Constructivism and Teaching - The socio-cultural context

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Introduction

It has recently become fashionable to talk about *constructivism* in relation to the teaching and learning of mathematics. I want to make clear at the start of this piece that the term *constructivist teaching* is not well defined, and further that it contradicts, philosophically, the meaning of constructivism as I understand it. In fact constructivism is not about teaching at all. It is about knowledge and learning. So I believe it makes sense to talk about a *constructivist view of learning.* And we might ask about the teaching which *results* from such a view of learning. It is possibly this which is meant when the term 'constructivist teaching' is coined, but I believe it is not pedantic to question its use. Personally I am very interested in the teaching which might result from a teacher's commitment to a constructivist view of learning, and that is what I want to work towards below.

Definitions

I still believe that one of the best starting points in thinking about constructivism in a mathematics educational context is a definition provided by Ernst von Glasersfeld (1987), although much has been written since then, in particular a definition from Confrey (1990 p108) which I also find helpful. Von Glasersfeld talks of constructivism as *a theory of knowledge*, and the following is my own paraphrase of his early definition:

The constructivist view involves two principles:

1. Knowledge is actively constructed by the learner, not passively received from the environment.

2. *Coming to know* is a process of adaptation based on and constantly modified by a learner's experience of the world.

It does not discover an independent, pre-existing world outside the mind of the knower

Kilpatrick (1987), referring to von Glasersfeld's principles, suggests "The first principle is one to which most cognitive scientists outside the behaviourist tradition would readily give assent, and almost no mathematics educator alive and writing today claims to believe otherwise. The second principle is the stumbling block for many people. It separates what von Glasersfeld calls *trivial* constructivism ... from the *radical* constructivism which is based on the acceptance of both principles."

It seems to me that the power of constructivism for mathematics education is encapsulated in this second principle. To relate this (briefly) to the learning of mathematics, it seems to say that *if* there is some independent, pre-existing body of mathematical knowledge we cannot know it except through our own experience, and we can *only* know what we ourselves have constructed, and modified according to further experience. For a detailed account of these ideas I recommend von Glasersfeld (1984) and (1987). It is important to point out that constructivism makes no ontological claims. In particular it does not dismiss the possibility that there is some pre-existing body of mathematical knowledge. It only claims that if there is, we can never know it in any absolute sense. (For further discussion of this, see Davis and Mason, 1989)

Constructivism and knowledge

It has been pointed out (e.g. Noddings 1990) that constructivism raises serious questions from an epistemological position. What does it mean, for example, to talk of individual construction as 'knowledge'? Noddings gives an example of a student, Benny, who had developed a particular process of calculation which satisfied him. This process could be seen by mathematicians of wider experience than Benny to be inadequate. Is there any sense in which Benny's process could be regarded as *knowledge*?

Epistemologists are often as concerned with the status of knowledge, and in particular *what is truth*, as with the experience of knowing. A constructivist view of knowledge is that it 'fits' experience. If that experience changes, the knowledge may need to be modified. Von Glasersfeld gave an example of a key fitting a lock. In order to open a lock it is not necessary for a key to *match* the lock ñ only to *fit* it. Many keys will fit a particular lock. However, when we want to open a lock which our key will not fit, it is necessary to get another key.

When we come up against circumstances which challenge our experience, we need to modify our expectations. For example, I might 'know' that radiators are good for warming hands.

When I place my hands on a boiling hot radiator, and burn them, I have to modify my expectations of radiators. In future I might test the radiator gently to gauge its heat, before placing my whole hand on it. I could thus be seen to have modified my knowledge of radiators.

The following anecdote was told by Rita Nolder from one of her experiences as a mathematics advisory teacher:

In a class of 11 year olds working with SMP, the teacher was going around helping students. Rita, feeling redundant, was listening to two boys working with the SMP book on *angle* . They were looking at a diagram of two triangles (i) with angles of 45,45,90 and (ii) with angles of 30,60,90.

One boy said to the other "This one's a triangle [the first], and this one isn't [the second]".

