Ecologies of participation in school classrooms

BOYLAN, M. <http://orcid.org/0000-0002-8581-1886>

Published version

BOYLAN, M. (2010). Ecologies of participation in school classrooms. Teaching and teacher education, 26 (1), 61-70.

Ecologies of participation in school classrooms

Mark Boylan
Sheffield Hallam University
m.s.boylan@shu.ac.uk
+44 114 2256012

A published version of this article appears as, Boylan, M. (2010) Ecologies of participation in school classrooms, T*eaching and Teacher Education, 26(1),* 61-70
doi:10.1016/j.tate.2009.08.005

Abstract

The concept of legitimate peripheral participation was developed by considering informal learning contexts. However, its applicability to school classrooms is problematic. This is particularly so when teacher centred and decontextualised procedural practices predominate as they do in *usual school mathematics* classrooms. Different meanings of participation in community of practice theory are identified. The applicability of legitimate peripheral participation to school mathematics classrooms is critiqued by considering: the nature of social practice, learning relationships, power, agency, and identity. Different forms of participation in school mathematics are discussed and the concept of *ecologies of participation* is proposed as a means to understand the complexity and multidimensionality of participation in both formal and informal learning contexts.

Key words: community of practice; participation; classroom practice, school mathematics; situated learning

Introduction

Lave and Wenger's *Situated learning: legitimate peripheral participation* was a seminal text in the development of a new paradigm of learning theory. It challenged the view of learning as a change in either the cognitive state or behavioural disposition of individuals - an acquisition view of learning - proposing instead that learning is social and situated (Fuller 2007; Handley, Sturdy, Fincham, & Clark, 2006; Hughes 2007; Hughes, Jewson, & Unwin, 2007; Lerman, 2000). Their theory foregrounds social

practice as do other socio-cultural theories of learning. However, its distinctive feature is the focus on participation as central to learning. Indeed, in Lave and Wenger's theory to participate is to learn. The concept of participation can be used to inquire into both the moment to moment engagement in social practice and the way these moments connect over time to develop a learning history that changes the learner's relationship to practice, to others engaged in practice, and as part of this, changes their identity.

The theory was developed in informal learning contexts. However, it is claimed that it is a generalised theory of learning and so also applies to formal educational settings (Lave, 1996; Lave & Wenger, 1991; Wenger, 1998). Although, they recognise that particular issues of analysis and interpretation might arise when the theory is applied to schooling (Lave & Wenger, 1991; Lave, 1996). This article seeks to identify the ways in which participation in school classrooms is similar to and different from those described by Lave and Wenger, through this to more generally elucidate and critique Lave and Wenger's theory and to argue for a more flexible conceptualisation of participation as central to learning. Of course, the forms of social practice found in school classrooms vary across many dimensions such as location, the type of school, pedagogical traditions, school subject and so on. As a means to investigate situated learning as participation, I focus on one particular form of learning in school, which can be referred to as *usual school mathematics* (Boylan, 2004) discussed in detail below.

School mathematics is a particularly worthwhile context for investigating learning as participation for a number of reasons. There is an extensive body of literature based on ethnographic and other qualitative as well as quantitative research that describes in detail the nature of social practices in school mathematics. In addition, situated theories of learning have been influential for some in mathematics education (Adler, 1998; Boaler, 1997a; Boaler, 2000; Boaler & Greeno, 2002; Boylan, 2004; Burton, 2002; Goos, Galbraith & Renshaw, 1999; Solomon, 2007; Winbourne & Watson, 1998; Watson & Winbourne, 2008a). Thus, some of the core concepts of Lave and Wenger's theory - legitimate peripheral participation and community of practice - have both been applied and problemetised in school mathematics contexts. Where particular aspects of Lave and Wenger's formulations have been critiqued, often analysis has refocused on to a more fluid understanding of situated cognition, broadly the approach taken in this article.

The article continues with an analysis of the different meanings of participation in different accounts of community of practice theory. A description is offered of the common practices in mathematics classrooms constructed from accounts in research literature and ethnographic research. The nature of practice, learning relationships, power, agency and identity, in relation to the concept of legitimate peripheral participation, are discussed. I suggest that participation is a useful analytical tool but needs to be viewed as being a multi-dimensional phenomenon with many possibilities. This leads to proposing the concept of *ecologies of participation* as a way to encompass the complex interweaving of formally legitimated practices and informal practices in which the importance of the extent and the meaning of the situatedness of practice shifts, sometimes moment to moment, as does the influence of participant identity.

Different meanings of situated learning as participation

Three distinct though related approaches can be found in the literature on learning as participation in communities of practice: that it is a conceptual tool for understanding learning, a model of the social formations and forms in which learning takes place, and an advocated way to organise learning. Distinguishing between these three perspectives would be easier if each of three key texts (Lave & Wenger, 1991; Wenger, 1998; Wenger, McDermott, & Snyder, 2002) gave an account of only one of them. However, this is not the case. Lave and Wenger's first formulation, the main focus of this article, includes all three approaches. In places it can be read as an ethnographic approach to learning focused on participation as key to situated learning. This has been referred to as broad view (Hodkinson & Hodkinson, 2004, cited in Fuller, 2007 see also Kanes & Lerman, 2008 for discussion of different versions of community of practice theory). Secondly, in its empirical descriptions of specific small tight knit groups engaged in practice together, we can find a narrower view with a greater focus on the communities of practice: the social formations in which learning and participation take place. Thirdly, they advocate for both their theoretical approach and also claim that formal learning situations would be improved if reconstituted so that the pedagogy becomes more aligned with a situated perspective on learning. This is taken up by Wenger (1998) in reference to informal and formal learning and then extended to issues in organisational development and management (Wenger, McDermott, & Snyder, 2002).

The way in which terms such as legitimate peripheral participation are used varies within key texts, between texts, and in the application of situated learning theory by other writers. In places such wide and changeable definitions are used for some concepts that they could refer to anything (Engeström, 2007) or as Watson and Winbourne put it:

> There is a danger in constructing descriptions of learning which include everything we do, communities of practice which include everywhere we go. (2008b, p. 6)

One issue they and others (Barton & Hamilton, 2005; Tusting, 2005) point to is the lack of concepts that can explain in detail what occurs in learning situations.

It is not possible here to carry out the textual archaeology to properly disentangle the different uses in and between the three key texts. However, a brief survey of the three different uses will clarify the focus and argument of this paper. I will start by considering what this article is *not* centrally about. Recent articulations by Wenger and others, uses the concept of participation in practice to describe designed learning communities (Wenger, 1998) and intentionally created formations in organisations which have the purpose of training, staff development, group, individual or organisational learning or change, or information management (Wenger, McDermott, & Snyder, 2002). Although an important purpose in analysing forms of participation in school classrooms ought to be to find ways to make them more participative and richer sites for learning, in this article the way in which insights from situated learning suggest possible changes is pedagogical practice is not fully explored. Where alternative practices are signposted the main intention is analytical. By contrasting these with prevalent practices theoretical issues are highlighted. Nevertheless, the discussion of forms of participation in school classrooms does support the need to transform classroom practice and implicitly points to directions for change.

