# Teachers' Perceptions of Pedagogical Change with Information Communication Technologies in No-fee Primary Schools in a Developing Context: A Cultural Historical Activity Theory Analysis

**Joanne Hardman**
School of Education
University of Cape Town

**Sakafuku Tshink**
School of Education
University of Cape Town

## Abstract

*Research indicates that Information and Communication Technologies (ICTs) impact positively on students' attainment in primary school mathematics classrooms, depending on the nature of the pedagogy used (Higgins, Xiao, & Katsipataki, 2012). However, how ICTs are used pedagogically depends on how teachers perceive them (Bray & Tangney, 2017). Over the past decade, South Africa has invested heavily in ICTs in education, in the hopes that their use may impact positively on extremely low outcomes that are recorded in mathematics and reading in the country (Spaull, 2013). This investment, however, has not paid dividends, calling into question exactly how ICTs are used in teaching/learning in this context. This paper seeks to address teachers' perceptions of teaching with ICTs in order to ascertain whether teachers do indeed use ICTs in their classrooms and whether they believe this changes their pedagogy thereby impacting positively on outcomes in mathematics at a grade 6 level. Interviews with 6 teachers across 4 non-fee-paying schools, using Cultural Historical Activity Theory as a frame, indicated that teachers do indeed believe that their pedagogy has shifted with the use of ICTs and that this has had a positive impact on mathematics learning.*

**Keywords:** Teaching with technology, Cultural Historical Activity Theory; mathematics; primary school.

## *Introduction*

South Africa continues to perform at extremely low levels in mathematics and science as measured in international benchmarking tests such as the TIMSS tests, achieving a ranking at a grade 5 level of 45$^{th}$ out of 48 countries.

**Table 1 TIMSS 2015**

| International Benchmark | Grade 5 | Grade 9 | |
|---|---|---|---|
| | Mathematics | Mathematics | Science |
| Advanced (>625) | 1% | 1% | 1% |
| High (550-625) | 4% | 3% | 4% |
| Intermediate (475-550) | 12% | 10% | 9% |
| Low (400-475) | 22% | 21% | 18% |
| Potentials (325-400) | 28% | 35% | 28% |
| Not Achieved (<325) | 33% | 31% | 40% |

(http://www.naci.org.za/index.php/south-african-performance-on-the-trends-in-international-mathematics-and-science-study/)

This is of grave concern because South Africa spends more of its GDP on education than Germany, the US or the UK, who consistently outcompete South Africa in global benchmarking tests (https://www.fin24.com/Economy/sa-spends-more-on-education-than-us-uk-and-germany-20170105).

Further compounding the lack of attainment in mathematics in South Africa is a low level of content knowledge amongst grade 6 mathematics teachers (Spaull,2013). Reports by Hungi et al, (2011) (cited by: Spaull, 2013) indicate that only 32% of South African grade 6 mathematics teachers have acceptable levels of mathematics content knowledge. If teachers do not possess solid mathematical content knowledge, it is questionable how students can acquire the requisite concepts from them. There is, however, a large body of research (Tamim, Bernard, Borokhovski, Abrami and Schmid, 2011; Higgins, Xiao, Katsipataki, 2012; Li & Ma, 2010; Cheung & Slavin, 2013; Demir & Basol, 2014; Xie, Wang, Hu, 2018, Chuahan, 2017; Slavin, Lake & Groff, 2009; Slavin & Lake, 2008; Rakes et al, 2010) that indicates that the use of Information communication technologies improve primary schools attainment in mathematics. The potential of ICTs to improve attainment in mathematics has seen the South African government develop a White paper of E-Education (2004) with the following desired outcomes:

"Every South African manager, teacher and student in the general and further education and training bands will be ICT capable, that is, use ICTs confidently and creatively to help develop the skills and knowledge they need as lifelong learners to achieve personal goals and to fully participate in the global community by 2013" (Republic of South Africa, 2004, p.17)

As the last TIMSS testing round took place in 2015, two years after the White paper envisaged South Africans as able to 'fully participate in the global community', it is worth asking why large-scale interventions, discussed below, that equip schools with ICTs have not impacted on student outcomes in mathematics (Reddy et al, 2016). One possible reason is that it is not ICTs themselves that research indicates impact on attainment, but rather, how they are used pedagogically (Tamim et al, 2011; Author, 2014; 2015). Used as a device to deliver content in the absence of appropriate pedagogy, ICTs have no impact on attainment (Tamim et al, 2011). This, therefore, requires that teaching/learning, conceived of in this paper as two sides of one coin, become the focus of research into understanding how to use ICTs for optimal outcomes. Li & Ma, (2010) and Rosen & Salomon, (2007) systematically reviewed in excess of 1500 studies of teaching with ICTs to establish what kind of pedagogy is best suited to integrating ICTs into teaching. They argue for a 'constructivist' approach to teaching, which views students as active cognising agents who construct their own knowledge through interacting with the world in a student-centred environment. This view is somewhat rhetorically hollow, however, as it fails to indicate exactly what pedagogical practices must change from the traditional to the novel technology-based classroom and treats children as capable of constructing knowledge through discovery. We would argue that allowing students to 'discover' novel knowledge, or concepts leads almost certainly to misconceptions of things as empirical reality is not capable of generating the abstraction of certain schooled concepts, such as for example, Archimedes law (Karpov, 2005). However, the general idea that children actively construct knowledge is useful in approaching pedagogy with ICTs as ICTs potentially offer space for autonomous learning. This view is theoretically developed later in relation to Cultural Historical Activity Theory, where we argue for this framework as a foundation for understanding pedagogical change in context. While recognising the central role pedagogy plays in mathematical attainment with ICTs, it is important to note that pedagogy is highly dependent on teachers' beliefs, attitudes and perceptions regarding technology. This paper, therefore, investigates teachers' perceptions of pedagogy with ICTs and asks the following questions:

1. Do teachers think that pedagogy changes with the use of ICTs in non-fee paying, disadvantaged contexts? In what ways does it do so?
2. Does mathematical attainment improve with ICTs according to teachers?