The boy speaking seemed to have some image or concept of a triangle which included the first triangle, but not the second. Now, Rita believed that both objects were triangles. The boy made his construction according to his own experience. So did Rita. We might say that the boy was wrong and Rita was right. But this is to make judgements about truth without taking into account the circumstances from which the statements arise. What was the boy's experience which led to his statement? Why did he believe that the second shape was not a triangle?

The context in which a statement is made is crucial to the validity of the statement, and it is very difficult to say therefore when any statement is true without knowing this context. We might, for example, be tempted to say that an object with angles adding up to more than 180° could not be a triangle. However, a triangle on the surface of a sphere could fit this criterion. In plane geometry we might feel happy with the statement that the angles of a triangle add up to 180°. So, to understand the boy's statement in Rita's anecdote, it would be helpful to locate the discourse in a wider context, although this might be quite difficult to elicit.

A consequence of pupil talk and teacher listening is that the teacher is able to glean a sense of the origins of pupils' ideas and to challenge these in some way if it seems appropriate. Teachers often use such situations to advantage in creating 'cognitive dissonance' ñ for example, in offering an example which fits the conditions but not the results of some piece of reasoning. Sandy Dawson (1991) talks about ways of using classroom dialogue to challenge mathematical preconceptions in a Lakatosian tradition contributing to what he calls *fallibilistic* teaching.

Rita might have asked the boys why the second figure was not a triangle, and could have followed up her question with further examples and situations for the boy to consider, possibly extending his experience and causing him to modify his knowledge. This might be described as 'challenging the student's *misconceptions'*, but. if there are 'mis'conceptions, what then is a *conception*? Is this some form of knowledge which the 'mis'conception is not? Can a conception be independent of the person or circumstance of the conceiving?

Noddings' response to questions such as this is to recognise that constructivism cannot of its very nature make any statement about the status of knowledge, and so she claims that constructivism is *post*-epistemological. Von Glasersfeld, in the same volume, accepts

Noddings' position and modifies his own language, talking of constructivism as a theory of *knowing* rather than a theory of knowledge.

Perspectives on mathematics teaching

What is it that we think we are doing when we set out to teach mathematics in the classroom? The following two examples highlight particular perspectives on mathematics teaching:

ï There has recently been much discussion of the teaching of mathematics at primary level in terms of a move to whole class teaching in ability sets, rather than a small group, possibly thematic, approach which builds on individual experience.

ï We recently had an HMI inspection at Oxford in which criticism was made of a very theoretical offering, by PGCE interns, of statistical formulae as basis for a lesson on statistics to Year 12 students.

Why might a move to the formality of whole class teaching of mathematics at primary school cause some disquiet? If we want Year 12 students to know some statistical formulae, what is wrong with a straightforward, abstract, presentation of the formulae? These two examples seem to offer contradictory views. The suggestion for primary teaching seems to be that less influence be placed on creating contexts for mathematics, and more on presenting mathematics as a formal body of knowledge. The HMI criticism was of a formal offering which did not pay any attention to contexts in which such statistical formulae might be of value.

In both cases what seems crucial is *mathematical meaning*, and the making of meaning. Perhaps meaning is only possible when what is offered has somewhere to 'fit', so that students can construct something which makes sense to them. If the Year 12 students cannot make sense of the statistical formulae, what does the lesson achieve? Perhaps what is needed to assist this sense-making is the creation of some associated context which the students can appreciate. In primary teaching, the use of a thematic approach might be seen to provide contexts from which abstract mathematical ideas might arise and be meaningful to pupils. On the other hand a whole class approach with a more formal presentation of mathematics need not deny the importance of meaning. This relies heavily on the pupils' experiences on which the formal approach depends in order to be meaningful.

A problem arises when a teacher wants students' constructions to make sense in her terms; when constructions, meaningful to pupils, may not be adequate for the wider contexts which she has in mind. This raises questions about compatibility of knowledge between all participants in the teaching/learning enterprise. It is not so much a case of what is right or wrong, but how close are the conceptions of the various participants.