The move towards intentional or designed communities of practice is an extension of the sociological model developed by Wenger of the form and features of the "social configurations" within which learning as participation takes place (Wenger, 1998, p.5). Wenger describes his theory as "in the middle" (p.13) between a theory of social structure and of situated experience, and so although not a theory of social structure as such, his account of communities of practice is concerned with the way in which learning is structured (Kanes & Lerman, 2008). Wenger introduces constructs that

define what a community of practice is - mutual engagement, shared repertoire and joint enterprise - as well as theorising around issues of community boundary and relationships between communities of practice. In this article the focus is on participation rather than on the community of practice. Indeed I will mostly avoid using the term. Elsewhere I have argued that usual school mathematics classrooms do not fit this later (Wenger, 1998) community of practice model (Boylan, 2004, 2005). By identifying the way that participation in school classrooms differs from the construct of legitimate peripheral participation insights are possible into why this is the case. There have been a variety of more general critiques of the theory of communities of practice as found in Wenger's later work, including those based on the centrality of language and discourse (see Barton & Hamilton, 2005; Tusting, 2005). However, given that the focus in this article on legitimate peripheral participation, for simplicity a full discussion of these is not offered here. Later, in the conclusion, I do indicate how these approaches might support the arguments presented here.

This article then is mainly concerned with considering participation as a way of understanding learning. Lave and Wenger (1991, p. 37) describe situated learning as participation as an “analytical perspective”. As such it is an epistemological and ontological account of the nature of knowing and being in the world. Lave and Wenger’s focus on participation was developed by considering a wide range of apprenticeship learning situations, from traditional tailors through to participation in communities such as alcoholics anonymous. They assert that learning is best understood as not only arising from but, crucially, as *being* participation in social practices. Social practices take place within, and so create, patterns of relationships that socially and culturally legitimate participation. This is the community of practice. The concept of community of practice in this account is inseparable from legitimate peripheral participation and is defined by it rather than by other features as in Wenger's (1998) later account. A further key aspect of Lave and Wenger’s theory is the way in which engagement in practice is linked to the creation and maintenance of identity. Participation in communities of practice is not only about learning to do, but as a part of doing, learning to be (Lave & Wenger, 1991). Lea has proposed considering the theory as a heuristic (Lea, 2005) that is a means to enquiry into the learning. If the theory is to be a useful heuristic for understanding school classrooms then an expanded understanding of the nature of participation is needed.

Legitimate peripheral participation

As an analytical perspective the claim is made that legitimate peripheral participation is a feature of learning that can be found everywhere:

> We should emphasise, therefore, that legitimate peripheral participation is not itself an educational form, much less a pedagogical strategy or a teaching technique. It is an analytical viewpoint on learning, a way of understanding learning. We hope to make clear as we proceed that learning through legitimate peripheral participation takes place no matter which educational form provides a context for learning, or whether there is any intentional educational form at all (Lave & Wenger 1991, p. 40).

We are presented with a binary conception of participation, it is either *legitimate peripheral* or *full*, and further the former cannot be analysed into component parts or different aspects:

> Its composite character, and the fact that it is not difficult to propose a contrary for each of its components, may be misleading. It seems all too natural to decompose it into a set of three contrasting pairs: legitimate versus illegitimate, peripheral versus central, participation versus nonparticipation. But we intend for the concept to be taken as whole. Each of its aspects is indispensable in defining the others and cannot be considered in isolation (Lave & Wenger 1991, p. 35)

However, Lave and Wenger use the term in two different ways. Theorising from the journey of the newcomer to a group engaged in social practice, legitimate peripheral participation represents the means of moving - a trajectory - towards the fuller participation available to a 'master' or old timer in the practices. Thus, legitimate peripheral participation is socially warranted or legitimised by existing practitioners.

One immediate objection to identifying legitimate peripheral participation as a central means of theorising learning is that it does not account for the on-going learning of those who are full participants (Fuller, Hodkinson, Hodkinson, & Unwin, 2005). Full participation would appear to lead to completion of learning. This is not directly addressed by Lave and Wenger. However, they do consider a related question, the way social practices and forms of participation and the community change over time. Here a second sense of the meaning of legitimate peripheral participation is implied. Recognising change as central to communities of practice as newcomers become old

timers and old timers leave the community creating a generational cycle, Lave and Wenger write:

> Insofar as this continual interaction of new perspectives is sanctioned, everyone's participation is legitimately peripheral in some respect. In other words, everyone can to some degree be considered a "newcomer" to the future of a changing community (Lave & Wenger, p. 117).

Moreover in this formulation there is a sense that all participants are positioned peripherally to the social practice and the relations that arise through participation in practice (Kanes & Lerman, 2008). The trajectory of participation is emphasised rather than the position of participants in the social network at a particular moment.

There are then two meanings of legitimate peripheral participation, as an antithesis of full participation and more generally in the sense of peripherality to the practice and relations of participation. Although participation is central to Lave and Wenger's situated learning theory, part of its explanatory power is the way it helps us to understand a range of other phenomena that arise in social learning such as situatedness, learning relationships and trajectories of identity and belonging. I explore these and other features in relation to school mathematics as a prelude to addressing the central issue of forms of participation and suggest ways that extend understanding of participation so that it can be a multi-dimensional tool for analysis.

Usual school mathematics

At least some of the practices of 'usual school mathematics' are likely to be familiar to readers of this article from their own experience of learning mathematics in schools. This is a description of a typical mathematics lesson in secondary schools in the UK.

> *A typical lesson*
>
> *The children are sitting in rows facing the front, two to a desk. The teacher is at the front of the classroom standing at a whiteboard or blackboard. The first part of the lesson consists of an explanation of the content of the lesson by the teacher. The teacher shows the students how to carry out the necessary procedures to answer the questions they will practise later. The teacher works through examples that are graded in order of difficulty.*

During this first part of the lesson the teacher will ask questions of the class. Students indicate that they wish to answer by raising their hands or the teacher may select students by naming them. Generally closed questions are asked. The teacher will know the answer to them and they are asked in order to help construct the explanation of the procedure to be followed. In order to do this the teacher evaluates the students' responses, if the response is not the one required then the teacher asks additional questions in order to funnel the students toward the required answer.

After the procedures have been explained, the students practise similar written questions written on a whiteboard or OHP, worksheet or more usually from a textbook. Whatever medium the practise questions are given in, they will either be all of the same level of difficulty or will be graded, later questions requiring more procedural steps to be followed. Whilst the students practise, the teacher gives help to individual students who ask for it by repeating the explanation or offering additional or alternative procedures to be followed. The emphasis is on learning individually.

At the end of the lesson, the teacher gives the students answers to the questions practised. The next lesson is likely to be aimed at learning additional procedures related to the same topic or will move on to new procedures. The students are assessed on their ability to reproduce the learnt procedures through class exercises, homework, and informal tests. The students are given tests regularly, (generally every half or full term) which are use to group the students by ability (Boylan, 2004, p. 60).

It is notable that missing from this description of usual school mathematics is reference to the sort of mathematical practices engaged in. The pedagogical practices - explanation, exercises and so on - are disconnected from the type of mathematics that is learnt. That it is possible to construct a recognisable description of the practice of a school mathematics classroom without including a description of mathematics practices in itself raises issues about the nature of participation and crucially what is it that is being participated in.

Usual school mathematics refers to the pervasive form in which mathematics has been and continues to be taught in schools in the UK (Boaler, 1997a,1999, 2000; Boaler &

Greeno, 2002; Boaler, Wiliam & Zevenbergen, 2000; Boylan, 2004; Cotton, 1998; Ernest, 1998; Mendick, 2006; Nardi & Steward, 2003) and, in spite of the recent reform movement, in the US (Anderson, 1997; Cobb, Wood, Yackel, & McNeal, 1992; Gregg, 1995; Stigler & Hiebert, 1997). Many aspects of usual school mathematics are common features of the way mathematics is taught in schools elsewhere. In a study of seven countries (Australia, the Czech Republic, Hong Kong, Japan, the Netherlands, Switzerland and the US) the most common pattern found was for students to work individually, 90% of lessons making use of a textbook or worksheet, and in all countries teachers talked more than the students by a ratio of at least 8:1 (Hiebert et al, 2003). The most significant variation is in Japanese teaching where students engage in significantly more problems of medium and high complexity problems which cannot be solved by application solely with procedural knowledge.

