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An exploratory case study of computer use in a primary school mathematics classroom: New technology, new pedagogy?

JOANNE HARDMAN

JOANNE HARDMAN is a lecturer in Educational Psychology at the School of Education, University of Cape Town. Her research interests include using Sociocultural and Activity Theory as a framework for understanding learning and cognition in school and tertiary educational settings, tracking the development of mathematical concepts in children, computer-assisted learning and teaching; using developmental work research to provoke change in classroom settings and developing wireless technology as a learning/ teaching tool at a tertiary level.

Abstract

Because computers potentially transform pedagogy, much has been made of their ability to impact positively on student performance, particularly in subjects such as mathematics and science. However, there is currently a dearth of research regarding exactly how the computer acts as a transformative tool in disadvantaged schools. Drawing on a detailed case study of a Grade 6 mathematics classroom I address the question of whether the introduction of a new tool – the computer – into the classroom shifts a teacher's pedagogical practice. I do this by elaborating on Vygotsky's learning theory before discussing Activity Theory as a framework for analysing change within and between the activity systems of the classroom and the computer laboratory. By focusing on contradictions as dynamic forces of change, I demonstrate how we can track transformation within an activity system. Tracking these contradictions enables me to illustrate how the use of the computer potentially leads to a shift in the object of the mathematics classroom, which in turn, leads to shifts in other elements of the classroom. This article seeks to provide one illustration of the way in which Activity Theory can be used as a methodological tool to investigate pedagogical change within a classroom.

Introduction

In the past two decades computer-assisted teaching and learning have come to occupy an influential role in schools across the world. This is especially true in mathematics classrooms, where Papert's (1980; 1990; 1993) work and success with Logo has introduced a generation of students to this ephemeral microworld[1] (Campbell, Fein & Schwartz, 1991; Au & Leung, 1991; Yelland, 2003). Proponents of using technology to teach mathematics point to studies that indicate that computers and calculators can support and enhance problem-solving environments (Fey, 1984), can decrease the amount of time required to master skills, allowing for more time to be spent

1 First used by MIT Media Lab Learning and Common Sense Group, the term microworld refers to a miniature world in which students can explore alternatives, test hypotheses and 'discover' facts. Unlike a simulation which is not 'real' a microworld is treated as a 'real' world.

on developing conceptual understanding (Cox, Abbott, Webb, Blakeley, Beauchamp, Rhodes, 2004) and can facilitate the development of deeper understanding of algebraic ideas (Kaput, 1992).

South Africa currently faces a crisis in mathematics education which has seen it placed last[2] in the Third International Mathematics and Science Study (Martin, Mullis, Gonzalez, Gregory, Smith, Chrostowski, Garden, & O'Connor, 2000). If computers are indeed able to impact positively on mathematical performance, then placing this new technology in schools could help alleviate the deepening crisis, enabling shifts in pedagogical practices and thus potentially benefiting students' learning. Much has been made of the computer's ability to act as a catalyst to transform pedagogical practices in classrooms (McLoughlin & Oliver, 1999; Hawkridge, Jaworski & McMahon, 1990). However, there is a relative dearth of research regarding *how* the computer comes to transform pedagogy, especially in developing countries where access to this technology has only recently become available to students who are, in many cases, educationally and economically disadvantaged.The research reported on here is driven by the understanding that a novel tool can provoke conflict within the context into which it is introduced, leading to the transformation of the practices within that environment. This article therefore poses the following question: Do pedagogical practices shift when new tools are used in teaching and learning in a "previously[3]" disadvantaged mathematics classroom? This article attempts to use Activity Theory as an analytical tool to investigate whether the introduction of novel technology (in this case computer technology) into a classroom transforms pedagogy. It first sketches ways in which Russian Activity Theory, arising from the work of Vygotsky, may expand understandings of learning before elaborating the theory in terms of Engestrom's (1987) contributions.

