Revisiting the concept of ICTs as 'tools': Exploring the epistemological and ontological underpinnings of a conceptual framework

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Abstract

One of the challenges facing researchers investigating how information communication technologies (ICTs) are being used in teaching and learning environments, is devising a conceptual and analytical framework to guide the design, analysis and interpretation of empirical studies. In attempting to develop such a framework, researchers are forced to confront their underlying pedagogical, epistemological and ontological assumptions, especially in team-based research. This paper explores a four-staged conceptual framework that was developed as a way of understanding how ICTs are being integrated in teaching and learning activities in secondary schools in Grahamstown, South Africa. It attempts to make overt the assumptions about learning, teaching, knowledge and conceptions of reality that underpin this conceptual framework as well as the stance taken within the study itself.

Introduction

The field of information communication technology (ICT) has “emerged rapidly with little time for a robust intellectual tradition to be established” (Dillon 2004:138). Although there has been a concerted attempt to engage with underpinning learning theory (Jonassen, Peck & Wilson 1999; Wishart & Blease 1999) and pedagogy (John & Sutherland 2004; Lim & Barnes 2002; McCormick & Scrimshaw 2001; Loveless, DeVooged & Bohlin 2001; Leach & Moon 2000;), until recently (cf. Lankshear, Peters & Knobel 2000) the deeper epistemological and ontological assumptions underpinning the use of ICTs in teaching and learning environments have been implicit, under-emphasised or ignored entirely. Changes in hardware, software and connectivity, and related implementation strategies in teaching and learning environments, often appear to have taken center stage, backgrounding the more philosophical issues. Although a number of theorists, scholars, researchers and practitioners have proposed various conceptual frameworks as a way of understanding how ICTs are being used in teaching and learning activities, they have seldom made explicit their specific pedagogical, epistemological and ontological assumptions. Appropriating these conceptual frameworks to guide empirical studies becomes problematic, as the researchers need to second-guess the original theorist’s underpinning assumptions.

This is the dilemma that faced us as a group of researchers undertaking a multiple case study investigating the extent to which ICTs are being integrated in the curriculum in all 13 secondary schools in Grahamstown. What follows is an extension of our “shared conversations in epistemology” (Haraway 1991, cited in Tong 1997: 157-158) that emerged from our discussions about the underlying conceptual framework/s of the study. What makes this study complex, is that it is being
undertaken by myself and three students, two of whom are Education students, while
the third is an MSc student from the Computer Science Department, whom I am co-
supervising. The cross-disciplinary nature of the study confronted us with competing
knowledge frameworks behind what we understood by the “integration of ICT into
the curriculum”. This forced us to interrogate the philosophical assumptions that
inform our teaching, our knowing and our conception of the world.

Why is it so important to make these specific pedagogical, epistemological¹ and
ontological² assumptions explicit? Educational theorists have pointed out the
absurdity of thinking about teaching or learning without including any underlying
philosophical beliefs (cf. Carr, 1995 for example). Gamache (2002:286) comments
succinctly that: “All practice is rooted in some theoretical framework, if not explicitly,
then implicitly. Since methods are based upon epistemology, and epistemology is
based on ontology, educational practice is never value-free”. It became urgent for us
as researchers to clarify our conceptions of what we understood by “integrating”,
“embedding [or] diffusing” (Agostino 1999) ICT into the curriculum, as we
approached the research project with differing epistemological and ontological
perspectives. These perspectives impacted upon the conceptual framework for
understanding the use of ICTs in education that we needed to develop in order to
frame the study.

**Framing the study: Methodological stance**

In the first instance we were challenged as a research team to make explicit our
assumptions about how we approached the study. After much deliberation about the
various methodological, epistemological and ontological assumptions that underlie
any research enterprise, we eventually resolved to approach the study from a critical
realist position, ontologically; from a socio-cultural perspective epistemologically;
and from an interpretivist perspective methodologically.