It is important to stress that usual school mathematics is a construct. It describes the features of many mathematics classrooms yet the forms of practice found in particular classrooms and the ways in which meaning and participation is negotiated and contested is more fluid. Teachers and students do have scope to shape the exact forms of practice in their classrooms however rigid and unchanging practices might on the surface appear. Indeed a key claim of this article is that the complexity of situated learning cannot be described by fixed categories of participation. However, part of the argument for that claim is that legitimate peripheral participation is not a universal description of situated learning because it demonstrably does not describe learning in at least some school mathematics classrooms. Although usual school mathematics is a construct, it describes important features in mathematics teaching in schools in many contexts and is a suitable focus for analysing the nature of practice and participation in mathematics classrooms. Such an analysis now follows.

Situated social practice in mathematics classrooms

There is a particular theoretical and practical challenge in applying situated learning to formal learning situations. The forms of practices found in school and similar environments are infused with and support beliefs that emphasise cognitive rather than social aspects of learning. Learning is modelled as individual acquisition rather than social participation and is decontexualised rather than situated. However, as Lave argues, although the decontextualised nature of practices in schooling can tend to "mystify and deny the situated character of learning" this does not mean that the

schooling practice are not socially situated as "there is no kind of activity except situated activity" (Lave, 1996, p. 155).

Even though the pedagogical structure of learning in formal learning situations is different from that found in informal contexts, Lave and Wenger (1991) argue that legitimate peripheral participation is still central to learning. Recognising that there are differences between formal and informal learning contexts, they contrast a “learning curriculum that consists of situated opportunities” and a teaching curriculum that:

> Supplies – and thereby limits – structuring resources for learning, the meaning of what is learned (and control of access to it, both in its peripheral forms and its subsequently more complex and intensified, though possibly more fragmented, forms) is mediated through an instructor’s participation, by an external view of what knowing is about. (Lave & Wenger, 1991, p. 97)

Usual school mathematics fits the definition of a teaching curriculum. However, it is difficult to see in what sense learners can engage with this in a form that corresponds to the type of legitimate peripheral participation that occurs in situations where the relationship to apprenticeship learning is clear. Here Lave and Wenger infer that it is the instructor’s participation in the practice being learned that legitimates learners' participation, all be it in a mediated form. To use one of their apprenticeship examples, the argument they appear to make is that studying midwifery with a midwife in a classroom is a mediated form of the learning that happens if the student was to work alongside a midwife in the community or hospital setting, because the classroom based midwifery instructor continues to be a member of the midwifery community of practice.

I suggest that this argument contradicts a central principle of Lave and Wenger's approach: the situated nature of learning and participation. However, even if the argument is accepted school mathematics is not like this. The school mathematics teacher is not usually mediating their own engagement with mathematical practices as part of identifying and participating as a mathematician or in practices that involve mathematics. Rather teachers of mathematics are engaged in the practice of teaching school mathematics and it is through this engagement that their own learning and development takes place in respect to teaching mathematics. In transmissive pedagogies it is taken as given that teachers already have acquired the subject knowledge needed to teach and this does not require further development. Where

teachers are engaged in on-going exploration and learning of mathematics their pedagogy is unlikely to fit the characterisation of usual school mathematics but rather show features that allow for greater and different participation by students. In school mathematics the focus of the classroom routines is mathematics that is "broken down and predigested" (Boylan & Povey, in press 1) into isolated fragmentary facts and procedures which are then practised. Learning is taken to be the ability to reproduce these facts and procedures. There are important differences between school mathematics and the way mathematical practices are used outside of school as part of other social practices (Lave 1988; Nunes, Schliemann & Carraher, 1993) and the mathematics as practiced by mathematicians (Burton, 2004). These latter differences have been compared to the difference between "being forced to practise scales and becoming a pianist" (Watson, 2008, np.).

Learning relationships

In Lave and Wenger's model there are two basic positions identified, that of new comer and old timer. However, their discussion of trajectories of participation recognises other intermediary positions. Lemke points out that in apprenticeship situations the learning relationship is generally triadic (Lemke, 1997). As well as new comers and old timers, a third position is recognised, that of the established member or in the traditional language of craft apprenticeship, the journeyman. Lave and Wenger recognise the importance of peer to peer or near peer relationships and that it may be these and the way work practices are structured that support learning rather than mainly through master-apprenticeship relations. However, arguably the role of the established members, those who are no longer newcomers but are not yet full participants in the practice, is understated in Lave and Wenger's (1991) formulation.

In any case it is clear that the learning positions in a mathematics classroom are not like apprenticeship contexts; there is generally a single teacher and a relatively large number of students. Students in usual school mathematics classrooms do not usually learn alongside the teacher as the teacher engages in meaningful mathematical activity that has a purpose beyond demonstrating mathematical procedures. Nor do they necessarily engage in significant peer learning. The learning relationships are not triadic; there is an absence of an equivalent of the established community members found in informal learning communities.

The trajectory of participation of the students is not to become mathematics teachers (Adler, 1998; Lemke, 1997; Lerman, 1998). Nor could it be because the student and teacher are engaged in at least two different sets of practices. The student is performing practices that might be called 'learning school mathematics' (as well as a whole range of other practices including sometimes 'resisting learning school mathematics'). The teacher is engaged with teaching school mathematics. This means that the learner has no prospect of coming to share the same social position and relation to practice as the teacher in the school classroom that they are part of because they are not engaged in the same practices as the teacher. Thus for a student full participation in a mathematics community of practice is not possible at school unless a significantly different pedagogy is developed.

Power

Although Lave and Wenger recognise that power relations in situated learning are asymmetrical, the nature of how these power relations are enacted is not fully described. Various commentators have critiqued their theory for a lack of theorising of power in informal learning situations (Engström, 2007; Fox; 2000; Handley et al, 2006; Contu & Wilmott, 2004; Roberts, 2006). Moreover, it is not as simple as writing descriptions of these power relations into accounts of learning, for example, by viewing power as a property of a participants' place in the trajectory of participation. Contu and Wilmot (2003) use ethnographic data to indicate the complex ways power is contested through resistance and reappropriation by technicians as well as the ways that their forms of participation are also imposed. Roberts (2006) points to the way in which organisational forms and structures may constrain or create spaces for negotiation of meaning and practice. Engström (2007) highlights the way in which relationships and practices are shaped by external forces and forms of technology and Fox (2000) draws on Actor Network Theory to indicate that the distribution of power is itself contested in networks of practice in which agency lies not only with human participants but also with other parts of the actor network.