### *1.2. Context: South Africapost-apartheid curriculum reform and pedagogical change*

Following the first democratic elections in 1994, South Africa embarked on a process of curriculum change to develop a more cohesive and equitable curriculum for all. Under the apartheid government the curriculum, known as Christian National Education, was highly segregated and dominated by white, male underpinnings that marginalised people of colour (Hoadley, 2011). Numerous departments existed to enforce the curriculum which was heavily content based and what might be called teacher-centred. Under this curriculum, pedagogy was driven entirely by the teacher with pace and sequencing being tightly controlled by the teacher who 'transmitted' knowledge to students who were viewed as empty vessels ready to be filled with specific knowledge. The fundamental pedagogics proposed by this curriculum focused on rote memorisation and paid scant attention to the fact that students are active cognising agents, capable of constructing knowledge. 1998 saw the first curriculum reform under the new government, Curriculum 2005. Based on a constructivist philosophy, this curriculum aimed to be inclusive and outcomes based, with no content being expressly stipulated.

No thought is given to the existing curriculum. Instead schools (or local districts) are told they can choose any content and use a wide range of teaching methods as long as these develop citizens who display the agreed- upon critical outcomes. (South African Department of Education 2000b, p.19)

The critical outcomes mentioned were based on the constitution and aimed at developing creative and critical thinkers. However, exactly how to achieve this or, indeed, what a critical thinker is, was never specified. This curriculum was progressive in its view of pedagogy including various pedagogical techniques such as group work and a focus on student driven learning. This learner-centred approach contrasted with the fundamental pedagogics of the apartheid regime and promoted a view of students as active constructors of knowledge, with a teacher regarded as a guide or facilitator (Hoadley, 2011; 2018). However, by side-lining abstract knowledge, this curriculum conflated pedagogy with curriculum and led to serious critiques of the policy (Jansen, 1999). Significantly, by failing to stipulate content knowledge, the policy failed to understand the realities of South African classrooms. While some schools were privileged enough to develop their own content, the vast majority of schools and teachers were unable to develop materials to meet this novel curriculum. Hence in 2000 the curriculum was reviewed, and more structure was suggested. While the content knowledge was more specified under the review, pedagogy still was based on more of a constructivist foundation than under apartheid. While it is important to note that children are not empty vessels, which is implied in a transmission type pedagogy, it is also important to note that radical constructivism, which favours a discovery-based learning approach, can be pedagogically unsound (Karpov, 2005). Taken to its logical conclusion, if a child is left to learn entirely through discovery, they will acquire misconceptions about knowledge based on empirical instances of that knowledge. A young child, for example, might think that a dolphin is a fish because it has fins, but of course, a dolphin is more closely related to a cow than to a fish. This kind of knowledge needs to be taught in a structured manner and this is dealt with later in the paper.

The National Curriculum Statement (NCS) was rolled out in schools in South Africa in 2002 and by 2009 this curriculum was again under scrutiny for its focus on outcomes-based education and painfully low attainment in students' outcomes. The review of the NCS pointed once again at the problem of under specifying knowledge. As Young (2007) points out

What we have learnt is that, despite the good intentions of past efforts, an underspecified curriculum advantages those who are already advantaged – those who already have access to the knowledge needed to improve their life chances. (Young 2007, p.61)

The NCS Review Report put a focus on what is to be learnt, rather than vague outcomes, suggesting that 'clear content, concept and skill standards and clear and concise assessment requirements' replace the notion of outcomes (South African Department of Education 2009: 45). Revisions to the NCS did not specify a constructivist pedagogy, although the understanding that children are active in constructing knowledge was accepted. Following the review report NCS a new Curriculum Assessment Policy Statement (CAPS) was introduced that focused more on specifying knowledge and assessment standards. It might be, though, that the pendulum has swung too far back to a more traditional pedagogy as CAPS is very content and assessment heavy, leaving little time for teachers to engage in developing deep understandings of knowledge. This then is the curriculum reform against which this study plays out and it is against this background that ICTs have been implemented in schools as technologies to impact student attainment positively.

As noted, South Africa has spent a great deal of money on education and on equipping schools with ICTs. However, if we look at the table below, we can see that many schools do not have access to computers or connectivity.

**Table 2: Computer centres across provinces in South Africa**

| Province | No of schools | With computer lab | % |
|---|---|---|---|
| Eastern cape | 5676 | 596 | 11 |
| Gauteng | 2031 | 1529 | 75 |
| Free State | 1615 | 353 | 22 |
| KwaZulu Natal | 5931 | 992 | 17 |
| Limpopo | 3923 | 426 | 11 |
| Mpumalanga | 1868 | 290 | 16 |
| North West | 1674 | 371 | 22 |
| Northern Cape | 611 | 313 | 51 |
| Western Cape | 1464 | 886 | 61 |
| **Total** | **24793** | **5756** | **23** |

(NEIMS, 2011: 24)

As can be seen in table 2, only 23% of schools have access to a computer laboratory or centre. The costs of equipping schools with connectivity is estimated at around R16 billion (USD 1.5 Billion). (https://businesstech.co.za/news/internet/259171/heres-how-many-south-african-schools-dont-have-the-internet-or-a-computer-lab-and-what-it-will-cost-to-fix-the-problem/).