The critical realist position is being increasingly adopted in disciplines such as
Information Systems (Mingers 2004; Dobson 2002) where the research straddles the
science and social science domains. The field of ICT in Education straddles the same
domains and experiences similar tensions as an applied discipline. The critical realist
position, which holds “that there is a world existing independently of our knowledge
of it” (Sayer 2000:2), provides a “middle way between positivism’s fading path and
the unchecked caprices of hermeneutic analyses … the ameliorative ‘third path’ …”
(Harvey 2002:163). According to Benton & Craib critical realism is insistent upon

> “the independent reality of the objects of our knowledge, and the necessity of
  work to overcome misleading appearances [which] implies that current beliefs
  will always be open to correction in the light of further cognitive work
  (observation, experimental evidence, interpretations, theoretical reasoning,
  dialogue, and so on). Critical realism is thus ‘fallibilist’, in contrast to idealist
  and relativist theories of knowledge which insulate themselves from the

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¹ “Epistemology is the systematic consideration, in philosophy and elsewhere, of knowing: when knowledge is
valid, what counts as truth, and so on” (Packer & Goicoechea 2000:1).
² “Ontology is the consideration of being: what is, what exists, what it means for something—or somebody—to
be” (Packer & Goicoechea 2000:1).
possibility of being proved wrong by doing away with the idea of a knowable independent reality” (2001:121).

The usefulness of critical realism as a philosophical underlabourer\(^3\) (Bhaskar 1979; 2002) for ICTs in education, is that unlike positivism, it reminds us that the world – and especially for teachers and learners and their social reality – does not operate as the closed system of a scientific experiment, but is always an open system. In contrast to the postmodernist view that tends to “assume that because the world is so open, diverse and complex, nothing of lasting or universal application can be said about it, and because theory is so contestable and yet difficult to test, anything goes” (Sayer 2000:30), critical realists accept that “notwithstanding the daunting complexity of the world and the fallible and situated character of knowledge, it is possible to develop reliable knowledge and for there to be progress in understanding” (Sayer 2000:30). Critical realism thus “accepts the relativism of knowledge as socially and historically conditioned in the epistemological domain” (Mingers 2004:91).

Epistemologically, our view of knowledge settled on a sociocultural perspective which can be traced back to the ideas of Vygotsky (1978) and Wertsch (1991), and which emphasises the “characteristics of social participation, relationships (such as that between novice and expert, newcomer and old timer), the setting of the activity, and historical change” (Packer & Goicoechea 2000:227).

Methodologically we adopted an interpretive approach which aims to “understand the subjective world of human experience” (Cohen, Manion & Morrison 2000:22) [Italics added] and if possible “to explain the subjective reasons and meaning that lie behind social action” (Terre Blanche & Durrheim 1999:6) [Italics added]. Consequently we made use of questionnaires for our three participant groups: learners; subject teachers; and the ICT teacher or technician in charge of computer-related matters at the school; to obtain baseline data, to determine topics for discussion and select participants for in-depth interviews (subject teachers and the ICT teacher or technician) or focus group interviews (learners). Member-checking of the interview transcripts and follow-up interviews enabled us to flesh out specific issues. A discussion of our findings will be covered in subsequent papers. The purpose of this paper is to share some of our ideas about developing a framework to help us understand how the learners, teachers and technicians from the 13 schools in Grahamstown are using ICTs for teaching and learning.

Our initial findings from piloting our questionnaires, seem to indicate that there were at least four different ways in which learners, teachers and technicians claimed to be using ICTs for teaching and learning. Broadly speaking, ICTs firstly seemed to be used in a fairly unsophisticated way by merely re-presenting or re-reproducing in electronic form what could have been done on paper; secondly there were some instances where ICTs were being used within subject areas in ways which enhanced the teaching or learning activity – but specifically without access to the Internet; thirdly there were a number of instances where ICTs were being used to support a more collaborative approach to learning – with access to the Internet; and fourthly

\[^3\] Critical realism is becoming increasingly influential in the social sciences, with critical realist ideas being used as underlabouring precepts. That is to say, critical realist ideas are used to guide empirical research, with critical realism being a meta-theory that informs the construction of specific theories in the course of empirical research (Cruikshank 2002:49).
there was minimal evidence that the use of ICTs at the school may be changing the
traditional hierarchies at schools and transforming accepted cultural practices.

The distinctions between the use of computers with and without connectivity is
particularly important in a developing country such as South Africa, where not all
schools have computers or Internet access. For example, in the group of schools that
we investigated (12 of the 13 schools eventually contributing data), four schools have
no Internet connection at all and two schools have only one working computer each.
What is also noteworthy is that all 12 schools acquired all the computers they have
through various donations and fund-raising activities (Brandt 2006). None of the
computers have been supplied by the Department of Education, despite their policy
goal that: “Every South African learner 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 to achieve personal goals and to be full
participants in the global community) by 2013” (DoE 2003:10) (cf. 2005a).

In the second instance, our challenge was to develop a conceptual framework that
would provide some theoretical explanation for what we found in our pilot study and
what we thought that we would find once all the data was gathered. The development
of this conceptual framework was essential for selecting and synthesising the
literature, refining our design as well as informing our analysis and interpretation of
the data. We therefore decided to revisit the conceptual frameworks that have
previously been proposed.