Theoretical framework

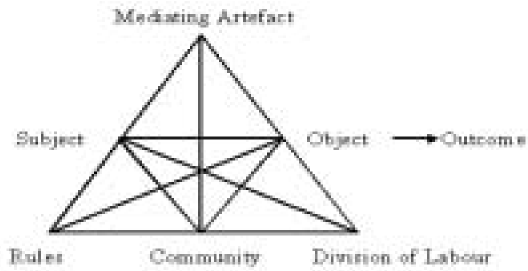
A fundamental premise of Vygotskian theory is that basic biological (or 'elementary') processes are transformed into higher cognitive functions through the use of culturally meaningful tools and signs (such as language) during social interaction (Vygotsky, 1978; Diaz, Neal & Amaya-Williams, 1993). As the child develops within his/her social world, these elementary processes are transformed by the child's interaction with his/her social world. Higher cognitive functions develop first as interpsychological functions, with (m)other initially guiding the child's activity, before being internalised as intrapsychological functions. Vygotsky (1978) refers to this area of directed activity as the Zone of Proximal Development (ZPD). Within this zone the child acts with the aid of an 'other' in order to understand and solve problems that s/he cannot solve unaided. Through mediated action, culture becomes internalised as a set of regulatory processes (Wertsch, 1991). It is here, within this 'zone of potentiality', that mediation as instruction provides an impetus for learning and consequently, change. In Vygotsky's (1978) notion of mediation within the ZPD we find a conceptual basis for theorising educational change within a socio-psychological framework. While Vygotsky's learning theory points the way towards an understanding of learning as distributed, it does not develop an analytical framework capable of situating learning within a wider context, accounting for the collective and dynamic nature of activities (Lim & Chai, 2004). Therefore, while the first generation of Activity Theory centres on Vygotsky's notion of mediation, this notion is still located on the level of the individual's actions and does not go far enough to illustrate how cognitive change happens within a collective context. The distinction between

2 The international average score for 38 countries was 487 points; South Africa achieved a total of 275 points.

3 I place previously in inverted commas to indicate my uncertainty regarding whether in fact the particular school reported on in this study has ceased to be disadvantaged. While the school certainly is no longer oppressed by the apartheid regime, it is, nevertheless, still disadvantaged from a purely material and human resource vantage point.

individual action and collective activity implied, but not articulated in Vygotsky's theory, was elaborated on by one of his colleagues, Alexei Leontiev whose famous example of the "primeval collective hunt" clarified the distinction between individual action and collective activity (1981, 210-213). The second generation of Activity Theory arose then out of Leontiev's three-level model of activity with its basis in the distinction between action, operation and activity (Engestrom, 1987). However, for some theorists (most notably Yrjo Engestrom) this model failed to develop Vygotsky's model into one of collective activity. Figure 1 illustrates the basic unit of analysis – an activity system – proposed by Engestrom's third generation Activity Theory model, which graphically expanded on Vygotsky's model (1987, 78).

Figure 1: Activity system



Engestrom 1987, 78

It is on this third generation Activity Theory model that I draw in this article. For activity theorists, change within and between activity systems is driven by contradictions (Russell, 2002; Engestrom, 1987), which emerge both within activity systems and between them. Contradictions may arise, for example, when a new tool such as the computer requires a new division of labour in teaching, or they may arise because participants from different activity systems have different objects and motives (Russell, 2002). Uncovering contradictions, then, enables us to formulate hypotheses on possible shifts in and between systems. In other words, identifying contradictions within a classroom, understood as an activity system, could tell us something about potential shifts in pedagogical practice. This paper uses Vygotsky's learning theory but seeks to situate his understanding of mediation within the wider social context, taking into account the community, rules and division of labour involved within an activity system (Engestrom, 1987; 1990) within a classroom, as is the case in this study.