The current paper is located in the Western Cape Province of South Africa. In this province there are 1464 schools (NEIMS, 2011). 61% of schools in this province have computer centres. This province has the second highest percentage of computer centres in South Africa with only Guateng (75%) having a higher number. The pass rate in the final year end (matric) examinations in grade 12 in the Western Cape is 81.5 %; this is 3rd after Gauteng 87.9 and the Free State 87.7. However, when adjusting for throughput from grade 1-12, the actual pass rate for the Western Cape is the highest in South Africa. https://www.news24.com/SouthAfrica/News/the-real-matric-marks-20170107. Taken together with the relatively high levels of computer access in this province, the Western Cape provides a useful context for examining optimal teaching/learning with ICTs. Two major interventions regarding ICTs have been implemented in the Western Cape over the past decade. These are discussed below.

*Khanya- computers as teaching/learning tools*

Rolled out in the early 2000s, the Khanya project aimed to put computers into 853 schools in previously disadvantaged areas of the Western Cape. Their goal was to "promote learning and maximise educator capacity by integrating the use of appropriate, available and affordable technology (mainly computer technology) into the curriculum delivery process".https://www.westerncape.gov.za/dept/department-premier/documents/public_info/F/19802?toc_page=9

The project focused mainly on equipping schools with computer laboratories and software, such as CAMI maths and Master Maths to assist in mathematics teaching. While this software is drill-and-practice software, it is still useful in reinforcing students' mathematical understandings. An evaluation of the project undertaken by Louw, Muller and Tredoux (2016) found that, while there was significant variation in outcomes, the project did indeed impact positively on student outcomes. The strength of the impact depended on the pedagogy enacted as well as the time that students used the computers, with longer periods of time correlating with more positive outcomes. While this research points to improved attainment in mathematics with computers in the Khanya project, the evaluation does not elaborate what pedagogical practices are useful in this attainment, outside of suggesting that integrating the computers into the lesson is a predictor of more positive outcomes. The current paper seeks to understand teachers' perceptions of their pedagogy in relation to ICTs in order to address this gap.

*Greenshoots: Teaching for learning with computers.*

A more recent intervention in the Western Cape is Greenshoots, an initiative that has been rolled out in 269 schools involving 112998 students and 2668 educators. The aim of this initiative is to improve mathematics outcomes by delivering an online math curriculum where students undergo termly tests, brain quests, and weekly consolidation exercises. For those students who have computers and connectivity at home, they are also able to do mathematics activities after school at home to further reinforce the knowledge being taught in school. Teachers can view what each student is doing on the computer and provide feedback in class as well as being provided with customised student analytics, indicating how each child is performing in the class. To date no systematic evaluation of this initiative has been published but anecdotal evidence from their website suggests that the schools involved are indeed improving students' maths attainment (https://www.greenshootsedu.co.za/our-vision--mission.html) These two initiatives, then, provide the context for ICT usage in the current study and it is largely in relation to these initiatives that the teachers' interviewed for this study record their perceptions of ICTs as teaching/learning tools.

## *3. Teachers' perceptions of ICTs*

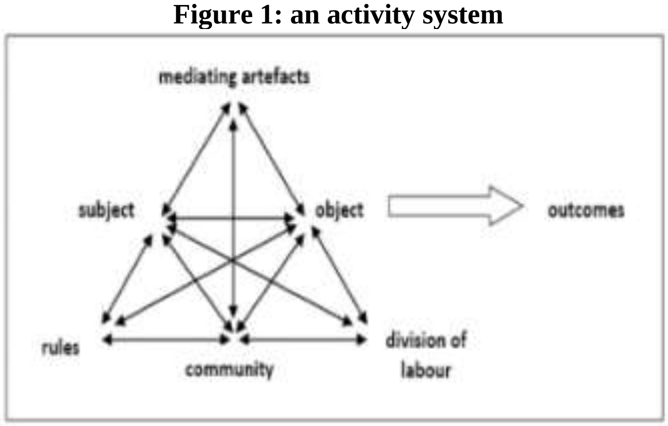
Research indicating that attitudes impact on behaviour is well established (Zimbardo et al, cited by Asiri et al, 2012). There is a large body of research (Karasavvidis, 2009; Blin & Munro, 2008; Hutchinson & Reinking, 2011) regarding teachers' perceptions of ICT use in their classrooms but substantially less information regarding their perceptions of exactly how technology changes their pedagogy. Findings to date regarding why pedagogy has not altered significantly in the face of ICT suggest that teachers tend to use technology to enhance rather than transform their pedagogical practices (Conlon, 2004; OFSTED, 2005; Smeets, 2005; Cubukcuoglu, 2015; Deaney, 2003; Pedretti et al, 1999, Zhao and Cziko, 2001; author, 2015; Mwendwa, 2017) and that a lack of sufficient time to either learn how to integrate technology or indeed to actually integrate technology into their practices impacts negatively on ICT usage (Condie et al, 2007; Smeets et al, 1999; Karasavvidis, 2009). Mwendwai (2017:410) also claims that "[teachers'] perceptions [vis-à-vis ICTs as pedagogical tools] can be determined by many factors such as the awareness of the innovation or change, the availability of the required resources and facilities as well as the competences required in the implementation process."While there is a significant body of research indicating that teachers' attitudes and perceptions regarding ICTs impacts on how they are used in pedagogical practice, there is a dearth of research findings regarding whether teachers think ICTs alter their pedagogy and, if so, in what ways these technological tools do so. It is this gap that motivated the current study.