The weight of each of these criticisms increases when the situated perspective is applied to school mathematics classrooms. Unlike work based or informal communities of practice, in which participation is voluntary (leaving aside the issue of economic necessity), participation in school mathematics as in other classroom practices is coerced (Lerman, 1998). This coercion happens on many levels, from the compulsory nature of schooling and curriculum, through assessment and setting practices, to the

day to day coercion to take part in classroom practices in particular ways. In the school classroom it is the teacher that has the authority to legitimate or even demand particular forms of participation as this description of one learner's experience of school mathematics illustrates

> He would write on the board "TO CALCULATE" and [then] he'd underline it. And we would write what we had to calculate and it would be "CALCULATION". I only ever got it right by chance.
>
> [Sometimes we would have to copy]. It would just be a complete scribble. I wouldn't have a clue what he was writing. And it would be (raises her voice in an aggressive tone and booming voice):
>
> "NOW CLASS IS THAT CLEAR AS CRYSTAL OR AS CLEAR AS MUD?"
>
> (Boylan, 2004, p.162)

This power is also exercised in relation to mathematical practices: for example, using a particular procedure to solve an equation or a particular algorithm in arithmetic.

Whilst power is under theorised, Lave and Wenger do acknowledge that a participant's power does not simply correspond to the length of time they have engaged in the practice. In analysing generational change in communities of practice they recognise the possibility of conflict between participants and that power is negotiated as relationships to practice change over time. Here too we find a gap between their theory and what happens in the classroom. The binary power structure, teacher-student, is embedded, fixed and lacks the complexity of the different positions and trajectories within apprenticeship learning. This is not to say that in a school classroom the teacher has a monopoly on power. In moment to moment interactions in classrooms sometimes overt and sometimes subtle contestation for position take place (Linehan & McCarthy, 2000, 2001). Power may be contested more directly when conflict arises over the extent to which school mathematics practices are to be the focus of participation (Boylan, 2002).

Although the theory is ethnographically based, their work has been criticised for lacking a historical perspective (Engström, 2007; Hughes, 2007) and that what counts as situated is somewhat limited with a lack of attention to the social location of practice in wider social relationships (Contu & Wilmott, 2003). In the case of school

mathematics we cannot even consider what counts as learning mathematics and how this is legitimised without locating the school classroom and school mathematics in a network of wider social, political and ideological relationships (Ernest, 1991). School mathematics in each classroom can only be understood in the context of prescription of curricular, assessment tasks and constraints on pedagogical practice.

It is possible, depending on circumstances, for teachers to ameliorate the worst aspects of school mathematics and in some cases to substitute alternative more transformative practices (see for example, Angier & Povey, 1999; Gutstein, 2006; Boaler, 2006, 2008). Teachers' power to significantly shape or change specific mathematical practices (as understood as curriculum content) is limited, bound as they are into regulatory assessment regimes. Nevertheless, where approaches to learning mathematics are enacted that allow students to engage with mathematical problems and also with each other in more meaningful ways, the meaning of the mathematical practices and mathematical objects also changes (Cobb et al., 1992). To give an example, using fractions as a means to investigate infinity gives a different relationship to the mathematical content and can engage learners in ways that practicing algorithms does not (Povey, Burton, Angier, & Boylan, 1999).

Agency

Lave and Wenger identify the roles that practices, artefacts and the organisation of the community itself have, in creating forms of participation and practice. In so doing they go some way to recognising that power is not something simply held by individuals but rather is connected to relationship to practice. However, in school mathematics there is a sense in which practices form a self reproducing system in usual school mathematics classrooms. For example, in the UK currently it is considered 'good practice' for teachers to begin mathematics lessons by informing students of written, measurable learning objectives by which the students progress in each individual lesson is measured (Boylan & Povey, in press 1). This practice itself constrains what the mathematical content of the lesson might be as it limits the possibility of engaging in mathematical learning that cannot be compressed into a single lesson or so easily defined.

When close attention is paid to the lifeworlds of learners, school mathematics practices and mathematical objects themselves are felt to have power over learners:

> I *just* don't *trust* them, numbers, I *don't* trust them. They've got a mind of their own and they're just all over the place and I can't make any sense of them (Boylan, 2004, p. 164, original emphasis).

One way of understanding how this can be so is through Actor Network Theory (ANT) which does not differentiate in advance between human and non-human parts of an actor network when analysing agency (Fox, 2000). In school mathematics the pedagogical practices and reifications of practices themselves constrains the forms of practice available. In ANT terms they are actors. Although more difficult to trace, mathematics practices can also play such an agentic role. For example, the way in which solving linear equations is commonly taught through particular algorithms limits the practices available when learning simultaneous equations.

A pedagogy in which mathematics practices are experienced as splintered fragments limits what are considered to be acceptable forms of pedagogical practice both for teachers and also importantly for students, some of whom may resist or be disturbed when experiencing a more connected curriculum. Such constraints and influences can not be read as simple causality but rather as tracings of relationships between intertwined and co-situated practices. The fact that many classrooms show a mixture of forms of mathematics teaching indicates that ascribing agency to social practices or mathematical artefacts does mean that although school mathematics may have a tendency to self-reproduction of practice they do not form a closed and unchangeable system. Nevertheless, changing practice requires a conscious and continual exercise of agency by teachers and students alike to create different types of relationships between participants and with mathematics.

Identity

> One way to think about learning is as the historical production, transformation and change of persons (Lave & Wenger, 1991, p. 51).

The linking of practice and identity is one of the most powerful aspects of situated perspectives and highlights the extent to which educators are neither imparting knowledge nor even simply helping their students to engage in particular social practices but rather to become particular types of human beings. Thus it opens avenues of inquiry to understand learners' longer term patterns of identification and

non-identification with school mathematics (Boaler, 2000; Boaler & Greeno, 2002) as well as in-the-moment patterns of participation.

However, identity formation is not an automatic or necessary feature of being part of a social group or engaging in practice. Fully connecting identity to participation requires a more careful account of the meaning of participation than that offered in Lave and Wenger's account. Bohm (1996) distinguishes between two meanings of participation: *taking part in* and *partaking*. To partake suggests embodied engagement in which there is a sense of connection with the practice, context and co-participants that allows situated practice to do its identity work upon us. Handley et al. (2006), highlight the importance of a sense of belonging in relation to participation:

> Can an individual be 'going through the motions' - appearing as a full participant - yet not participating in the sense of experiencing a feeling of belonging and, perhaps, of mutual commitment and responsibility? (p. 649)

Such commitment and responsibility is not generally a feature of usual school mathematics classrooms:

> As soon as you walk out the class…well actually as soon as the classroom starts, you don't really know anything, 'cause you've switched off. Off you walk in and you think, 'Oh another boring lesson' and you're off. As soon as you've walked out you've forgotten about that lesson (Boaler, 1997, p. 34).

Any account of participation as identity must take into account the possibility of non-participation and so dis-identification (Hodges, 1998). In school mathematics there is a growing body of literature that points to the way in which different patterns of participation and the historical and social location of students means that students have multiple identificatory possibilities with school mathematics and as learners of mathematics. Dis-identification is a frequent occurrence (Boaler, 1997, 2000; Boaler & Greeno, 2002; Boylan, 2004; Nardi & Steward, 2003) as evidenced by learners' avoidance of mathematics when it ceases to be compulsory (Brown, Brown, & Bibby, 2008).

These differences in both participation and identification require note to be taken of differences between participants and how they are socially positioned. This does not feature prominently in Lave and Wenger's account of participation (Griffiths, 2005;

Handley et al., 2006). Accounts from school classrooms indicate complex patterns of participation and identification in relation to gender and class that support a view of identity as work (Mendick, 2006) or the ways in which we story the self through participation (Povey & Angier, 2006). However, the ways in which one can story the self in relation to mathematics are limited not only by the practices of school mathematics as a whole but also by the way these practices are enacted in relation to particular groups of learners.