The basic relationships in Activity Theory as discussed in this study are outlined below:

- *Subject:* This is the focus of the study; for our purposes the subject is the teacher.
- *Mediating artefacts:* These are tools that the subject uses to act on the object space. In a crude formulation, one might view these as resources mobilised by the teacher. Significantly, these tools mediate thought during the interaction between the subject and the context within an activity. These tools are both material (for example, the blackboard) and psychological (e.g. language or symbolic systems such as algorithms). Crucially, tools are not neutral. They have an established history of use and carry within them cultural meanings (Saljo, 1999).
- *Object*[4]*:* The object of an activity system represents that problem space that the teacher and students are working on. For Engestrom the object "refers to the 'raw material' or 'problem' space' at which the activity is directed and which is moulded and transformed into outcomes with the help of physical and symbolic, external and internal mediating instruments, including both tools and signs" (Engestrom, 1987,

79). It is important to see the object as both material and ideal; that is, the object contains within it both the subject's motivation (for acting) as well as the actual material problem space acted on (Kaptelinin, 2005). Most activity theorists today agree that the basic characteristic of an activity system is its object[5] orientation (Popova & Daniels, 2004; Hardman, 2004b; 2005). Hence, identifying what object is being worked on within a specific context, will help to illuminate the activity system as a whole. Tracking the object, however, represents something of a challenge as it is notoriously difficult to "catch" (Foot, 2002). I have argued for methods of tracking the object (Hardman, 2005) and present a shorter version of those arguments here. First, as the object represents the motive for the existence of the activity, and as it is the subject's motivation that drives this, interviews can be useful tools for unpacking motives. Second, what the teacher says and does in the classroom enables us to develop a picture of what it is that he/she is working on in the lesson; consequently, identification of the tools used by the teacher enables one to (potentially) identify the object of the system.

- *Rules:* These are norms, conventions and social interactions of the classroom, which drive the subject's actions. Rules in the classroom can, for example, be directives for appropriate behaviour (such as putting up one's hand when answering a question, rather than shouting out) or could relate to how the teacher treats the children and expects them to treat each other. Classroom rules are generally informed by policy. So for example, the introduction of Outcomes-Based Education has impacted on classroom interactions, with teachers at least paying lip service to the understanding that children are active cognising agents who need to acquire knowledge through engaging with their context rather than solely through transmission.
- *Community*: The subject is a member of a community who participates in acting on the shared object. There is a division of labour within the community, with responsibilities, tasks and power continuously being negotiated (Cole & Engestrom, 1993). In the case study reported here the community comprises the teacher and the students who work together on a shared problem in the mathematics classroom. In a wider sense, the teacher and students are members of the community of the school; teachers are members of teacher unions or members of a community of mathematics teachers.
- *Division of labour*: This is both vertical and horizontal and refers to the negotiation of responsibilities, tasks and power relations within a classroom as well as throughout the school. In this study the teacher's role in the traditional classroom is to teach and students' roles are to learn. The introduction of the computer can potentially force a shift in the roles of teacher and students, with students functioning more as teachers of other students in the computer laboratory.

Research design and methods

The instructional context

The school is located in a farming area outside Cape Town. School fees, a proxy variable for socio-economic status, are R150[6] per annum. While this is a relatively small amount, only approximately

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4 I use Engestrom's (1987) definition here rather than Leontiev's (1981). While there are important similarities between these theorists, there are also fundamental differences, most notably in their understanding of the object. For more on these differences readers are referred to Kaptelinin (2005).

5 While I refer to a single object, I am aware that multiple objects might be worked on at any one time while an activity unfolds.

6 The mean annual school fees in the Western Cape are R700 (HSRC, 2005).

1/3 of the parent body is able to pay this. Parents are heavily involved in the school and are encouraged to attend computer lessons after school hours so that they too can become computer literate. The school is small, catering for 167 students. Most of the students in the school are described by the principal as coming from extremely poor backgrounds. A feeding scheme is in place in the school to ensure that children have at least one meal a day. Although located in a relatively remote farming area, the school has benefited from a programme driven by the Western Cape Education Department under the Khanya Project initiative, that aims to bridge the digital divide, while also addressing the shortage of teacher capacity (particularly but not only in mathematics) through harnessing technology to support and strengthen teaching and learning in disadvantaged classrooms (Hardman, 2004a). At the time of this study, computers had been in the school for one full year; hence a level of familiarity with the novel technology was assumed.