## *4. Theoretical Framework*

This study has as its theoretical foundation Cultural Historical Activity Theory (CHAT) (Engestrom, 1987) because this theory can situate complex human action within the activity system in which it plays out. Developed out of Vygotsky's cultural historical theory and Leontiev's Activity Theory (1981), CHAT situates an individual act within a socio-historical context that shapes how cognition develops (Vygotsky, 1978). Vygotsky (1978) describes developmental pedagogy, that is pedagogy capable of developing a child cognitively, as involving mediation of schooled (scientific) concepts within the zone of proximal development (ZPD). The ZPD represents a unique social space that opens through dialogical interaction between the teacher and the taught. Primary mediating artefacts, for Vygotsky then, are sign and symbols. This Vygotskian view of pedagogy views children as active cognising agents who construct knowledge with the structured assistance of more expert peers. Learning, then, leads to development (Daniels, 2001). Current approaches to teaching with ICTs have indicated that this kind of pedagogy, sometimes referred to as 'constructivist pedagogy' is the most effective pedagogical approach to use when teaching/learning with ICTs (Cox & Webb, 2004; Li & Ma, 2010; Rosen & Salomon, 2007). In South Africa, the context for this study, the government has explicitly endorsed this active stance towards pedagogy (DBE, 2016). However, an understanding of pedagogy arising from the work of Vygotsky does away with rhetorically hollow phrases such as 'teacher-centred' or 'learner-centred' because it understands that teaching in a school necessarily implies learning and vice versa. It is this notion of pedagogy as involving the structured guidance of a more expert 'other' in a problem-solving situation that informs the current paper. This recognises both teacher and taught as central in the process of teaching/learning, which are dialectically entailed.

Deviating from Vygotsky's (1986) focus on semiotic mediation as a primary developmental tool, Leontiev (1981) focuses on practical activity as the source of development. For Leontiev an activity is collective and is driven by a need to transform the object of an activity, which can be material or ideal. Actions are individual and are carried out through routinised operations in order to meet goals within the activity. Engestrom (1987; 1999) expands on this Leontivian view of human activity by developing a notion of community, rules and division of labour. Contradictions characterise activity systems and can be thought of as double-binds. Contradictions are sites of dynamic change and can happen within and between activity systems. For Kuutti (1996; 34) contradictions "manifest as problems, ruptures, breakdowns, clashes," which lead to the transformation of the system over time. According to Engestrom (2001) "An expansive transformation is accomplished when the object and motive of the activity are reconceptualised to embrace a radically wider horizon of possibilities than in the previous mode of the activity" (37). In relation to pedagogical practices with ICTs, this kind of transformation would see the development of a novel pedagogy. Figure 1 below represents an activity system.

**Figure 1: an activity system**

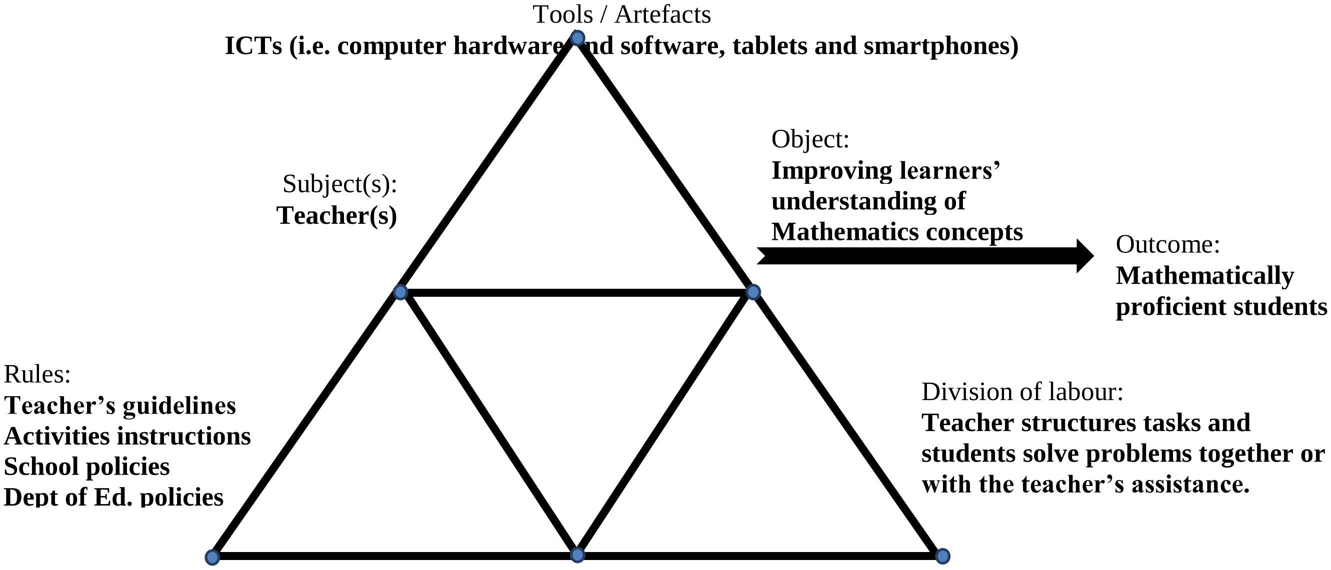



Adapted from Engestrom (1987: 97).