It is not possible here to review this in relation to all the ways class, gender, ethnicity and other social differences constrain identity possibilities and participation in school mathematics. As an example I focus on the way the concept of ability frames participation and identity in school mathematics in UK secondary (high) schools. Even in the first year of school, pupils arrive with established identities related to their (socially constructed) ability in mathematics (Reay & William, 1999). This involves a high level of awareness of rank in the classroom (Boylan 2004). This ranking is established and reinforced by the setting (tracking) of students by ability regulated by regular testing. Pupils are continually positioned in relation to each other and rank pervades the practices of school mathematics in terms of which class a student is placed in and relationships within classes.

In Lave and Wenger's model, in informal situations the trajectory of identity is towards being full participants. However, in school the key trajectories of identity are not towards being a mathematician or even a school mathematician but towards 'success' or 'failure', to being 'good' or 'bad' at (school) mathematics and as part of this to being a ‘set one’ or ‘bottom set’ student and so on. Once these identity possibilities are imposed by setting they tend to be self reinforcing as they determine the nature of the mathematical practices and the pedagogical practices that are available to the learner in the classroom (Black, 2005; Boaler, Wiliam, & Brown, 2000; Wiliam & Bartholomew, 2004). That identity possibilities are imposed does not mean that identity itself is. Considering identity as something that people do rather than something that they are (Mendick, 2006) recognises that it is an ongoing process of creation and maintenance in which participants are not only positioned by practices or others but are active in positioning themselves (Askew, 2008). School mathematics, including setting practices, creates limits and opportunities for particular sorts of identity action.

Thus far, for ease of argument, I have largely presented usual school mathematics as a uniform whole. However, learners experience different sorts of school mathematics

depending on positioning in terms of ability. In the setting practices we see one of the ways in which the classroom practices and mathematical practices connect as the set constrains the mathematics studied. Moreover, setting by ability in mathematics also exemplifies the way in which to understand learning as situated requires extending description beyond the boundaries of the immediate practices and social relations. Ability and setting is connected to social class (Wiliam & Bartholomew, 2004), and to an ideologically constructed historically situated mathematics curriculum (Ernest, 1991) and so to socially constructed ideas of what constitutes legitimate mathematical activity for particular groups of learners.

Forms of participation in school mathematics

In outlining Lave and Wenger's theory I identified two understandings of legitimate peripheral participation in their work. Firstly, they propose a binary conception of participation as either legitimate peripheral or full participation but with recognition that other trajectories of participation are possible. The previous discussion of learning relationships, situated practice and identity indicated that peripheral participation in this sense is not found in school mathematics classrooms. We may also consider the way in which peripherality invokes a sense of less than full participation. In the stories of learning in practice given by Lave and Wenger, they describe in some detail the paths learners trace in engaging in aspects of practice that are less complex and challenging than that of full participants. Wenger offers a succinct account of this aspect of peripheral participation as it:

> … provides an approximation of full participation that gives exposure to actual practice. It can be achieved in various ways, including lessened intensity, lessened risk, special assistance, lessened cost of error, close supervision or lessened production pressures (1998, p. 100).

It might be thought that the way in which procedures in school mathematics are articulated as fragmented algorithms are examples of the close supervision or special assistance that Wenger refers to above. However the essence of school mathematics is to participate in these very practices. They are not necessarily preparation for anything beyond the classroom or only being a gateway to future study or employment. Such practices are also disconnected from mathematics as experienced outside school. Moreover, many studies have shown that school mathematics is an arena of

risk for participants in terms of anxiety, sense of self esteem, and personal and public shame (Boylan, Lawton, & Povey, 2001; Boylan, 2004; Boaler, 1997; Boaler, Wiliam, & Brown, 2000). A phenomenological study of participation found that a crucial factor in enabling participation was security of identity (Ashworth, 1997). If anything school mathematics practices represent an area of heightened risk for many learners. This risk, particularly in relation to sense of identity may act as a barrier to participation (Boaler & Greeno, 2002).

If school students are not legitimate peripheral participants in school mathematics then how might their participation be described? Both Lave and Wenger in their on-going development of situated learning theory recognise that different forms of participation are possible (Lave, 1996; Wenger, 1998). Wenger (1998) proposes an expanded range of possible trajectories of participation, these are: an inbound trajectory that appears to correspond most closely to Lave and Wenger's legitimate peripheral participation; insider trajectories to conceptualise the ongoing trajectory of full participants; boundary trajectories where participants' participation is connected to brokering across different communities of practice; outbound trajectories as people move away from the practices; and a form of peripherality that never leads to full participation. In addition, Wenger recognises that identity is also produced through what we do not participate in as well as what we do participate in. He argues that in order for participation to be peripheral and so less than full there is necessarily an element of non-participation.

However, this relatively benign form of non-participation is different from the marginality that some participants may experience. In an account of training as a teacher, Hodges (1998) describes her experience of alienation in terms of marginal participation that goes beyond Wenger's description in that it recognises the way in which this is connected not only to the local situation but also to wider relations of power and exclusion in society. I contend that marginal participation is the normal form of participation for students in school mathematics. The students have a marginal role in the production of the mathematics practices that appear to them as "from another world" (Boaler, 2000). Their relationship is marginal because of the extent to which the practices of school mathematics are marginal to their lives and concerns. This is true in the sense that it is something they have to do rather than choose to do. Further, the students' purposes in engaging in the practices may only be tangentially related to actually learning school mathematics itself rather than a range of other reasons.

I outlined earlier two conceptions of legitimate peripheral participation: firstly, the relationship between novice and expert and secondly, the relationship of all participants to the focus practice and to the relationships of practice that enable practice to happen. Participation in school mathematics is marginal in both these senses. Students have a relationship of marginality to the teachers. They also experience mathematics as isolated and alienating. Importantly, participants are also expected to place their personhood on the margins as they make what may be "agonising compromises" (Hodges, 1998, p. 285) as they participate. If legitimate peripheral participation takes place in communities of practice then the marginal participation in usual school mathematics that takes places in classrooms and classes is best described as occurring in regimes of practices (Boylan, 2004, 2005).

However, such marginality is not experienced evenly by all students. Even if they are not engaged in the development of the practice itself, some students have backgrounds and foregrounds (Skovsmose, 1994) and a history of success in school mathematics that means that their participation in the school mathematical practices is more engaged and active. For some students success in mathematics is a passport to future academic or vocational identity and the procedures of mathematics may themselves be more relevant to these students' foregrounds (Boaler, Wiliam & Brown 2000; Mendick 2006). As discussed the nature of practices varies considerably both in terms of curriculum content and pedagogic practices across sets and within sets (Black, 2005; Boaler, Wiliam & Brown, 2000; Wiliam & Bartholomew, 2003). Those students in lower sets are more likely to be offered mathematics that is disconnected, procedural and more difficult to partake of. Moreover, students in different sets experience their relationship with their teachers differently (Solomon 2008).

However, participation in school mathematics need not be marginal. There have long been alternative practices, for example emphasising pupil inquiry, open mathematical tasks, pupil discussion and social construction of knowledge. In such classrooms the relation to mathematics, classroom practice, and relationships between participants are very different (see Angier & Povey, 1999; Boaler 2006, 2008). Different forms of participation are possible and Lave and Wenger's model of legitimate peripheral participation in communities of practice will be more applicable. Moreover, in many school mathematics classrooms a range of different types of mathematics and pedagogy can be found. The possibility of such variations in forms of practice, itself

tends to support the value of understanding taking part in practice through a more fluid conceptualisation - ecologies of participation.