Exploratory case study

As this study seeks to understand how a teacher used computers to teach mathematics in a rural farm school, it adopts an exploratory case study design (Yin, 1993). In order to develop a deep, nuanced understanding of the context, data were collected over the duration of a year. The case was selected based on the following criteria:

1. Access to computers: There are sufficient computers for children to work on. In this study, pairs of students worked at a computer.
2. Disadvantaged school: The learner profile is one of disadvantaged, Afrikaans-speaking predominantly 'coloured[7]' children (where 'disadvantage' refers to low socio-economic status as determined by the proxy variable of school fees).

This analysis reports on one case study in a rural farm school.

The participants

The participating teacher, B is a 38-year-old male who has been teaching for 13 years. He has a 4-year diploma from a teachers' training college. His teacher training did not focus specifically on mathematics; however, mathematics was part of his curriculum at college. He is considered the specialist mathematics teacher in the school and teaches mathematics to both Grade 6 and 7. Although he has received only two hours of training in the use of computers, he has a computer at home that he uses to familiarise himself with various programmes. He believes that computers are essential for assisting the children in his school to bridge the digital divide.

There are 30 students in B's Grade 6 mathematics class. The average age of the children at the time of the study was 11 years and 3 months.

Methods

This study seeks to disclose how a teacher in a rural farm school uses a computer to teach mathematics and whether the use of this new technology alters his pedagogy. In order to probe this question it was necessary to compare the teacher's pedagogical practices across the context of the face to face and computer lessons. To this end both types of lessons were videotaped. This article focuses on an in-depth analysis of two face to face and two computer lessons, which were representative of the teacher's general pedagogical practices across the two contexts. These lessons were videotaped, the video tapes transcribed, and these transcriptions were

[7] I recognise that the use of racial classifications serves to perpetuate inequality; however, as these terms still have currency in post-Apartheid South Africa and still serve to impact heavily on people's lives, I make use of this term in this study as descriptors that continue to carry meaning in this context.

coded in terms of categories arising from both the empirical data and from the theoretical frameworks used in this study.

Furthermore, in order to ascertain the teacher's motivation for computer use and indeed to probe the teacher's understanding of the computer as a teaching/learning tool, interviews were conducted before each observed lesson. A semistructured interview schedule was used to guide the discussion. The questions were open-ended in order to encourage the respondent to develop a narrative around teaching with computers. Questions probed the teacher's epistemic assumptions regarding teaching and learning mathematics as well as the teacher's thinking on the use of computers as teaching/learning tools; the use of ICT and non-ICT tools; rules in the traditional and computer classrooms; division of labour; motives for acting on objects and the objectives of ICT and non-ICT lessons. Each interview took 1 hour and 45 minutes and was audio-recorded and transcribed.