What we can see in figure 1 is that a subject acts using mediating artefacts on an object in order to achieve and outcome. With takes place in the context where rules afford and constrain behaviour and in which various roles are enacted by different individuals (division of labour). If we populate this with an actual empirical example, we could say that the teacher is the subject of the activity and s/he uses ICTs (mediating artefacts) to develop students' mathematical understanding of a topic (object) in order to achieve mathematically competent students (outcomes). This plays out in a setting in which students and teacher have specific roles (division of labour) and are governed by specific rules (for example, don't surf the internet in the computer laboratory). The community refers to those people who share a common object; in the case of schooling, this is very often just the teacher and the taught, although it could include subject advisers and computer technicians. The CHAT framework enables us to analyse pedagogy along the various dimensions outlined in figure 1. This provides for a nuanced and detailed view of pedagogy.

In this paper, CHAT serves as an analytical framework for analysing teachers' perceptions of pedagogical change with ICTs. We can hypothesise what the activity system of an ICT based mathematics lesson could look like in Figure 2 below.

**Figure 2: Teaching and learning Mathematics concepts with ICTs: Activity system**




We use the dimensions outlined in figure two, namely subject, object, tool, rules, division of labour, community and outcomes to generate an analytical framework to track pedagogical change across the various nodes of the activity system.

## 5. *Materials and Methods*

The current paper makes use of a multiple case study method for collecting interview data from 6 teachers across 4 schools (Yin, 1984). As the study investigated teachers' perceptions of pedagogy, an interview was selected as the best method for gathering perceptual data. It is recognised, however, that perceptions and attitudes are often at odds with actual practice. However, as teachers' perceptions of ICTs have been found to impact on how they are used pedagogically, this method enables us to track this with some accuracy. Ethical clearance was obtained from the School of Education University of Cape Town and consent forms were signed by participating teachers. Permission to work in schools with teachers was obtained from the Western Cape Education Department.

### a. Subjects

Six teachers, across four schools, were interviewed for this study. Their demographic details are recorder in table 3 below. All teachers teach mathematics at a grade 6 level using ICTs. Tabulated below are the details of the demographic data gathered from the schoolteachers.

**Table 3: Primary School Teacher demographic data**

| **Demographic details** | Teachers | | | | | |
|---|---|---|---|---|---|---|
| | Teacher A | Teacher B | Teacher C | Teacher D | Teacher E | Teacher F |
| **Gender** | Female | Male | Male | Female | Male | Male |
| **Age** | 55 | 43 | 27 | 57 | 37 | 24 |
| **First language** | Xhosa | Xhosa | Xhosa | Afrikaans | Afrikaans | Afrikaans |
| **Qualifications** | Honours in Education | Senior Diploma specializing in Science and Technology | PGCE | PD and NPDE | B.Ed | Bachelor of Science and PGCE |
| **Years of teaching experience** | 27 | 19 | 4 | 38 | 8 | 7 Months |
| **ICT Training** | Yes | Yes | Self-taught | Yes | Not formal | Yes |
| **ICT competence** | Edmodo, CAMI Maths, computer | CAMI Maths, computer | CAMI Maths, computer | Computer, CAMI Maths | Computer, youtube, google classroom, CAMI Maths | Computer, youtube, Google Ed. Level one, MS Office suite |
| **ICT currently at school and/or using** | CAMI Maths, computer | CAMI Maths, computer | CAMI Maths, computer | Smartboard, tablets, computer, internet, projector | Smartboard, tablets, computer, internet, projector | Smartboard, tablets, computer, internet, projector |
| **Tools used before ICT** | Board, textbook, some concrete things such as pictures, scales | Board, textbook | Board, textbook | Board, textbook | Board, textbook | Board, textbook |

As we can see above, all 6 teachers are teaching in their second language as English is the medium of instruction at all the schools. All teachers can use computers and 3 of the 6 use CAMI maths currently. CAMI maths is best thought of as a drill and practice type software which is useful for reinforcing students' knowledge of topics covered in face to face lessons (Author, 2008). There is a great range in experience of teaching with one teacher only teaching for 7 months and another teaching for 38 years.

**b. The schools**

All schools in this study are non-fee-paying schools. In terms of section 21, non-fee-paying schools are disadvantaged schools that are entirely funded by the government and therefore do not charge school fees. Schools are classified into quintiles, from most poor to least poor. A quintile 1 school caters to the poorest 20% of all schools while a quintile 5 is lest poor. Money is allotted to schools depending on which quintile they fall into with quintile 1 receiving the highest governmental funding and quintile 5 the lowest.

**Table 4: the schools**

| School | Teacher | Quintile | Number of students | Number of teachers | Average class size |
|---|---|---|---|---|---|
| A | A & B | 3 | 1250 | 31 | 41 |
| B | E & F | 5 | 1629 | 37 | 45 |
| C | C | 5 | 1650 | 35 | 45 |
| D | D | 1 | 298 | 8 | 38 |

## *6. Data collection*

Data were collected using face to face interviews. The rationale for this collection method lies in the fact that semi open questions can lead to more detailed descriptions of perceptions and beliefs. For Mathers et al. (2002:1) interviews "are very labour intensive but can be the best way of collecting high quality data" (Mathers et al., 2002:1). Interviews were constructed specifically to elicit teachers' perceptions of pedagogical change across the various nodes of the activity system: tools, rules, division of labour, community, object and outcome. We were also interested in seeing whether any contradictions, or double-binds emerged from the interview data. Interviews took between 15 and 25 minutes, depending on the teachers involved and were audio recorded. Interviews were transcribed within one week of collection.