Revisiting a conceptual framework for understanding the use of ICTs in
education

As a starting point, we revisited the conceptual framework proposed by Robert Taylor
more than 25 years ago. Taylor proposed his “tutor-tutee-tool framework” to “help
those who would like to get an organized initial grasp on an apparently complex field
[that of computers in education]” (1980:10). In short, he differentiated between the
use of a computer as a ‘tutor’ that effectively ‘teaches’ the learner via pre-
programmed material; as a ‘tutee’ which conversely affords the learner the
opportunity to ‘teach’ the computer via programming the computer; and as a ‘tool’
which relieves the learner of routine and tedious mechanical tasks. What is
noteworthy for the purposes of our discussion is that the ‘tool’ use was deemed the
least important for educational purposes. Taylor specifically says that: “most
computing-and-education people do not see this mode as something they want to
focus primary energy upon” (1980:9).

Although Taylor (1980) hints that the ‘tutor’ mode has its pedagogical roots in
behaviourist- informed programmed instruction, and that the ‘tutee’ mode, as used
by Papert (1980), is inspired by the cognitive constructivist theories of Piaget, the
theoretical foundations for the ‘tool’ mode are not made explicit. “In the hopes of
fostering a dialogue” (Robinson 2002:97), about ICTs in the curriculum I would like
to extend the ‘shared epistemological conversations’ of our research group to this
Forum, by suggesting that by making the theoretical assumptions underpinning
Taylor’s ‘tool’ mode explicit, it might clarify how this concept can be used to describe
certain uses of ICTs in a more nuanced way that allows us to re-appropriate the term
“tool” in describing not only how we use ICTs as tools within the curriculum, but why
certain uses of this “tool” are potentially more integrative than others.
What is understood by “integrating” ICT into the curriculum?

A number of authors have attempted to clarify what is understood by “integrating ICT into the curriculum” by describing the range of ways in which computers are used. Some authors describe ICT integration in a fairly self-evident, but unproblematic way: “Technology integration is meant to be cross-curricular rather than become a separate course or topic in itself” (Flanagan & Jacobsen 2003: 124). Other authors have attempted to differentiate more subtle types of ICT integration. For example, Bialobrzeska and Cohen (2005) claim that there are three levels of integrating ICTs into learning, namely, functional practice, integrative practice and transformational practice. They explain that when “learners use the computer in basic and functional ways to do the things that the computer can do well – such as word processing, document presentation, spreadsheets, producing graphs and searching for information on the Internet” (Bialobrzeska & Cohen 2005:32) they are engaging in functional practice. By contrast, when learners use programs to engage in more sophisticated activities, for example drafting and re-drafting a piece of writing; they claim that this constitutes integrative practice. The third level of integration, they maintain, is “characterised by learning which occurs as a result of activities and opportunities which do not exist in a computer-less environment” (Bialobrzeska & Cohen 2005:33). They provide examples of collaborative online projects and synchronous chats to illustrate this point.

Similarly, McCormick and Scrimshaw (2001:38) distinguish between three levels of pedagogy, where the use of ICTs makes existing practice “more efficient or effective, where it is extended in some new way, and where it is transformed”. Bottino (2004: 555) refers in a comparable manner to three models of using ICT in classroom activities, namely the “transmission model, the learner centred model and the participative model”. Coupal describes three waves of teacher ICT professional development as ““literacy uses (a technology centred pedagogy); adaptive uses (a teacher-centred, direct instruction pedagogy); and transforming uses (a student-centred, constructivist pedagogy)” (2004:591).

In their studies of ICT integration in schools in Hong Kong, Yuen, Law and Wong (2003) proposed three models of ICT adoption in schools. The first model, which comprised the majority of the cases in their study, they called a ‘technological adoption model’. They explain that “this model is likely to be found in the initial stages of innovation where the immediate concern of the school leaders [is] whether the teachers [are] able to master the necessary skills or technologies” (Yuen, et al. 2003:164). They further explain that the most commonly observed pedagogical practices in these schools were “expository and inductive approaches” (Yuen, et al. 2003:164). The second model, which they term the ‘catalytic integration model’ describes the “deliberate integration of ICT into the teaching and learning processes as an integral part of the curriculum” (Yuen, et al. 2003:166). They explain that the “pedagogical practices in these schools were mostly task-based, problem-based and [made use of] social-constructivist approaches” (Yuen, et al. 2003:166). The third model, which they term the ‘cultural innovation model’, teachers were challenged to “rethink their personal attitudes, beliefs and values about their roles as educators ... For a few teachers, this may have led them even to reconceptualise their understanding of schooling and society” (Yuen, et al. 2003:168).
While these are helpful distinctions, I suggest that Hokanson and Hooper (2000) have come closest to helping us understand the concept of ‘integration’. Hokanson and Hooper differentiate between what they term ‘representational’ and ‘generative’ use of computers. They conceptualise ‘generative’ use as the “capability to generate thought” (Hokanson & Hooper 2000:547), while ‘representational use’ is used to describe how computers are used to merely ‘re-present’ or reproduce information in another medium. This is similar to the “functional practice” described by Bialobrzeska and Cohen (2005). Here the computer is incorporated within a task, but its purpose it to ‘re-present’ information, not to generate or construct new information. In essence, it can be said to function as a “representational tool” (Suthers 2000).4