Ecologies of participation

The argument in this article is that situated learning in usual school mathematics classrooms cannot be understood through the concept of legitimate peripheral participation. So far the purposes of participants and activity in school mathematics classrooms have generally been assumed to be centrally concerned with participating and learning school mathematics. However, this is not necessarily the case. Earlier in discussing outcomes of participation in terms of identity and belonging, I reviewed ways in which learners dis-identify or experience alienation. From this we can infer that learners will have experienced "many 'lags' in participation, when a person is engaged in 'doing' and yet is withdrawing from an identification with the practice" (Hodges, 1998, p. 279). However, even the notion of lags in participation may obscure the way in which, within participants own lifeworlds, their purposes may have little to do with school mathematics. For example, forms of participation in certain classroom practices may be aimed at maintaining or creating forms of identity and relationship with the teacher and others and may have very little to do with learning mathematics of any type at all (Askew, 2008; Askew, Brown, Denvir, & Rhodes, 2000). Such practices may occur within and as part of appearing to participate in the rites of school mathematics. In other situations where there is a great deal of dis-identification and resistance to school mathematics different practices may arise or be inserted that disrupt and compete with school mathematics practices (Boylan, 2004).

Boaler and Greeno (2002) suggested the notion of ecologies of participation to conceptualise differences in identification with mathematics in contrasting classrooms that are either discussion based or procedurally focused. Ecology is used as a metaphor, apparently, to indicate the way in which forms of participation cannot be pre-mapped but rather need to be investigated as they arise in the complexity of the interrelationship of the figured world, positioning and authoring of participants (Holland, Lachicotte, Skinner, & Cain, 1998). I propose that developing and extending the ecological metaphor from a situated perspective also allows account to be taken of the interrelation of a particular situation and sets of practices with the other systems they are part of. Lemke, in discussing Lave & Wenger's theory, argues that learning can be reconceptualised as taking place in eco-social systems which can model the complex networks of linked and interdependent relations (Lemke, 1997). Actor Network Theory

and connected perspectives also offer much in this regard. Ecological metaphors developed in this and related framings of social relations and forms such as filaments (Latour, 2005) or the rhizome (Deleuze & Guattari, 1987) may be helpful to develop an understanding of participation taking place in different but interrelated timescales (Lemke, 2000). This approach allows for concepts such as peripheral participation to be used as a means to understand specific moments of learning, for example in individual teacher-student encounters, even in contexts where over longer time periods participation is marginal. Watson and Winbourne (1998) have suggested a way to theorise how sets of practices and pedagogies that are more akin to those found in communities of practice may develop or be developed in a sequence of lessons or even in single lessons through the concept of local communities of practice.

Thinking in terms of ecologies of participation and by extension analysing particular forms of ecologies of practices (Boylan, 2004) offers a number of possibilities. Firstly, it recognises legitimate peripheral within communities of practice as one form of participation within one type of social configuration. It acknowledges the different sorts of formations in which participants learn in practice that do not fit into the community of practice model (see Engström, 2007 and Roberts, 2006 for examples). Lave and Wenger's theory of situated learning was one approach to decentering the role of the teacher and teaching to bring the learner and learning to the centre of analysis. Thinking in terms of ecologies of practice offers a moving centre. When learning is understood as the flow and creation of meaning in the social ecology, the focus and frame of understanding will change depending on the situation and the analytical purpose. Possible framings and foci might be: on the learner (novice) as an embodied person engaged in identity as work; the teacher (old-timer); other participants; the practices themselves, including both the practice around which a social grouping is apparently constituted and the practices that in that moment are the ones in which participators are partaking; the reifications of practice; and/or the situatedness as the web of historical and social forces in which participation and so learning occurs. In addition the ecological metaphor opens the conceptual frame for understanding learning to allow for multiple paradigms, including recognising both participation and acquisition as useful metaphors and analytical tools depending on the particular situation (Sfard, 1998).

The ecological metaphor stresses that participation is a multi-dimensional way of being in the world in which the extent and nature of participation emerges as part of the

interplay of the meaning of the practice in the lifeworld, the on-going identity work of the participant, and the constraints and possibilities of the situation. Such participation can be described through multiple continuums (rather than binaries) with many possibilities across each dimension. Some of the dimensions and limits of these continuums which bound the possibilities are: taking part/ partaking of, imposed participation/voluntary participation, enthusiasm/reluctance, support/resistance, risking identity/securing identity, engagement/disengagement, maintaining identity/transforming identity, and marginal/ legitimate peripheral. In addition, as participation unfolds the degree of emotional, intellectual, embodied, relational and socio-cultural involvement will change. Which dimensions will be particularly important in understanding learning, cannot, I believe be, determined in advance or separate from the context of the situation. Further the concept of ecologies of participation allows for understanding how teacher learning may take place through forms of participation that correspond to legitimate peripheral participation in teacher communities of practice whilst simultaneously students' participation and learning may have a variety of different characteristics including marginality.

A more elaborated account of ecologies of participation in school mathematics would need to include an account of mathematics classroom practices and social practice as discursive. Here it could build not only on linguistic analysis from a participative perspective (Barton & Hamilton, 2005; Tusting, 2005) but also the significant body of work that is developing within mathematics education from a discursive perspective (see for example, Lerman, 2001; Walkerdine, 1988; Walshaw, 2004)

Communities of practice

In this paper I have focused on legitimate peripheral participation. However, a parallel series of arguments can be made in relation to Wenger's later model of communities of practice. Indeed, elsewhere I have criticised Wenger's model for its ability to account for the varied forms of participation and practice that occur (Boylan, 2004). Studies of participation informed by literacy studies and linguistic analysis support this suggesting that understanding change, moment to moment interaction and the reification of meaning requires more fluid frames to analyse practice (see Barton & Hamilton, 2005; Linehan & McCarthy 2000; Tusting, 2005). Barton & Hamilton (2005) also draw on Actor Network Theory and other sociological perspectives to address issues of agency and power. These approaches to extending understanding of communities of practice are relevant to re-analysing the meaning of participation and to developing an analysis

in terms of ecologies of participation. What defines an ecosocial system as different from an ecosystem is what the system and its constituent parts mean to us (Lemke, 1997). From a discursive perspective Tusting writes:

> Semiotic events are not merely produced by semiotic systems but co-produced by semiotic, material, personal and social systems - from these you cannot straightforwardly abstract merely the semiotic elements (2005, p. 42).

Similarly, given the close relationship between participation and meaning, the argument of this article is that participation too cannot be abstracted, as it changes moment to moment and is socially constructed in time, from the specific semiotic, material, personal and social systems of the participants and practices that constitute the ecology of practices.

Conclusion

In this article I have argued that the concept of legitimate peripheral participation is not sufficient to understand either the forms of participation of participants in usual school mathematics classrooms or the reasons why the available forms of participation are as they are. Much of what is true of school mathematics is, arguably, true for other school subjects if pedagogies are based on the transmission of facts or procedures. If legitimate peripheral participation is not found in usual school mathematics classrooms this undermines the claim made by Lave and Wenger that it is a universal feature of situated learning.

However, Lave and Wenger's model is powerful in a number of ways in relation to learning in school classrooms. Firstly, it is a description of *one* form of participation and *one* particular social formation that arise in some informal learning situations. This is a useful comparison for formal contexts. Secondly, it supports and informs interventions to transform pedagogic practice. However, to be a useful heuristic and analytical perspective the concept of participation itself must be emphasised rather than a particular and contingent form of participation that may not be found in school and other formal learning situations. Lave and Wenger identified and theorised the importance of participation as learning as part of the development of situated learning theory but by generalising from one contingent form of participation, participation is, in a sense, removed from the situatedness of the context. Understanding learning as

taking place in and through ecologies of participation allows for both learning and participation to be understood as situated.