## *7. Results And Discussion*

The question this paper seeks to answer is whether teachers think their pedagogical practices have changed using ICTs and if so, in which ways they have changed. We mobilise CHAT as an analytical framework in which to understand pedagogy in terms of various dimensions: subject; tools; rules; object; division of labour; outcome and community. It is possible for pedagogy to alter across all these dimensions, none of these dimensions or one of these dimensions.

**Subject position**

All 6 teachers believe that students learn through actively engaging with content. So, for example teacher B responds to a question about how children learn by stating:

Extract 1: Teacher's perceptions of how children learn

Teacher B: Um, some is by doing and obviously some by seeing and by being actively, actively involved in the, in thelearning.

Teacher D: I think it must be learner-centred. They must do things on their own. The teacher is only supposed to guide them. They must also learn from each other.

Teacher F: I think children learn best by interaction.

Given the government's focus on active learning, it is hardly surprising that all teachers in the study indicated that children learn activity. However, when questioned about how children learn mathematics, specifically, a contradiction arose in the accounts. For example, teacher B says:

And sometimes even, you don't, if they don't understand, because Maths is like, it's, it's, uh, it's a delicate subject where they must, they must listen, they must understand for them to really, for the learning to, to be actively okay and for them to move forward. They must … listen what's happening so that they don't confuse matters. …uhm, practice. They must practice.

On the one hand, teacher B states that children learn actively but on the other hand, he states that they learn mathematics rather passively through repetition and listening. This primary contradiction in the subject position is not uncommon in teaching, where one is required to allow time for deep autonomous learning but also required to transmit a body of knowledge. There is a clash between allowing children more time to explore versus getting them to practice what has been taught and listen to what you are saying.

Extract 2: Teachers' competence to use ICTs- subject position ICTs

Teacher B**:** So, it's not like, uh, I have a qualification for it. But I did CAD, so I have that background. So, yes, I'm comfortable with ICTs, yes.
Teacher A: yes, I can use. But I wasn't trained. It's uhm, myself, I taught myself. I can say I feel competent.
Teacher E: competent? To use the computer? Yes. I am confident in that.

5 of the 6 teachers indicated that they felt competent to use ICTs such as computers and iPads. While teacher D does use computers, she feels less competent using them than teaching face to face.

**The object**

The object is that problem space that is worked on in the activity to produce an outcome. In general, one would assume that the object of a mathematics lesson is to develop students' understanding of mathematics; however, this might not be the actual object being worked on.

*Traditional face to face lesson*

Extract 3: Object in face to face lesson: mathematical understanding

Teacher A; It's their understanding uhm, of maths. They lazy you know, they lazy to read. So you tell them, and then you show on the board.
Teacher C: ah, yes to teach them mathematics. To get that understanding. But they don't read.
Teacher F: Um the kids don't want to think, they don't want to read anymore. So I believe with repetition and getting them interested in the topic at hand, you know making it practical to them.

The stated object of all teachers related to teaching mathematics so children would understand it. However, there is a contradiction in the object, which is outlined below:

Extract 4: Contradiction: mathematical understanding versus curriculum coverage.

Teacher F: but they have to pass. So you know, you have to cover the topics, you have to finish and time is tight. With uhm, with CAPS there's all the assessments and the content it's a lot.
Teacher D: also it's the marks, it's to get them to grade 7. So you have to do all that work, they can't miss that work, you see?
Teacher A: I use concrete things, to show them to solve the problem. But it's time. It takes time and there is a lot of work to do so I think some get left behind.

**Computer lesson**

More than one object emerged in the ICT lessons.

Extract 5: Motivation as an object

**Teacher C:** Yeah, because learners, they like technology. They are very lazy to work with books, to read books, so they like technology.
**Teacher B**: So, I think, yes, with ICTs like in lessons, it makes them understand better than the teacher sitting in front like giving them information. Because they like it too much.
**Teacher A**: Because like before I didn't used like the computers and the projectors in my class. Like when I'm just teaching without them, I can see like most of the learners, some of them they are bored like with my lesson. They are tired. They don't even want to listen to the lesson. Or some of them, they are playing like while I teach.
**Teacher F**: For example, some learners, they don't like maths, actually. But when they go to the computers, they say, Oh, maths is like this one, and they, when they watch those videos, they say, Okay, okay, it's nice.

Extract 6: Creativity as an object

**Teacher A;** I can say that the computers they bring creativity, they develop the child's creativity.
**Teacher F**: it's definitely helping them to be creative, uhm, just to go beyond the textbook and things.

Extract 7: Mathematical understanding as an object

**Teacher B:** My results haven't, have not improved like for the best. But then I can see like some of the learners they are getting there. At least I'm getting like some learners. So, I will be… I'll judge it maybe after two years if like I'm really getting the results right with ICTs. But it helps their understanding of maths, it does.
**Teacher F:** Um when you look at a normal standard textbook the textbook can only give you so much only because you wouldn't want the textbook to look like this. Um you get three examples of a shape. If I go onto Google right now Google images tetrahedron I get moving ones, I get stationary ones, I get silver ones, gold ones, shaded ones, a kid that drew one. And kids are like oh my goodness, this textbook is just limiting them to that specific... And if, in their heads they believe it's just that to them, that's all it is but if I open up Google and we scroll for pages and pages look at that daaieen [that one], look at die een [this one], look at that one, look at that. So I used to teach in classrooms I can't wait for the date when it's, when it's fully rolled out.
**Teacher E:** Um like I said previously I think it's, I'm expanding their thinking slightly more and um you know you can always bring back what you just had on the screen yesterday. We are not excellent artists so today I'll draw my cube, ah this looks fantastic [laugh] tomorrow I have to try again, tomorrow again might not be, but just so I can show that same thing.