**ICTs as representational tools**

Suthers describes computers as representational tools as “software interfaces in which users construct, examine, and manipulate external representations of their knowledge” (2000:2). These tools “may range from basic office tools such as spreadsheets and outliners to ‘knowledge mapping’ software” (2000:1). The use of ICTs as representational tools seems to be underpinned by a fairly technicist and instrumentalist view where the main focus is on the mastery of computer skills per se. The approach of “learning to use computers” seems to be underpinned by a behaviourist approach to learning that focuses primarily on learning about or from computers (Jonassen, Peck & Wilson (1999). Here the role of the learner is to “absorb the material defined by the teacher” and where the “outcomes are judged by the [learner’s] ability to reproduce material” (Kember 2001:215).

The pedagogic assumptions informing the use of ICTs as representational tools seem to be “instructivist” or “transmissionist” (Reeves & Hedburg 2003), or alternatively “didactic” (Kember 2001). From a traditionalist perspective, Kember describes the teaching role as a “didactic process of transmitting knowledge” and emphasizes that the “teacher is responsible for ensuring that learning takes place” (2001:215). The representational use of ICTs by teachers would seem to correlate well with the first of three forms of pedagogic use proposed by McCormick and Scrimshaw (2001) – to improve teaching efficiency.

**Epistemologically**, I suggest that restricting the understanding of the integration of ICTs into the curriculum to the use of ICTs as representational tools, in sense of ‘re-producing’ information, seems to necessitate an objectivist or empiricist (Benton & Craib 2001) and instrumentalist (Hassan 2003) view of knowledge. The problem with this view of knowledge is that by “treating knowledge as static and unchanging, schools are misrepresenting the true character of knowledge, which is revisionary, creative, personal and pluralistic in nature” (Schwab in Loveless et al. 2001:74). Moreover, the problem with “too great a focus on an objectivist perspective on knowledge can lead to an ‘expert-driven’ approach to knowledge management that is incapable of dealing with highly tacit and distributed organizational knowledge” (Sørensen & Lundh-Snis, cited in Hislop 2002). While this caution comes from the

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4 It can be argued that the term “reproductive tool” might more accurately describe the concept of re-producing information without necessarily generating or constructing new information, but this term carries with it distractive meanings! I am aware that our use of the term “representational” may conflict with Jonassen’s description of ‘mindtools’ as “knowledge representation tools for thinking” (Jonassen 1996:2).
knowledge management literature, it is probably a salutary lesson for teachers who limit their use of ICTs in the curriculum to representational tools that have only “use value” (Barnett cited in Hassan 2003). According to Hassan (cited in Barnett 1997:91):

Instrumentalism is what gets things done, and is the dynamo that made capitalist materialism so world-conquering. Instrumentalism take the world largely as given and attempts to find means of living ever more productively and efficiently in it. Working within a narrow horizon of epistemological assumptions, knowledge is valued here insofar as it has a use value.

This view of knowledge does not overtly acknowledge the ideological nature of knowledge and therefore ICTs are often construed as being value-free, rather than culturally-laden. ICT skeptic Bowers’ main thesis is that computers are not culturally neutral; instead they “reinforce or marginalize culturally specific patterns of thought and communication in how the technology encodes the cultural assumptions of those who designed them” (2000:22). He is afraid that if members of other cultures “accept computers uncritically as a culturally neutral technology and as the latest expression of modern progress, they may not recognize how their interactions with computers are changing them.” (Bowers 2000:22-23). Bowers expands further that “computer-mediated experience not only reinforces particular patterns of thinking but also legitimates a specific ideological orientation” (Bowers 2000:31). While I don’t completely subscribe to Bowers’ view that the “globalization of computer-based culture is becoming an even more destructive form of colonialism that was experienced in the nineteenth century” (Bowers 2000:10), as researchers living in a Third world country with particular cultural histories and economic constraints, we do need to be aware of uncritically perpetuating the belief that ICTs are culturally neutral. We do need to be mindful of the issues that ICT skeptics such as Bowers and others (cf. Oppenheimer 2003; Cuban 2001; Stoll 1999) have raised.