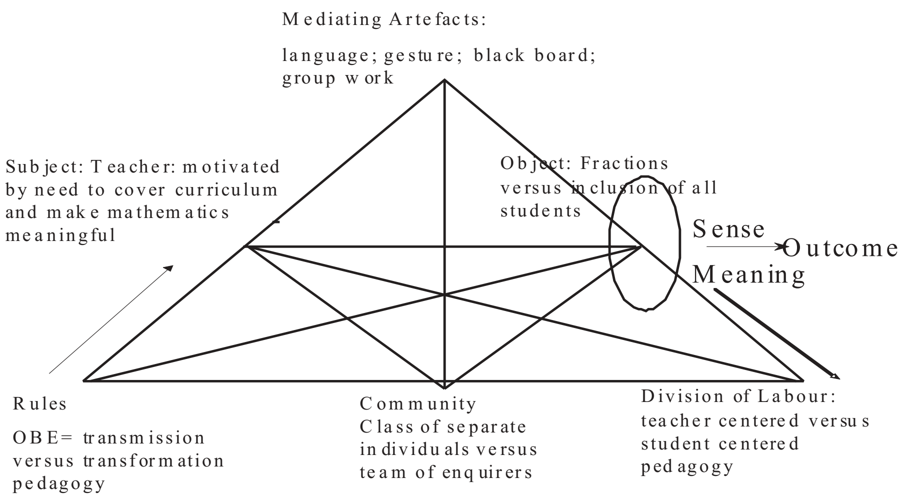
Results and discussion

The results are reported in two sections. First the interview data, aimed at eliciting the teacher's understanding of how s/he uses the computer in the classroom, are reported. Secondly, actual practice is investigated to establish what object[s] the teacher acts on in the different contexts and whether the computer has led to a shift in pedagogical practice across the different contexts. This study's interest in investigating potential shifts in pedagogical practice is addressed by focusing on contradictions that arise within these two contexts. These contradictions are tracked by focusing on the how the teacher talks about computer use in the mathematics classroom.

Intended usage

Figure 2 is a graphical representation of data gathered from an interview with B.

Figure 2: In the face to face lesson



Rules/subject contradiction

In Figure 2 we can get a sense of the teacher's perception of the activity system he inhabits in the classroom. Driven by the new move towards Outcomes-Based Education (OBE) the teacher states that he favours tools such as group work to act on the object of his lesson, fractions. His stated motive for teaching fractions is to equip students with mathematical knowledge that will be useful to them in later life as well as preparing them to succeed in Grade 7. He is also motivated by the need to cover the curriculum quickly. While there is no obvious tension between these motives, Extract 1 begins to suggest a developing contradiction between coverage of curriculum and development of mathematically literate students. Constrained by time and hampered by students' general lack of knowledge even at a Grade 6 level, the teacher struggles to accomplish his task in an hour lesson. One begins to note a contradiction emerging between the policy imperatives to use OBE (rules) and the teacher's need to cover the curriculum efficiently and ensure that the students pass. This contradiction plays itself out as a tension between the teacher's epistemological assumptions regarding the need to teach mathematics in a didactic, whole class discussion, and OBE's demand for more student-centred, group work driven interactions. The contradiction between the rules of the system and the teacher is represented in Figure 2 by an arrow.

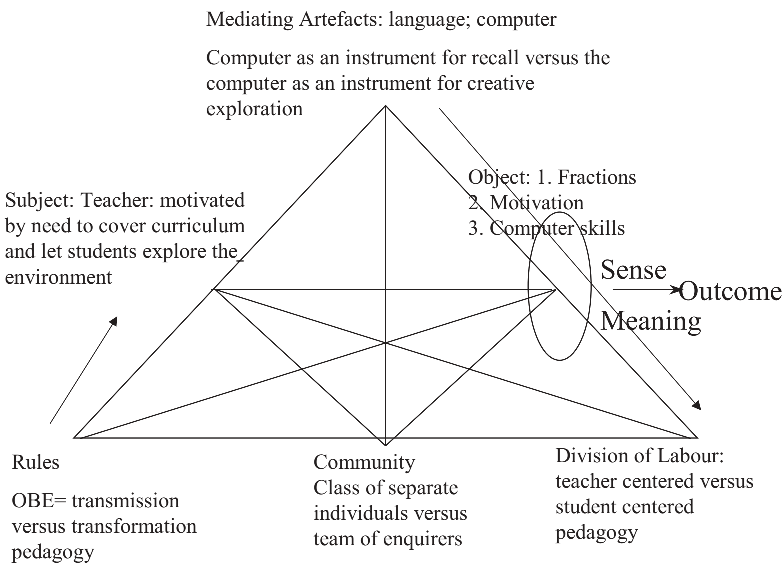
Extract 1: Coverage of the curriculum versus producing mathematically literate students

> B: … um, we try to teach something in an hour's time in a day some of them won't catch what we're saying and then they've got to go home and struggle with mom and then knowing that mom or dad doesn't know anything they won't ask. … The other thing is also that um, because there's big classes as a teacher you don't get enough time in an hour to reach each kid. Um, you just saw what we did now, um, I think I spent 10 minutes with one. You've got to have a one on one if you wanna teach some of them maths. Some kids are bright and that's fine and you can use them to help the other kids but then again, um, some of them don't want to be taught by um their fellow class-mates.