What is quite interesting is the contradiction that exists in the object of a face to face lesson, namely curriculum coverage versus mathematical understanding, seems to fall away in the ICT based lessons. While a lot of research (Karasavvidis, 2009; USDE, 2000) indicates that teachers require more time to integrate ICTs into their pedagogy, results from this study indicate that teachers feel ICTs give them more time to cover the work in depth.

Extract 8: ICTs alleviate time pressures

Teacher E: um I find that I have more time um usually writing things on the board, let, let's take for example if I take technology now. I've got a textbook for them, I've got my teacher's guide with the answers and everything. Right so once we do revision or once we do the corrections or giving them answers to their homework I don't have to go write that answers on the board. I can display the answers meanwhile I'm going checking their work where I couldn't get to all of those things. So technology in the classroom is buying me some time to be interacting with the child.

**Community**

The community in the face to face lessons is narrower than in the ICT based lessons, including just the children and the teacher. In the ICT lessons, teachers indicated that the head of department as well as the principal had a more active role in the lessons than in the face to face classroom. Interestingly, teachers indicated that parents took no active role in either the face to face or ICT based lessons.

**Tools**

Prior to the implementation of ICTs in schools, teachers used textbooks, the blackboard and one instance, concrete props to teach mathematics. The introduction of ICTs has led to them using iPads, computers, and power point presentations.

**Rules**

The introduction of ICTs has led to a slowing in pace that allows students to move through the work at their pace, without the teacher controlling pacing as strongly as in the face to face lesson.

Extract 9: pace is slower in the ICT lessons

**Teacher F**: In the class it's like you must hurry up and get this done, but in the lab, it's different, you can get to those sums and do them uhm more , I would say, more slow.

**Division of Labour**

In a traditional face to face lesson, a teacher teaches, and children generally listen and engage in set activities. Power inheres in the teacher and is very asymmetrical. In ICT based lessons this shifts with the roles changing to students acting as teachers to their peers. Collaboration increases and power is less asymmetrically held by the teacher.

Extract 10: Division of labour shifts in the ICT lessons

Teacher E: …you can see how they group up and start showing one another. And it gets them to talk. And this one says look at that one over there or, but this is how I, we start talking to each other especially when I ask them questions so they can engage with me they start talking amongst each other.

It's like you know when you go to the movies everybody's watching the movie and then you ask did you see that? [Laughs] I'm watching the same movie. So it's, I think it all boils down back to that excitement that exists in the class now because of that in my opinion.

Teacher B: It's differ. Because, you know, sometimes they are more involved when they are using technology, okay? Together. They are involved together.

**Outcomes**

When asked whether they thought ICTs impacted positively on mathematics outcomes, all teachers agreed that it did so, but that results have not yet shifted significantly because the ICTs have only been implemented recently into the school. In the traditional face to face lesson, teachers indicated a primary contradiction in the outcomes between a mathematically competent students versus the achievement of grades.

We can graphically represent the activity systems of both face to face lessons and ICT based lessons in the following way:

