult to master, but there are serious conceptual dilemmas that students would invariably encounter if they have an urge to understand what the notion of negative number is all about. The question why a product of two negative numbers should be positive is probably the most famous of these dilemmas" (Sfard, 2000, p. 158).

- **The tool of language**

Following the tradition of activity theory (and other social theories of learning before that), language is seen as a tool. That is, it helps the group and its members achieve their purposes and helps individuals get what they want. Participation in the language practices of communities that we take part in increases as knowledge of the community norms increases.

It is not only words and phrases that are commonly used in communities that is important here, but the discourses that underpin particular uses of language. For example, it is common for teachers to use a question when they are actually giving a command and are certainly not expecting an answer; e.g. "Would you like to open your textbooks now?" At other times a statement is a question; e.g. "I presume you all know how to start.". Such ambiguity is understood better by children in higher socio-economic areas because this pattern of language use is a middle class habit (see Zevenbergen, Sullivan and Mousley, 2000).

Children who have richer backgrounds of experience also cope better with ambiguities of language use in varied contexts. For example, the notion of a "fraction" is a very complex one whose use differs in various home, school and community activities such as sharing discrete or continuous objects of various sorts, advertising of petrol prices, and calculating bank interest. Children need to make sense of the meaning of "fraction" in these contexts as well as in the more abstract and formal context of school mathematics, and do so better if they have been raised in environments where mentors (parents, friends, teachers) have helped them to see underpinning ideas and hence connections.

In any such context, making meaning through the activity of language use (and language making) is a joint activity because it is common experience that builds the understandings held by a group and its members. Again, individual teachers and students make an impact on both the development of language in specific contexts and the ways in which it can be used - and hence on the course of lessons.

Implications of the theory of situated cognition

All epistemological theories (i.e. philosophical &/or psychological theories about the nature of knowledge) are just that - perceptions of a group of people about what knowledge is and how it can be known. Commonly we think of this as how learning takes place, although theories of knowledge are not necessarily theories of learning and are rarely theories of teaching. They do allow us, however, to think about implications for pedagogy. What do theories of situated cognition imply for mathematics teaching?

The most obvious advice to teachers is to recognise that transfer of knowledge from one context to another or from concrete experience to abstract reasoning will not necessarily happen without support, and may be more difficult than assumed. Students need time and appropriate activities in order to build a knowledge of relationships between their everyday and their school-mathematics experiences, as well as between the various components of the mathematics curriculum. They also need carefully-sequenced activities, questions, and opportunities for discussion if they are to move from specific physical activity to abstracted generalisations. Similarly, students need encouragement to apply their useful out-of-school mathematical strategies to school content and opportunities to see how other students do this.

The idea that learning takes place in a framework of participation, and not in an individual mind, means that there needs to ample time and space (in the form of discussion, reflection, and representation of ideas in varied formats) for understandings -to be developed through human interaction and mediated by the differences in perspective among the co-participants. Teachers also need to take the time to set up and develop the social group's expectations. Are errors seen as opportunities for learning by all? Is it important for the class to learn number facts or achieve a certainly level of other performance than it is to have winners and losers in competitive activities? What patterns of interaction are likely to be more productive that teacher-dominated questioning-and how could that expectation of both teachers and students be changed?

Next, it is important to consider the contributions that all participants can make to a community of learning. There are times when it is useful for teachers to tell, explain and demonstrate, but also times when students need to listen to, consider and respond to their own or each others' ideas. Social negotiation of mathematical ideas does not happen merely with reporting back of strategies and solutions - much more stimulation is required.

Modelling the asking of probing questions (Why ...? How ...? What if ...? If ...?) and expectations that students will ask these is one appropriate strategy. Setting some open questions that require more than procedural knowledge is another.

Likewise, the belief that knowledge is created by social groups acting together has implications that go further than allowing or requiring group work. It must involve consideration of how groups are structured, what patterns of interaction are encouraged between class members, and what types of activity (not all physical!) are most useful? What group identity is sought, and how can it best be achieved?

The notion of **distributed cognition** is vital. If knowledge is created by co-participants in a learning activity, individuals will need encouragement to "make it their own". Some teachers use a closure activity that encourages reflection and articulation, such as journal writing; but there are others forms of metacognitive activity that will encourage children to personalise knowledge. If learning is truly a group activity, we also need to consider how it is best assessed. Similarly, if we cannot describe individual "learning" separately from changes in a social role or identity, what does this mean for reporting?

The community of understanding that our students need to be socialised into is that of mathematicians. This seems obvious, but what occurs in most classrooms is far from what mathematicians do. Teachers are generally good at teaching the tools (words, symbols, simpler processes) that mathematicians use; but most have had less practice themselves in schools of other mathematicians traditions (e.g. traditional patterns of speech related to problem solving and proof). Socialisation into being a good student is more common that socialising into being a mathematician. This must raise questions about the nature of core work in both primary and secondary classrooms, and about the patterns of daily interaction and assessment that would support this.