Object/division of labour contradiction

Perhaps one of the greatest contradictions that this teacher has to face emerges from the new move in South Africa from transmission-based pedagogy to a more progressive Outcomes-Based Educational setting (DoE, 2000; Moll, 2002). This contradiction plays out in the classroom as a tension between the use of group work ("you've got to have one on one if you wanna teach ...") to promote student-centred pedagogy and the developing tension between being able to cover the curriculum and reach all children in the large classes, while encouraging the development of creative autonomous learners.

Figure 3: In the computer laboratory



Tool/division of labour contradiction

The introduction of the computer as a tool has required a new division of labour due in part to the novelty of the tool but also due to the fact that the teacher is unable to assist all students with the computer tasks. Hence students have become teachers of other students. This new division of labour opens up exciting new possibilities for student-centred pedagogy.

Tool/object contradiction

For the teacher, the object of the lesson is to develop students' higher order engagement with mathematical content ("…what I am trying to do is get them to understand fractions using the computer"). However, for the teacher, the computer simply is unable to serve as a tool to act on this higher order (what he calls "learning") object; rather, the computer becomes a tool for developing drill and practice skills, a lower order cognitive skill. For this teacher then, there is a contradiction between the tool (computer) and object. In response to a question probing the effectiveness of the computer as a learning tool (that is, a higher order cognitive tool), the teacher indicates this tension in the following extract where he suggests that the computer is a low level, rather than a high level cognitive tool.

Extract 2: Contradiction between tool and object

> If we talk about learning, right it's [the computer] a nice skill they can use, but um, learning, I think we are still in the beginning stages and I don't feel that it's that effective in the learning process so far.

There is therefore, a contradiction between the fact that the tool only appears useful as a drill and practice tool whereas the object that the teacher wants to act on, or indeed, believes he is acting on, is higher level cognitive skill such as the conceptual understanding of fractions.

Rules/subject contradiction

At the microlevel, in the day-to-day use of the computer in the classroom, the teacher creates his own rules for using the computer, which provide affordances and constraints to students' computer engagement. These rules generally discourage children from exploring the software or acting creatively on the computers, as in this case at least, the teacher feels threatened by his own relative lack of knowledge when using the computer. The teacher's apprehension regarding experimenting with the novel technology is evident from the comment that he makes on the teachers' reaction to the introduction of computers into the school: "… they seeing that they're teachers and then how is a teacher supposed to be stupid now and then this is now a new thing. And they shouldn't be so afraid to play around with it, you know". There is thus, a contradiction between the policy drive (DoE, 1996) to develop creative technologically literate students and this teacher's need to curtail creativity in order to ensure that students do not regard him as ignorant.

For B, the objects acted on in the computer lesson are the students' motivation (B*:* "it is actually a tool that we can use, it's like a carrot keeping it in front" *(*dangles his pen in front of his face*)* and fractions. However, the contradictions around how to use the computer as a tool (contradictions between the computer as an instrument for recall, recording and practice versus the computer as a instrument for investigations) impact on the activity system, forcing contradictions between the teacher's desire to use the computer to teach mathematics in a creative way and the reality of its use as a recall and recording device.

The interview data indicate that the teacher works on different objects across the two contexts. The contradictions emerging in both the face to face and the computer classrooms are suggestive of potential transformations in practices in both arenas. Arguably, the single largest force driving this transformation is the introduction of Outcomes-Based Education and, similarly, the introduction of the computer as a tool that can facilitate the development of creative, student-centred learning contexts capable of producing the kind of teachers and students demanded by OBE. I therefore explore the actual lessons to see how tools are used by the teacher and whether this leads to a shift in pedagogical practice.