A further concern with this view of knowledge is that it serves to conflate epistemological and ontological assumptions: “the idea that the world is [construed to be] the same as our description of it” (Scollon 2003:77). As Patomaki & Wight elaborate:

Epistemology and ontology become tied together (what Bhaskar calls the epistemic fallacy); what is known is what can be experienced and/or observed and what is, is what can be known. Nonobservable theoretical entities are treated instrumentally. They are “mere fictions,” useful perhaps but in no sense can they be considered real’ (2000:217).

*Ontologically,* the assumption underlying the limited use of ICTs as representational tools seems to pre-suppose a naïve realist conception of the world “claiming unmediated access to the Truth” (Sayer 2000:2). As Bredo (1994) notes:

“This approach thus involves tacit belief in ‘representationalism’, the belief that symbols mirror reality. ... The educational equivalent of this belief is the view that knowledge representing how the world ‘really’ is must be transmitted to students. When they have the same statements in their heads as the teacher, it is presumed that they ‘know’ something”.


While the use of ICTs as representational tools has a definite role to play in developing technical skills, my concern is that the use of ICTs should not be limited to their use as representational tools only. Leach and Moon (2000) provide a range of examples of ICT activities recommended in the National Curriculum for England and Wales that seem to limit the use of ICTs primarily as representational tools. They complain that these ICT opportunities “would seem to be at best random, at worst banal and inconsequential” (Leach & Moon 2000:390). Similar comments can be levelled at the South African curriculum, especially at the Grade 10-12 level, where the use of computers is relegated to the two subjects, Information Technology and Computer Applications Technology, perhaps unintentionally ignoring the integration of ICTs across the curriculum (Hodgkinson-Williams 2005a).

I suggest that the use of representational tools does not necessarily require engagement within or across the curriculum and is therefore not truly integrative. On the other hand, where computers are used “generatively” (Hokanson & Hooper 2000), then of necessity, ICTs will be integrated to a greater or lesser extent within some aspect of the curriculum. Hokanson and Hooper claim that:

“What is important about computer use is not being able to word process, or view a multimedia presentation, but the ability to interact with the computer in the manipulation and creation of knowledge through the rapid manipulation of various symbol systems. The value is not in more efficient representation but in improving the capability to generate thought” (2000:547) [Italics added].
The ‘generative’ use: ICTs as cognitive tools

One way of using ICTs “generatively” is to use them as “cognitive technologies” (Pea 1985), “technologies of the mind” (Salomon, Perkins & Globerson 1991), “mind-extension cognitive tool” (Derry & LaJoie 1993), “mindtools” (Jonassen 1996) or “cognitive tools” (Jonassen & Reeves 1996). The notion of ‘tool’ proposed 40 years ago by Bruner helps inform the use of these metaphors: “Man's use of mind is dependent upon his ability to develop and use "tools" or "instruments" or "technologies" that make it possible for him to express and amplify his powers” (1966:24). Bruner acknowledges that the term “tools” is often understood pejoratively, but that he is primarily interested in the flexible manner in which they are used:

I know that the terms "tool" and "technology" and even "instrument" offend when one speaks of man as dependent upon them for the realization of his humanity. For these words denote "hardware," and it is mostly "software" that I have in mind—skills that are tools (Bruner 1966:25) [Italics added].

This idea was taken up almost 20 years later by Pea (1985) in his seminal paper, “Beyond amplification: Using the computer to reorganize mental functioning”, in which he proposed the primary role of ICTs (then only computers sans connectivity) is to “chang[e] the tasks we do by reorganizing our mental functions, not only [amplifying them]” (Pea 1985:168). Since then a number of theorists, researchers and practitioners have taken up the challenge to substantiate this notion (Liu & Bera 2005; Jonassen, Peck & Wilson 1999; Jonassen 1996; Derry & LaJoie 1993).

While the underlying learning theory is to some extent implicit in both Pea (1985) and Salomon, Perkins & Globerson’s (1991) discussions of “cognitive technologies” and “technologies of the mind” respectively, Jonassen (1996) and Jonassen, Peck and Wilson (1999) have made their constructivist commitments crystal clear.