The social or cultural setting

The social environment of the classroom is good at throwing up constraints which challenge individual perceptions. People often have different views of a situation. If these views seem incompatible, there is a need for reconciliation which can lead to the social mediation of individual knowledge. Through discussion or argument, the participants negotiate new positions which leads to shared meanings developing. Such negotiation is not bargaining, but a genuine offering of individual perspectives and meanings for consideration by others. It involves making an effort to listen to and understand other perspectives. As a result *common* , or 'taken-as-shared' (Voigt, 1991) meanings develop in a classroom.

No classroom environment is an isolated box. It is part of a wider community (of school and beyond) which has cultural practices and social norms. There are therefore acts or actions or activities which happen because they are part of this socio-cultural setting. This includes mathematical, educational and social acts as well as combinations of these. Lave and Wenger (1991) talk of a *community of practice* to encompass the customs, social and cultural, of a particular community and its ways of operating. We can envisage a mathematical *community of practice* which has its established (even ritual) acts, and the classroom environment draws on these, modifies them for its own use and ritualises its own practices.

A few examples might make this clearer:

- Pupils standing when an adult enters a classroom is part of a school's social rituals;
- Teachers asking pupils questions to which the teachers already know the answers is part of the culture of teaching mathematics (e.g. Pimm, 1987);
- Performing the operation of multiplication before that of addition in a computation is a mathematical custom;
- Making assumptions that classroom geometry is Euclidean is part of classroom mathematical culture.

I have deliberately thrown around words like *social*, *cultural*, *ritual*, *custom* to emphasise the bases of some of the acts or actions we take for granted within certain social or cultural settings. We might argue that all acts are socially embedded, and that all objects associated with such acts are cultural tools. For example, the custom of using *exposition and practice* in the teaching of mathematics might be seen as part of the cultural practice of traditional mathematics teaching. It was largely taken for granted until challenged by individual teachers seeking to implement a more investigative approach, and ultimately by the Cockcroft report which pointed to its limitations. The blackboard and chalk might be seen in this context as cultural tools. Their use is widely understood, and no one in a classroom doubts what they are or why they are there. The use of chalk by a teacher as a missile for waking up dreaming students has largely disappeared from classroom cultural practice as a result of changes to educational norms. The use of chalk in this way nowadays could result in a serious challenge to these norms.

The wider cultures in which the school is situated impinge on the classroom in ways often unnoticed because of participants' familiarity with them. However, a teacher recently pointed to an issue which had become important in her classroom. She noticed the hyperactivity of a pair of Asian boys ñ highly participative, very demanding of attention, very voluble ñ as compared to the very passive, quiet, undemanding, self-effacing behaviour of Asian girls in the same class. She recognised that she wanted to influence these behaviours to enable the girls to participate more fully, and hopefully achieve more. This could mean requiring the boys to be more considerate, less demanding and more disciplined in their work. She also recognised that such requirements might contradict the cultural expectations of these girls and boys in their family environments. While wanting to respect their culture, she wanted to change their manifestation of it in her classroom in order to achieve better mathematical learning (as she saw it) for all.

The socio-cultural context of classroom meaning

In order to consider meaning-making in mathematics classrooms for participants, both individually and collectively, we have to recognise its dependence on individual experience and socio-cultural practices. This is the subject of an area of study known as Activity Theory, originated by Russian psychologists in the Vygotskian tradition, and developed with rather different emphases by socio-cultural theorists in the United States and Europe. Referring to Leont'ev (1981), Crawford (1991) suggests that Activity Theory "describes the process through which knowledge is constructed as a result of personal (and subjective) experience of an activity. Leont'ev stresses the inseparability of human mental reflection from those aspects of human activity that engender it."