Actual use: Identifying the object of the lesson:

Extract 3: Business as usual 1: Teaching mathematics in a Grade 6 classroom
Object: curriculum content (mathematics)

The lesson began 5 minutes ago; the teacher began the lesson by drawing rectangles and squares on the board and colouring these in to illustrate fractions; he used questions to probe students' understanding of fractions. He has now moved on to test students' knowledge regarding the different types of fractions one gets.

1. **Teacher** What kinds of fractions do we get?
2. **Students**: Proper fraction, improper fraction, mixed fraction *Teacher writes these on the board*.
3. **Teacher**: What is another word for a proper fraction?
4. **Students**: Common fraction
5. **Teacher**: Common fraction (*writes it on the board*).
6. Does everyone understand?
7. I am now going to explain what a proper and an improper fraction are and (what) a mixed fraction is. *The teacher goes on to explain the different kinds of fractions one gets; he then tests whether children have understood by 1) asking questions and 2) getting them to essentially reproduce his text on the board.*

Tools, objects, division of labour, community and rules

What we see in Extract 3 is the teacher's use of language and the blackboard as tools to act on students' understanding of the curriculum content, in this instance, different types of fractions. Students too, in this extract, appear to be working on understanding the curriculum content: that is, both teacher and students share a common object.[8] This object tells us something about the division of labour in the classroom. It is clear that it is the teacher who primarily determines mathematical meaning in this class and the students' role is one of learner, or, at the most basic level, reproducer of the teacher's text. This asymmetrical relation is maintained by rules governing interpersonal relations (such as who may talk and for how long they may do so).

[8] Of course, their motivation for sharing this object might differ; whereas the teacher might be motivated by the need to develop students' understanding, the students could be motivated by a variety of things, not least of which might be the desire to be perceived as a 'good' student by the teacher. Our inability to infer motives from observations must make us cautious about our interpretation of the object of the lesson.

Extract 4: Business as usual: Teaching mathematics in a Grade 6 classroom
Object: curriculum content (computer)

The lesson began 10 minutes ago. The teacher has spent this time telling students where to sit. He then goes on to direct them to access the work that they must complete in this lesson. He reads the instructions off the computer and guides their task engagement.

1. **Teacher** : You must do the following,
2. Do the following for me,
3. You click on 'my computer'.
4. You click on my computer.
5. You may double click
6. or click once and on your keyboard enter.
7. Right? *No response from students*
8. Next one, next move you go to you may double click onto 'common on server',
9. Ok double click

The teacher goes on to read the instructions for the day's task from the computer (the students are required to complete a computer-based worksheet on fractions based on the work they completed in class the previous day).

Tools, objects, division of labour, community and rules

The primary tool used by the teacher in the computer laboratory is language. Here the object of the lesson becomes the technical skills required to act on the computer. This is a different kind of object from the face to face lesson and consequently, division of labour in the computer class might be expected to differ from the face to face lesson. Whereas it is the teacher who has power over meaning in relation to mathematics, when it comes to the transmission of technical computer skills, it is not automatically clear that it is the teacher who decides what counts as meaningful. In fact, one might even anticipate that children could have expertise in relation to the computer that the teacher lacks. This potential threat to the teacher's power is revealed in this laboratory lesson by the strengthening of control over classroom rules, with the teacher restricting the kinds of actions students can perform on the computer by rigidly controlling the pacing, sequencing and selection of content studied. Therefore, while power relations should shift in the computer laboratory due to the shifting object, this teacher does not readily relinquish power and, consequently, strengthens his control over the lesson to minimise this threat.

In summary, analysis of the videotaped lessons uncovered the following tools and related objects outlined in Table 1.