“Constructivist theories have their roots in Piaget and focus on the active character of the learners, interacting with the environment either singly or with others; learning is the resulting construction and qualitative reorganisation of knowledge structures” (Packer & Goicoechea 2000:228). Salomon, Perkins and Globerson highlight that the “cognitive effects with computer tools greatly depend on the mindful engagement of learners in the tasks afforded by these tools” (1991:2). The main focus of the use of cognitive tools is on the individual learner and his/her relationship with ICT in what Salomon, Perkins and Globerson (1991) refer to as an “intellectual partnership”. Jonassen develops this idea and defines tools as “computer-based tools and learning environments that have been adapted or developed to function as intellectual partners with the learner in order to engage and facilitate critical thinking and higher-order learning” (1996:9). The predominant focus seems to be on how the individual learner constructs meaning. As Loveless, DeVoged & Bohlin (2001:67) note: “Constructing knowledge from information requires far more that the ability to use a variety of ICT techniques or skills with the latest range of software applications: it relates more to an ability to question, access, interpret, amend, analyse, construct and communicate meaning from information”. This type of ICT integration seems to accord well with Bialobrzeska and Cohen’s (2005) second level of integrating ICTs into learning, namely, integrative practice.
Pedagogically, the assumptions underlying the use of cognitive tools seem to accord with a cognitive constructivist view of learning (Piaget), where the role of the teacher develops into that of listener, critical questioner, facilitator and prompter of ‘cognitive conflict’. As Wadsworth (1989) explains:

**Critical exploration** is a method of questioning students that can be used by teachers (or parents) to help lead students into productive cognitive conflict (disequilibrium)”. The purpose of critical explorations is to determine what constructions (rules and generalisations) a student has regarding the content under discussion. The teacher can then pose questions designed to conflict with the reasoning underlying the child’s construction (Wadsworth 1989:158) [italics added].

In terms of the use of ICTs as cognitive tools by teachers, this use seems to correlate well with the second of three forms of pedagogic use proposed by McCormick and Scrimshaw, namely to extend teaching in “some new way” (2001:38). Jonassen (1996: 37-39) outlines the ideal sequence of activities that a teacher wanting to encourage the use of cognitive tools needs to take: 1) Form the groups; 2) Clarify the group goal; 3) Negotiate tasks and subtasks to be completed; 4) Monitor individual and group performance; and 5) Reconcile differences in interpretation or approaches to the goal.

Epistemologically, McCormick and Scrimshaw observe that: “Those who take a mainstream cognitive constructivist view ... see knowledge as in the head, and matching reality outside the head; i.e. there is a form of objectivity” (2001:42). Winograd and Flores (cited in Bredo 1994) state clearly the underlying view of knowledge of ICTs as cognitive tools: “Knowledge is a storehouse of representations, which can be called upon for use in reasoning and which can be translated into language. Thinking is a process of manipulating representations”.

In terms of ontological assumptions, von Glasersfeld, father of “radical constructivism”, stated that constructivists “deliberately and consequentially avoid saying anything about ontology, let alone making any ontological commitments” (cited in Packer & Goicoechea 2000:228). However, as Gamache (2002:286) noted: “epistemology is based on ontology”, there must of necessity be ontological assumptions underlying constructivist epistemological statements, even if they are implicit. Winograd and Flores (cited in Bredo 1994) shed some light on the implied assumptions underlying the use of cognitive tools:

At its simplest, the rationalistic view accepts the existence of an objective reality, made up of things bearing properties and entering into relations. A cognitive being “gathers information” about those things and builds up a ‘mental model’ which will be in some respects correct (a faithful representation of reality) and in other respects incorrect.

Although we have isolated only cognitive tools from the range of tools (e.g. information resources, knowledge modelling tools, performance support tools, information gathering tools) that Jonassen (1999) categorises for use in ‘constructivist learning environments’, I suggest that similar pedagogical, epistemological and ontological assumptions may underpin these tools as well.
The ‘generative’ use: ICTs as mediational tools

What we have termed the use of ICTs as “mediational tools” has been called “computer mediated communication” (Romiszowski & Mason 1996:438) and “learning networks” (Harasim, Hilz, Teles & Turoff 1995). Harasim et al. (1995:4) define learning networks as “groups of people who use computer mediated communication networks to learn together, at the time, place and pace that best suits them and is appropriate to the task”. Mediational tools include e-mail, computer conferencing, discussion lists, bulletin boards and internet relay chat.