**Figure 3: Teachers' illustration of the face to face lesson activity system**

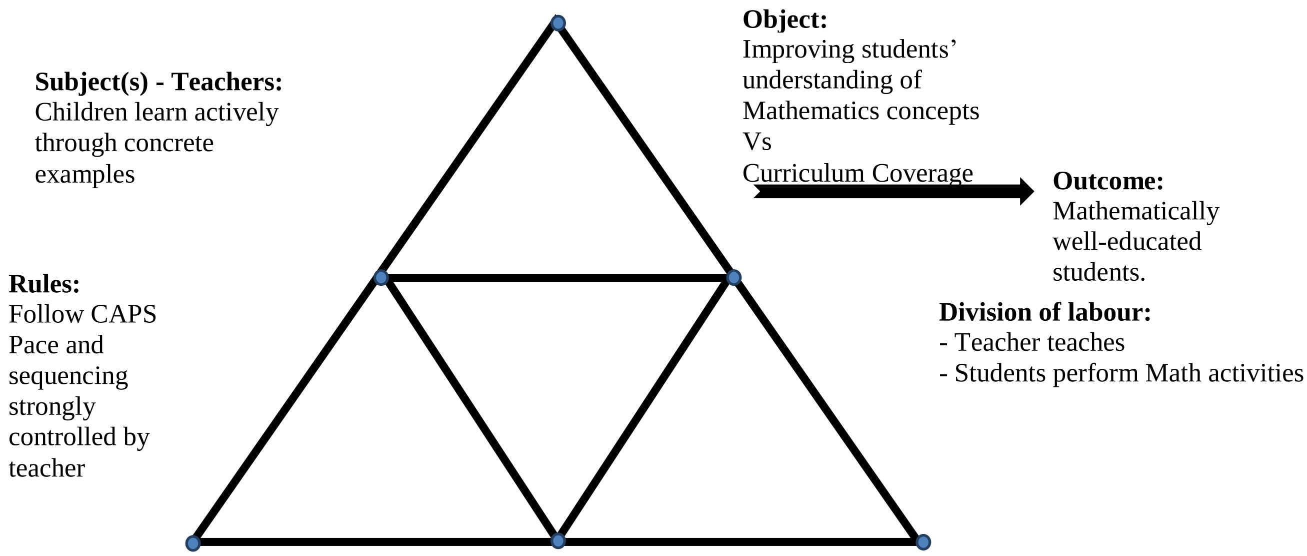
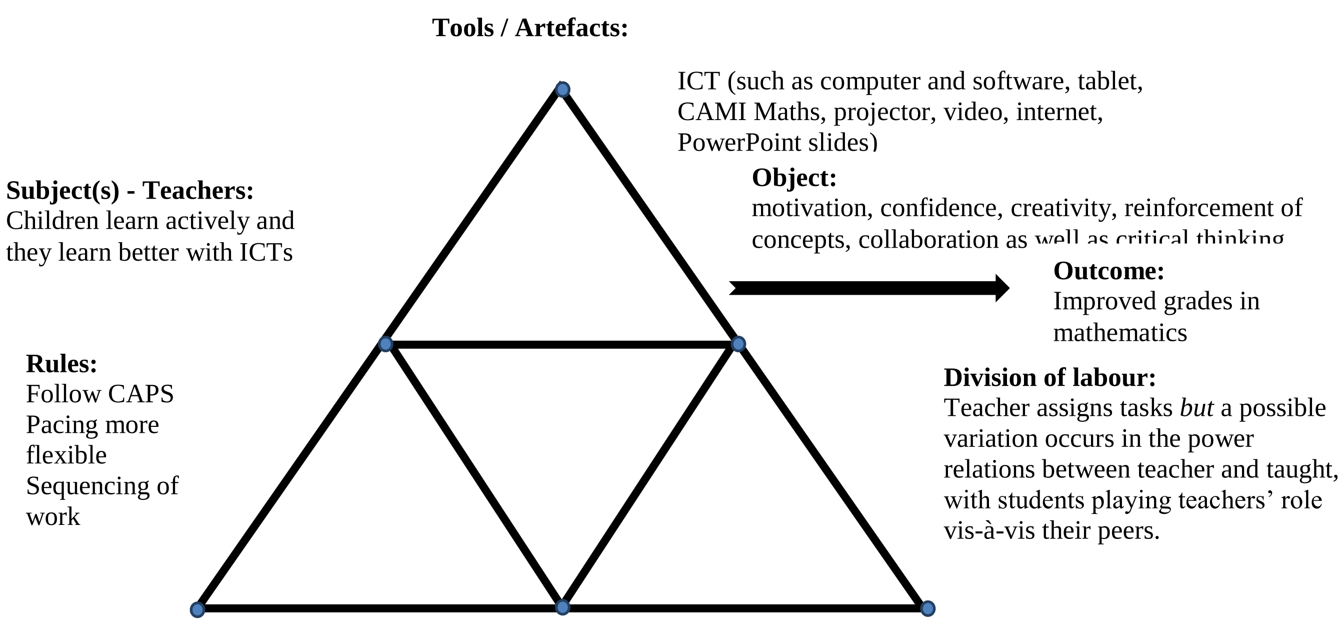



**Figure 4: Teachers' illustration of the computer-based classroom activity system**




If we look at the figures above, we can see that teachers believe their pedagogy has altered with the introduction of ICTs into their lessons. In a traditional face to face lesson, teachers exert more control over the rules of the activity than in the ICT lessons and the community is narrower than in the ICT based lesson. In their traditional lessons, teachers face primary contradictions in the object and outcome of teaching mathematics, with tensions arising between covering the curriculum and developing deeper mathematical understanding.

This relates to time as a significant influencer of teaching. Having to cover a content and assessment heavy curriculum, teachers are torn between developing students' mathematical understanding and slowing pacing to do so, and conversely, having to tighten pace in order to cover the curriculum. Somewhat counterintuitively, given the research to date (Karasavvidis,2009; USDE, 2000), in ICT base lessons teachers feel that they have more time and flexibility to develop students' mathematical understanding. No contradictions in the ICT lessons were evident in the data collected. This is not to say that in practice no contradictions do exist, but it does suggest that teachers are, as yet, unaware of any of these contradictions. The object of the ICT lessons is broader than in the face to face lessons, with creativity, motivation, and collaboration featuring as important spaces that are worked on to develop the outcome of mathematically proficient students. In relation to tool use, there is a shift between chalk and talk pedagogy, which all teachers describe as 'boring' for students to a more interactive pedagogy afforded by the ICTs.

### *Conclusion*

South Africa continues to achieve extremely poor results on international benchmarking tests of mathematics and science (Blignaut, Els, Howie, 2010; The Economist, 2014). In a bid to address this issue, the government has embarked on a nationwide programme to implement ICTs into schools with the intention of developing technologically literate students as well as developing mathematics understanding. While there is a body of research indicating that teachers' perceptions of ICTs impact on how they are used pedagogically, there is a dearth of published research indicating exactly how teachers think their pedagogy alters with their introduction of ICTs into schools. The current study sought to address this gap by interviewing 6 teachers across 4 non-fee-paying schools in the Western Cape Province of South Africa. These schools represent the poorest schools in the province. A significant finding in relation to learning lies in the shift of object between traditional and ICT lessons: in the ICT lessons teachers all indicated that motivation was an object of the activity. Motivation is central to learning; simply put, a child who is not motivated to learn will not do so. It appears from this study that ICTs have a large role to play in developing motivation. Findings indicate that teachers believe that their pedagogy shifts from a transmission-based pedagogy in the traditional lesson, to a more collaborative pedagogy in the ICT lessons. Given the cultural historical theory of learning (Vygotsky, 1978) informing this paper, the finding that pedagogy shifts to a more collaborative one in ICT lessons is promising, as theoretically, children will learn better when motivated by a more expert peer in their ZPD. A caveat is in order though; there is often a disjuncture between intended and enacted pedagogy in schools. While teachers may be convinced that their pedagogy shifts, further research into the actual class is required to confirm this shift. For this, detailed observations of pedagogical practices in traditional and ICT lessons is necessary.

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