9247 words

References

Adler, J. (1998). Lights and limits: Recontextualising Lave and Wenger to theorise knowledge of teaching and of learning school mathematics. In A. Watson (Ed.), *Situated cognition and the learning of mathematics* (pp. 161-177). Oxford: Centre for Mathematics Education, University of Oxford.

Anderson, S.E. (1997). Worldmath curriculum: Fighting eurocentrism in mathematics. In A. Powell & M. Frankenstein (Eds.), *Ethnomathematics: Challenging eurocentrism in mathematics education* (pp. 291-306). New York: SUNY Press.

Angier, C. & Povey, H. (1999). One teacher and a class of school students: Their perception of the culture of their mathematics classroom and its construction. *Educational Review,* 51(2), 147-160.

Ashworth, P. (1997). The Meaning of Participation. *Journal of Phenomenological Psychology,* 28(1), 82-103.

Askew, M. (2008). Social identities as learners and teachers of mathematics. In A.Watson & P.Winbourne (Eds.), *New directions for situated cognition in mathematics education* (pp. 59-78). New York: Springer.

Askew, M., Brown, M., Denvir, H. & Rhodes, V. (2000). Describing primary mathematics lessons observed in the Leverhulme Numeracy Research Programme: A qualitative framework. A paper delivered at the 24th Conference of The International Group for the Psychology of Mathematics Education, Hiroshima, Japan: 2, 17-24.

Barton, D. & Hamilton, M. (2005). Literacy, reification and the dynamics of social interaction. In D. Barton & K. Tusting (Eds.), *Beyond communities of practice,* (pp. 14-35). Cambridge: Cambridge University Press.

Black, L. (2005). 'She's not in my head or in my body': Pupil participation in teacher-pupil interactions in the primary school classroom. Paper presented at First Socio-cultural Theory in Educational Research and Practice Conference. University of Manchester September 2005. Available from http://orgs.man.ac.uk/projects/include/experiment/laura_black.pdf

Boaler, J. (1997a). *Experiencing school mathematics: Teaching styles, sex and setting*. Buckingham: Open University.

Boaler, J. (1997b), Setting, social class and survival of the quickest. *British Educational Research Journal,* 23(5), 575-595.

Boaler, J. (1999). Participation, knowledge and beliefs: a community perspective on mathematics learning. *Educational Studies in Mathematics,* 40, 259-281.

Boaler, J. (2000). Mathematics from another world: traditional communities and the alienation of learners. *Journal of Mathematical Behaviour*, 18(3), 379-397.

Boaler, J. (2006), How a detracked mathematics approach promoted respect, responsibility and high achievement. *Theory into Practice*, 45(1), 40-46.

Boaler, J. (2008), Promoting "relational equity" and high mathematics achievement through an innovative mixed-ability approach. *British Educational Research Journal,* 34, (2), 167–194.

Boaler, J, & Greeno, J. (2002) Identity, agency and knowing in mathematical worlds. In J. Boaler (Ed.), *Multiple perspectives on mathematics teaching and learning,* (pp.171-200). Westport: Ablex Publishing.

Boaler, J. Wiliam, D. & Brown, M. (2000). Students' experiences of ability grouping - disaffection, polarisation and the construction of failure. *British Educational Journal,* 26(5), 631-648.

Boaler, J. Wiliam, D. & Zevenbergen, R. (2000). The construction of identity in secondary mathematics education. In J.F. Matos and M. Santos (Eds.), *Proceedings of the Second International Mathematics Education and Society Conference (MES2),* (pp. 192-202). Montechorro, Portugal: Centro de Investigaçãem Eduação da Faculdade de Ciências Universidade de Lisboa.

Bohm, D. (1996) *On Dialogue*. London: Routledge.

Boylan, M. (2002). Teacher questioning in communities of political practice. In P. Valero & O. Skovsmose (Eds.), *Proceedings of the Third International Mathematics Education and Society Conference (MES3)* 1, 182-191. Helsingor: Centre for research in mathematics education.

Boylan, M. (2004). *Questioning (in) school mathematics: Lifeworlds and ecologies of practice*. Unpublished PhD Thesis. Sheffield Hallam University.

Boylan, M. (2005). School classrooms: Communities of practice or ecologies of practices. Paper presented at the First Socio-Cultural Theory in Educational Research Conference' September 2005 Manchester University UK. http://orgs.man.ac.uk/projects/include/experiment/mark_boylan.pdf

Boylan, M, Lawton, P. & Povey, H. (2001). "I'd be more likely to speak in class if...": Some students ideas about increasing participation in whole class interactions. In M. Heuvel-Panhuizen (Ed.), *Proceedings of the 25th Conference of the International Group for the Psychology of Mathematics Education (PME)*, 2, 201-208. Utrecht: Freudenthal Institute.

Boylan, M. & Povey, H. (In press 1). Promoting equality in the mathematics classroom. In M. Cole (Ed.), *Equality in the secondary school: Promoting good practice across the curriculum*. London: Continuum.

Brown, M., Brown, P. & Bibby, T. (2008), "I would rather die": reasons given by 16-year-olds for not continuing their study of mathematics. *Research in Mathematics Education,* 10, (1), 3-18.

Burton, L. (2002). Recognising commonalities and reconciling differences in mathematics education. *Educational Studies in Mathematics,* 50(2), 157-175.

Burton, L. (2004). *Mathematicians as enquirers: Learning about learning mathematics.* Dordrecht: Kluwer.

Cobb, P., Wood T., Yackel, E. & McNeal, B. (1992). Characteristics of classroom mathematical traditions: an interactional analysis. *American Educational Research Journal,* 29(3), 573-604.

Contu, A. & Wilmott, H. (2003). Re-embedding situatedness: the importance of power relations in learning theory. *Organization Science*, 7(2), 269-276.

Cotton, Tony. (1998). *Towards a mathematics education for social justice.* Unpublished PhD Thesis, University of Nottingham.

Deleuze, G, & Guattari, F. (1987). *A thousand plateaus: Capitalism and schizophrenia*. Translated by Massumi, Brian. Minneapolis: University of Minnesota Press.

Engeström, Y. (2007). From communities of practice to mycorrihizae. In J. Hughes, N. Jewson & L. Unwin (Eds.). *Communities of practice: critical perspectives*. (pp. 41-54). Abingdon: Routledge.

Ernest, P. (1991). *Philosophy of mathematics education*. London: Falmer.

Ernest, P. (1998). The culture of the mathematics classroom and the relations between personal and public knowledge: An epistemological perspective. In F. Seeger, J. Voigt & U. Waschescio (Eds.), *The culture of the mathematics classroom* (pp. 245-268). Cambridge: Cambridge University Press.

Fuller, A. (2007). Critiquing theories of learning and communities of practice. In J. Hughes, N. Jewson & L. Unwin (Eds.), *Communities of practice: Critical perspectives* (pp. 17-29). Abingdon: Routledge.

Fuller, A., Hodkinson, H., Hodkinson, P. & Unwin, L. (2005). Learning as peripheral participation in communities of practice: a reassessment of key concepts in workplace learning. *British Educational Research Journal,* 31(1), 49-68.

Fox, S. (2000). Communities of practice, Foucault and actor-network theory. *Journal of management studies,* 37(6), 853-867.