The social constructivist learning theory (Vygotsky 1978) that underpins this collaborative e-learning has been well documented (McCormick & Scrimshaw 2001). This view holds that learning does not happen in a void, but occurs within a social environment which not only brings with it the history, traditions and “wisdom” of the social environment or particular society, but also provides the learner with a resource of other learners, each with their own knowledge, experience and expertise, with whom to share ideas, negotiate meaning and work towards shared understandings. Learners “act as partners in developing learning experiences and generating knowledge, and their collaborative construction of meaning is enhanced via different perspectives on shared experiences” (Dede 2000: 281). The learning process is viewed “not as the transmission of knowledge from the knowledgeable to the less knowledgeable, but as engagement in culturally authentic activity, participation in a community of practice” (McCormick & Scrimshaw 2001:39). Various theories that highlight the “importance of studying relations among individuals, mediating tools, and the social group” (Bottino 2004:557) include situated cognition (Cognition & Technology Group at Vanderbilt 1993; Lave & Wenger 1991; Brown, Collins & Duguid 1989), activity theory (Lim 2002) and distributed cognition (Salomon 1993).

Pedagogically, mediational tools are based on cooperative learning precepts (Johnson & Johnson 1987; Slavin 1983). According to Abrami, “cooperative learning strategies are teacher-imposed structures designed to foster increased cognitive engagement and motivation to learn by encouraging positive interdependence and individual accountability among learners” (2001:121). Various pedagogical strategies are used to encourage mediation, including computer-mediated seminars and case study discussions (Romiszowski, Jost & Chang, 1990; Romiszowski & De Haas, 1989); virtual classrooms (Hiltz, 1994); “learning circles” (Riel, 1999) and online debating (Hodgkinson & Mostert 2005). Although Yuen et al. (2003), don’t refer directly to the use of the Internet, their espoused social-constructivist approach suggests the use of ICTs as mediational tools within their ‘catalytic integration model’.

Epistemologically, McCormick & Scrimshaw explain that knowledge, seen from a social constructivist perspective, is a “social process of knowledge construction ... [in which] ...Meaning is created through participating in social activity” (2001:39). Sutherland et al. elaborate that both teachers and learners “bring implicit theories and perspectives to any new learning situation and these influence what they pay attention to and thus the knowledge they construct” (2004:415).

Ontologically, there are a range of orientations that could underpin social constructivist approaches, i.e. relativist to possibly critical realist, but fundamentally there is a separation between assumptions of knowledge and the world it represents.
Practically the use of ICTs as mediational tools is predicated on the availability of Internet connectivity, which is problematic in developing countries. In the instance of the research project from which this conversation arose, Internet access is currently available in only eight of the 13 schools in Grahamstown. This reminded us of the wider context of social affordances which impact upon the integration of ICTs into the curriculum. One of the major concerns is that the lack of access to (or affordable access to) ICT may be limiting teachers and learners from certain schools in South Africa from engaging in the opportunity to the “quality” education afforded by ICTs; thus perpetuating the historical inequalities, not necessarily according to race, but certainly according to the socio-economic levels and historical disadvantage of the parents and the schools (Hodgkinson-Williams 2005b).

**The ‘generative’ use: ICTs as transformational tools**

Perhaps one of the greatest challenges in the 21st century is how to harness ICTs to help us prepare for “an unknown future” (Barnett 2004:247). As Pea noted over 20 years ago, “because the cognitive technologies we invent can serve as instruments of cultural redefinition (shaping who we are by changing what we do), selecting values for educational goals becomes a crucial issue” (1985:168).

In essence the underpinning **learning theory** is a fully-realised socio-cultural theory, where learners are fully exposed to “both multiple and competing interpretations of the world” (Barnett 2004:250) to which ICTs afford access. Barnett highlights the personal uncertainty that this ‘supercomplex’ world can invoke and suggests that the major learning task will be a “matter of learning to live with uncertainty” (2004:252). The environment in which the learner will need to learn, will no longer be stable or predictable and “the actual learning processes themselves will also need to be both high-risk and transformatory in character” (Barnett 2004:257). Bredo says (1994) “Acting with the environment … contrasts with acting on it, because it presupposes that it will turn around and alter oneself in return. The production of a well-coordinated performance then involves a kind of dance between person and environment rather than the one-way action of one on the other”.

**Pedagogically**, Barnett suggests that teachers will need to “engage students as persons, not merely as knowers” and that teachers will need to “entice students into new cognitive spaces” … inviting the learner to “take up his or her own stances, and help form the courage to do so” (2004:257). This ‘transformatory curriculum’ as Barnett suggests, calls for “relatively open relationships between teacher and taught” (2004:258).