Most school mathematics is operational. Particular processes are being learned and these are not necessarily seen as part of a bigger structural picture. For example, algebra and its functions need to be seen as generalised arithmetic, and the decimal place value system as underpinning fraction and measurement systems.

The appeal of situated cognition

The claim summarised by Brown, Collins, and Duguid (1989), that knowledge is inseparable from the occasions and activities of which it is the product (p. 32), helps to explain results that are often surprising. We have all known times when students have been taught a computational process but cannot apply it to word problems, and times when they complete problems at the end of a chapter successfully but cannot do the same problems as part of a mixed set of problem types. Frequently students have had experiences of a mathematical phenomenon or process in everyday "real world" contexts but do not apply the resulting knowledge while in class. They solve a familiar problem easily mentally but have trouble solving it - and sometimes even recognising it - as a written equation or algorithm. Similar situations arise when students are seen able to do something in a mathematics class, but seem quite unfamiliar with an applied version of the same idea in, say, a Physics class, or a work-situation outside of schooling - the **"numeracy"** challenge. Non-mathematics teachers and employers complain that mathematics teachers aren't doing their job, while the mathematics teachers can point to positive mathematics test scores or other assessment of (apparent) learning in mathematics classrooms.

Even within the mathematics classroom itself, a key idea mastered successfully in one context (such as division of whole numbers) seems to present difficulties in another, e.g. when operating with decimal fractions or measurements or in algebraic factorisation.

Situated cognition makes such phenomena more understandable and suggests that we could work more actively to prevent or remediate them

It is useful, too, to think of learners as apprentices, to identify what needs to be learned for full participation in a community and how this might best be facilitated in a social setting. But what community? Assumptions about schools being communities similar to workplaces where apprentices participate are open to criticism (see, for example, Adler, 1998; Lerman, 1998). These critics point out that teachers do not aim to produce mathematicians, and are not mathematicians themselves. A mathematics classroom community is a community not of mathematics but of schooling, where students are becoming more experienced students:

"Thus, while Laver and Wenger's intentions are for a general theorising, and they attend at moments ... to the specificities of schooling, they in fact side-step difficulties in using their conceptualisation to interpret and explain teaching and learning in school" (Adler, 1998, p. 169).

Actually, Lave herself proposed that the apprenticeship model should not be imported uncritically into schools. She made a (problematic) distinction between this model involving a "learning curriculum" rather than a "teaching curriculum".

The feature of the theory that appeals most to me is its focus on group inquiry and sense-making. It accounts for diversity in students' understandings as well as goals but sees these as essential and positive resources for learning in a classroom community (Greeno, 1997). Further, in discussing the dialectical development of individual knowledge through interactions in social contexts, the theory encourages us to think about the gap between what is known by students and the knowledge of various communities where mathematics is used. Another drawcard for me is its recognition of the multi-faceted nature of knowledge-making and of our social world.

Situated cognition

> ... emphasizes the relational independency of agent and world, activity, meaning, cognition, learning and knowing. It emphasizes the inherently socially negotiated quality of meaning and the interested, concerned character of the thought and action of persons engaged in activity ... in, with *and arising from the socially and culturally constructed world.* This world is itself socially constituted. (Lave, 1991, p. 67)

At the very least, the notion of cognition being bound in particular contexts and inseparable from the social situation and activities of which it is the product should raise questions about:

(a) the ability of learners to apply knowledge gained from the out-of-school contexts to school tasks,

(b) the ability of learners to transfer school knowledge to broader contexts,

(c) ways that involvement in typical processes used in mathematics teaching and learning shapes knowledge of mathematics, what mathematics is, and how it can be used;

(d) other messages that participation in school mathematics gives students.

However, it is clear that the theory of situation cognition raises many more worthy questions for teachers, academics and curriculum developers.

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Some of Sfard's papers are at her web-site: **http://construct.haifa.ac.il/~annasd/sfard.htm** – last accessed 15 November 2001

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Editor's Note

Jean Lave may be taken as one of the early, and important pioneering steps in situated cognition. It is important to realise that she has been contributing significantly to mathematics education for a long time. Early glimpses of her focus on the situation, as a crucial aspect of understanding what a student knows, and can do, appears in Robert Davis's similarly pioneering monograph *Learning Mathematics: The Cognitive Science Approach to Mathematics Education*, Croom Helm, London, 1984.

Davis describes the way arithmetic procedures were carried out during supermarket shopping, meal preparation, and other everyday settings. This study highlighted the practical effectiveness of situated or contextualised problem solving skills, contrasted with pencil-and-paper classroom instruction and practice. A pencil-and-paper test of addition, subtraction, multiplication, and division, applied to whole numbers, fractions, and decimals, was contrasted with actual everyday activities carried out in real contexts. The results showed that her adult subjects scored a test average of about 59%, whereas their everyday success on the parallel "test items", in context, was 100% correct - error-free (Davis 1984 pp 159-160)! Lave's paper, referred to by Davis, is:

Lave, Jean. (1982). 'Arithmetic procedures in everyday situations': Paper presented at the Fourth Annual Conference of the Cognitive Science Society, Ann Arbor, Michigan, 4-6 August.)