The relationship between a constructivist approach to mathematics teaching and social and cultural norms in mathematics classrooms is explored by Cobb et al. (1991). Their paper offers a critique of Activity-Theory, both in its Russian and American manifestations, and in particular the related socio-cultural movement currently exciting educational interest in the United States. They address the work of Ilyenkov, in the Russian school, who suggests that 'objects as cultural tools serve as carriers of meaning' ñ i.e. carrying meaning for their use in a practice. These objects include formal mathematical symbols, and so 'these symbols are for him (Ilyenkov) cultural tools that carry meaning'. A consequence of this is the view that 'children's development of abstract mathematical thought is supported by instruction designed to engage them in the social practice of using formal symbols'.

This reminds me of the classroom work of David Hewitt (Open University, 1991) involving his 'rulers' activity to influence students' perceptions of algebra and their familiarity with formal symbols. It is well known (e.g. Kuchemann, 1981) that pupils have difficulty with the abstract use of symbols and their manipulation. Hewitt's very stylised approach is designed specifically to overcome such difficulty by creating a social practice in which symbol manipulation is logical and meaningful and in which attention is attracted away from the symbols and their use, rather than towards them.

Socio-cultural theorists view learning as integration into a community of practice (for example Lave and Wenger, 1991) in which social actions are identified (for example the mathematical manipulation of abstract symbols according to given conventions) and classroom activities designed (for example the rulers activity). Cobb et al suggest that "the teacher's role in this activity is to forge the last link in the chain by ensuring that children execute the specified social actions that make it possible for them to isolate ideal mathematical forms when they solve tasks". Social actions are seen to be more broadly based than social *inter*actions. Thus the interactions of children in classroom activities are a small part of their enculturation into the required social actions. This is reminiscent of Bruner's work on scaffolding, with the teacher performing the role of 'consciousness for two' (to do for students what they cannot yet do for themselves) in relation to Vygotsky's *Zone of Proximal Development*. (See for example, Bruner, 1985)

Where is this going?

I run the risk of trivialising a very complex area by being so brief and stopping here. What I find exciting about the links between constructivism and socio-cultural theory is the potential to explain children's development of mathematical knowledge in terms of its individual and social construction under the influence of social and cultural practices. In particular I am interested in the teacher's role in this process, having considered the implications of a constructivist philosophy for mathematics teaching through a close study of the work of individual teachers (Jaworski 1991). I am worried by notions of 'integration into a community of practice' which seem to suggest an apprenticeship model of learning which subordinates the learner to established practices. On the other hand, empowerment of the learner may only be possible once compatibility with and confidence in established practices is achieved. The patterns which I observed in my research pointed to the development of autonomy of the learner, but the teaching/learning process involved had to produce learners who could work confidently within the norms of the conventional curriculum and its national assessment since their only means of demonstrating their success publicly was via this system.

I should like to summarise the relationships outlined above by viewing learning as the individual construction and social mediation of knowledge within a community of practice. Thus:

1 Knowing is an action participated in by the learner. Knowledge is not received from an external source.

2 Learning is a process of comparing new experience with knowledge constructed from previous experience, resulting in the reinforcing or adaptation of that knowledge.

3 Social interactions within the learning environment are an essential part of this experience and contribute fundamentally to individual knowledge construction.

4 Shared meanings develop through negotiation in the learning environment, leading to the development of *common* or 'taken-as-shared' knowledge

5 Learning takes place within some socio-cultural setting - a 'community of practice' in which we can think of social *actions* as well as social *interactions*.

The fifth point here is weak, and reflects my worries about the links between constructivism and socio-cultural theory. However, one crucial tenet of constructivism is missing from the five points, and that is the radical nature of constructivism in that it deliberately says nothing of ontology. In my study (1991), I have elaborated the tensions which arise for teachers in working with absolutist knowledge paradigms, in the form of mathematics curricula, from a constructivist perspective. Viewing knowledge as a social construction in terms of the social actions of a community of practice may be one way of reconciling these tensions in theory. This raises questions about the practical manifestations of such reconciliation.

One place to start might be through re-analyses of classroom situations which researchers have described from a constructivist perspective, looking this time through a socio-cultural lens.

I am interested in pursuing these ideas further with interested others within the UK.

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