**Epistemologically**, our current conceptions of knowledge are no longer adequate. According to Barnett “learning for an unknown future has to be a learning understood neither in terms of knowledge or skills but of human qualities and dispositions. Learning for an unknown future calls, in short, for an **ontological turn**” (2004:247) [Italics added]. In other words, the central issue is no longer one of knowledge per se, but one of being. As a way forward, Barnett suggests that the pedagogical task will be an **ontological one** – “the formation of authentic being” (2004:259). The teacher will be tasked with engendering qualities such as “carefulness, thoughtfulness, humility, criticality, receptiveness, resilience, courage and stillness” (Barnett 2004:259).
Onotologically, this ‘supercomplex’ world can be informed by a critical realist approach as it allows for a change in theory (transitive dimension\(^5\)) without a consequent change in what the theories are about (intransitive dimension\(^6\)) (Sayer 2000:12)

While this transformational conception of tool might seem somewhat ethereal at the moment, we are already seeing isolated examples of relationships between teachers and learners where the learner knows a great deal more technically than the teacher. This calls for a change firstly in the disposition of the teacher, who needs to muster sufficient humility, receptiveness and courage to be open to recommendations made by the learner. At the same time the teacher needs to provoke a level of criticality and carefulness in the learner to use his/her technical knowledge and skills with humility and thoughtfulness.

Possible conceptual framework for understanding the integration of ICTs

At the risk of oversimplifying the complex issues in developing a conceptual framework, Table 1 summarises the four-stage conceptual framework for understanding the integration of ICTs that we are proposing.

Table 1 Four stage conceptual framework for understanding the integration of ICTs

<table>
<thead>
<tr>
<th>Computer requirements</th>
<th>Representational tool</th>
<th>Cognitive tool</th>
<th>Mediational tool</th>
<th>Transformational tool</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least a standalone computer</td>
<td>At least a standalone computer</td>
<td>At least a computer with Internet connectivity</td>
<td>At least a computer with Internet connectivity</td>
</tr>
</tbody>
</table>


| Learning assumptions   | Behaviourist Learning about or from computers (Jonassen, Peck & Wilson 1999) | Cognitive Constructivist (Piaget) | Sociocultural (Vygotsky) | Sociocultural (Vygotsky) |

| Pedagogical            | Role of the teacher: | Role of | Role of | Role of teacher: |

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\(^5\) “In critical realist philosophy, those features of human agents, their social practice and conceptual means which are involved in the production of knowledge, by contrast with the ‘objects’ about which knowledge is sought” (Benton & Craib 2001:186).

\(^6\) “A technical term in critical realist philosophy, used to refer to the real objects of scientific knowledge, which are held to exist and act independently of our beliefs about them” (Benton & Craib 2001:182).
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</thead>
<tbody>
<tr>
<td><strong>Ontological assumptions</strong></td>
<td>Naïve realist</td>
<td>Naïve realist</td>
<td>Relativist-critical realist</td>
<td>Critical realist</td>
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</table>
Conclusion

As a group of researchers involved in a team-based research project, we were faced with two challenges, namely to make explicit our assumptions about how we approached the study and to devise a conceptual framework to help us understand how ICTs are being integrated in the curriculum in secondary schools in Grahamstown in South Africa. In terms of the first challenge, we resolved to approach the study from a critical realist position, ontologically; from a socio-cultural perspective epistemologically; and from an interpretivist perspective methodologically. In terms of the second challenge, we have attempted to share our ‘epistemological and ontological conversations’ in the formulation of our four-staged conceptual framework that was developed as a way of understanding how ICTs are being integrated in teaching and learning activities in our context. The conceptual framework suggests that there are at least four fairly distinguishable uses of computers as ‘tools’, namely ‘representational tools’ where ICTs are employed to merely re-produce information in another medium; as ‘cognitive tools’ where ICTs are harnessed to generate and develop ideas by individuals primarily; as ‘mediational tools’ where ICTs are engaged in supporting the co-construction of knowledge; and finally as ‘transformational tools’ that start to challenge our current conceptions of teaching and learning and thereby help us to re-shape who we are by challenging what we do.

As the study is still in progress, we would invite comments from members of the ITFORUM that could help us refine, revise or re-work this emerging conceptual framework.

References


Hodgkinson, C.A & Mostert, M. (2005). Online debating to encourage student participation in online learning environments: a qualitative case study at a


Acknowledgments
I would like to express my thanks to critical readers, Kevin Williams, Bruce Brown and Sally-Ann Robertson, for their insightful suggestions. The ICT in Education study in Grahamstown is supported by funding from the National Research Foundation, South Africa.