Goos, M., Galbraith, P. & Renshaw, P. (1999). Establishing a community of practice. In L. Burton (Ed.), *Learning mathematics from hierarchies to networks* (pp. 36-61). London: Falmer.

Gregg, J. (1995). The tensions and contradictions of the school mathematics tradition. *Journal for Research in Mathematics Education,* 20(5), 442-446.

Griffiths, M. (2005). A feminist perspective on communities of practice. Paper presented at the First Socio-Cultural Theory in Educational Research Conference' September 2005 Manchester University UK. http://orgs.man.ac.uk/projects/include/experiment/morwenna_griffiths.pdf

Gutstein, E. (2006). *Reading and writing the world with mathematics*. Routledge: New York.

Handley, K., Sturdy, A., Fincham, R. & Clark, T. (2006). Within and beyond communities of practice: making sense of learning through participation, identity and practice. *Journal of Management Studies,* 43(4), 641-653.

Hiebert, J., Gallimore, R., Garnier, H., Bogard Givvin, K., Hollingsworth, H., Jacobs, J., Miu-Ying Chui, A., et al. (2003). Teaching mathematics in seven countries: Results from the TIMSS 1999 video study. National Centre For Educational Statistics: Washington DC.

Hodges, Dianne. (1998). Participation as dis-identification with/in a community of practice. *Mind, Culture and Activity,* 5(4), 272-290.

Hodkinson, P. & Hodkinson, H. (2004). A constructive critique of communities of practice: Moving beyond Lave and Wenger. Paper presented at OVAL Research Group, University of Technology Sidney, 11th May.

Holland, D., Lachicotte, W., Skinner, D. & Cain, C. (1998). *Identity and agency in cultural worlds*. Cambridge, Ma.: Harvard University Press.

Hughes, J. (2007). Lost in translation: Communities of practice, the journey from academic model to practitioner tool. In J. Hughes, N. Jewson & L. Unwin, (Eds.), *Communities of practice: Critical perspectives* (pp. 30- 40). Abingdon: Routledge.

Hughes, J., Jewson, N. & Unwin, L. (2007). Introduction: Communities of practice: a contested concept in flux. In J. Hughes, N. Jewson & L. Unwin, (Eds.), *Communities of practice: Critical perspectives* (pp. 1-16). Abingdon: Routledge.

Kanes, C. & Lerman, S. (2008). Analysing concepts of community of practice. In A. Watson & P. Winbourne (Eds.), *New directions for situated cognition in mathematics education* (pp. 303-326). New York: Springer.

Latour, B. (2005). Reassembling the social: An introduction to actor network theory. Oxford: Oxford University Press

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Lave, J. (1988). *Cognition in practice*. Cambridge: Cambridge University Press.

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

Lea, M. (2005). 'Communities of practice' in Higher Education: Useful heuristic or educational model? In D. Barton & K. Tusting (Eds.), *Beyond communities of practice,* (pp. 180-197). Cambridge: Cambridge University Press.

Lemke, J. (1997). Cognition, context, and learning: A social semiotic perspective. In D. Kirshner. & J. Whitson (Ed.) *Situated cognition: social, semiotic and psychological perspectives* (pp 37-56). Mahwah, NJ.: Lawrence Erlbaum Associates.

Lemke, J. (2000). Across the scales of time: artefacts, activities and meanings in ecosocial systems. *Mind, Culture and Activity,* 7(4), 273-290.

Lerman, S. (1998) Learning as social practice: an appreciative critique. In A. Watson (Ed.), *Situated cognition and the learning of mathematics* (pp. 33-42). Oxford: Centre for Mathematics Education, University of Oxford Department of Educational Studies.

Lerman, S. (2000). The social turn in mathematics education research. In J. Boaler (Ed.), *Multiple perspectives on mathematics teaching and learning* (pp. 19-44). Westport: Ablex Publishing.

Lerman, S. (2001). Cultural, discursive psychology: A sociocultural approach to studying the teaching and learning of mathematics. Educational Studies in Mathematics, 46:87-11.

Linehan, C. & McCarthy, J. (2000). Positioning in practice: understanding participation in the social world. *Journal for the Theory of Social Behaviour,* 30(4), 435-453.

Linehan, C & McCarthy, J. (2001). Reviewing the "community of practice" metaphor: an analysis of control relations in a primary school classroom. *Mind, Culture and Activity,* 8(2), 129-147.

Mendick, H. (2006). *Masculinities in mathematics*. Maidenhead: OUP.

Nardi, E, & Steward, S. (2003). Is mathematics T.I.R.E.D? A profile of quiet disaffection in the secondary mathematics classroom. *British Educational Research Journal,* 29(3), 345-367.

Nunes, T., Schliemann, A., and Carraher, D. (1993). *Street mathematics and school mathematics.* New York: Cambridge University Press.

Povey, H., Burton,

Reay, D. & Wiliam, D. (1999), "I'll be a nothing": structure, agency and the construction of identity through assessment, *British Educational Research Journal*, 25(3), 343- 354.

Roberts, J. (2006). Limits to communities of practice. *Journal of Management Studies,* 43(3), 623-639.

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

Skovsmose, O. (1994). *Towards a philosophy of critical mathematics education*. Dordrecht: Kluwer.

Solomon, Y. (2007). Experiencing mathematics classes: ability grouping gender, and the selective development of participative identities. *International Journal of Educational Research,* 46, 8-19.

Stigler, J, & Hiebert, J. (1997). Understanding and improving classroom mathematics instruction: an overview of the TIMMS video study. *Phi Delta Kappa*, September 1997, 14-21.

Tusting, K. (2005). Language and power in communities of practice. In D. Barton & K. Tusting (Eds.), *Beyond communities of practice,* (pp. 36-54). Cambridge: Cambridge University Press.

Watson, A. (Ed.) (1998). *Situated cognition and the learning of mathematics*. Oxford: Centre for Mathematics Education Research, University of Oxford Department of Educational Studies.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity*. Cambridge: Cambridge University Press.

Wenger, E., McDermott, R. & Snyder, W. (2002). *Cultivating communities of practice: A guide to managing knowledge.* Boston, Ma.: Harvard Business School Press.

Walkerdine, V. (1988). *The Mastery of Reason: Cognitive Development and the Production of Rationality*. London: Routledge.

Walshaw, M. (Ed.) (2004). *Mathematics education within the postmodern*. Greenwich: Information Age Publishing

Watson, A. (2008). School mathematics as a special kind of mathematics. Paper presented at International Commission for Mathematics Instruction (ICMI) Centennial Symposium. Rome, March 2008, available at http://www.unige.ch/math/EnsMath/Rome2008/WG1/Papers/WATSON.pdf

Watson, A. & Winbourne, P. (Eds.) (2008a). *New directions for situated cognition in mathematics education.* New York: Springer

Watson, A. & Winbourne, P. (2008b). Introduction. In A. Watson & P. Winbourne (Eds.), *New directions for situated cognition in mathematics education* (pp.1-12). New York: Springer.

Winbourne, P. & Watson, A. (1998). Participating in learning mathematics through shared local practices in classrooms. In A. Watson (Ed.), *Situated cognition and the learning of mathematics*, (pp 93-104). Oxford: Centre for Mathematics Education, University of Oxford Department of Educational Studies.

Wiliam, D. & Bartholomew, H. (2004). It's not which school but which set you're in that matters: the influence of ability grouping practices on students' progress in mathematics. *British Educational Research Journal,* 30 (3), 279-293.