Table 1: Tool usage and objects acted on across the two contexts

Context	Tools	Object[s]
Face to face lesson	**Linguistic** **Material** **Non-verbal actions**	Curriculum content (predominantly procedural knowledge around fractions); behaviour regulation
Computer lesson	**Linguistic** **Material** **Non-verbal actions**	Curriculum content (predominantly procedural knowledge around computer skills); the computer; behaviour regulation

A cursory look at Table 1 indicates that the teacher uses material, linguistic and non-verbal actions as tools to act on particular objects within the traditional classroom. Interview data suggested that the predominant object of the face to face lesson is curriculum content (teaching/learning of fractions, in this particular instance). What emerges from the video data is that the teacher uses various tools, which enable the teacher to act on different types of objects. So, for example, non-verbal actions, such as pointing at a child to direct his/her attention or to select them to answer a question, are used to manage interaction in the classroom and regulate students' behaviour.

In the computer laboratory, the teacher becomes more formal; there is less reliance on language as a tool to explain mathematical content and more reliance on language as a tool to regulate behaviour. This move to a more formal manner is to be expected given the nature of the physical space of the computer laboratory, which is set out to encourage transmission style pedagogy as well as the meanings that attach to the notion of a "laboratory" as that space where formal scientists carry out important tasks (Zandvliet & Stracker, 2001). What we see is the teacher using language almost exclusively to direct students' actions in relation to the computer. Learning computer skills, literally how to access and exit a task becomes the object of the lesson. In this type of context, where the computer becomes the object of the lesson, it is perhaps, unsurprising that understanding fractions drops almost entirely into the background. Where the computer is used as a tool, it is used to act on lower level cognitive skills, such as drill and practice, with the students practising what they have learnt the previous day in the classroom. The need to practise what has been learnt is crucial to laying down memory paths for the developing child. Therefore, while it might initially seem problematic that the computer laboratory appears to be a space where students merely practice what they have already learnt, rather than learning new mathematical content, this is in fact necessary for optimal learning to occur. Of course, a further explanation as to why the computer is not used to teach new mathematical content, but rather used as a drill and practice tool, relates to the fact the computer is relatively novel (having only been in the school for one full year at the time of this study); hence, once teachers and students familiarise themselves with the new technology, we may expect to see shifts in how the computers are used.

The introduction of the computer into mathematics teaching and learning has forced contradictions within the mathematics lessons across these two contexts. One of the most obvious and challenging contradictions is between the use of the computer as an instrument for recall, recording and practice and its use as an instrument for exploration. This contradiction emerges, perhaps, because teachers are being called on to use this new technology within the relatively new educational space established since the introduction of OBE. There are continuing tensions between making sure the curriculum is covered by well performing students and the need to foster creative, inquirers, capable of constructing meaning from their environment under the expert guidance of the class teacher. The need to use the computer as a tool has required that the teacher re-think teaching and learning in his mathematics classroom, leading to contradictions between the use of the computer as a tool for drill and practice and its use as a creative tool for developing students' understanding of mathematics. We can see from this case study that there are contradictions in both the computer and the traditional classroom, suggesting that these systems are indeed going to change; and it is these changes that we need to study in further research.

Conclusion

Computers have been placed in disadvantaged schools in the Western Cape in order to bridge the digital divide and develop mathematically and technologically literate students (DoE, 1996; Hardman, 2004a). The assumption appears to be that this novel technology will transform pedagogy and, consequently, change students' mathematical performance. This article began with the intention of investigating whether pedagogical practices do shift in the face of new tools such as computers. A case study does not permit one to make general statements about how something might be used in different situations (or, indeed, even in similar situations). However, it does provide for a thick description of the processes underlying the object of study. Using Activity Theory's notion of contradictions as dynamic 'forces' driving change within the activity system, it is clear from the interview data that there is a developing contradiction between the computer as a tool for creative student-centred learning and the computer as a tool for lower level drill and practice skills. This contradiction emerges in the observation data as well. As contradictions are suggestive of change, we can anticipate that the introduction of the computer as a novel tool may indeed lead to shifts in pedagogical practice. How teachers deal with and overcome these contradictions will determine how this novel tool is appropriated by teachers within our schools.

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