TECHNOLOGY AND PROFESSIONAL DEVELOPMENT TOWARDS CRITICAL TEACHING AND LEARNING: A NARRATIVE ACCOUNT

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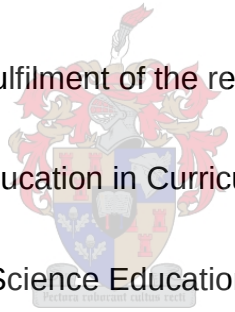

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DECLARATION

By submitting this thesis, I declare that the entirety of the work contained therein is my own, original work, that I am the authorship owner thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

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Faiq Waghid Date: 25 January 2011

ABSTRACT

This thesis explores the use of educational technologies in grades 10 to 12 life sciences classrooms at a local high school. I argue that the application of educational technologies in science classrooms has the potential to engender critical teaching and learning, and to contribute to professional development.

By reflecting on my own professional development as a science teacher over the past three years (2008-2010), I show that the use of educational technologies cultivates moments of critical pedagogy that link strongly with reflective teaching, critical thinking and transformative learning. Drawing on two intertwined narratives, I show how educational technologies can enhance reflective teaching whereby, firstly, teachers can take seriously theories and expertise in their practices; secondly, organise their classrooms so as to facilitate critical learning; and, thirdly, take up broader institutional and social issues.

In addition, I show that the use of educational technologies opens up pedagogical spaces for critical thinking and transformative learning – that is, whereby learners learn creatively, actively, engagingly and reflecting on their own practices.

OPSOMMING

Hierdie tesis ondersoek die gebruik van onderwystegnologie in grade 10 tot 12 lewenswetenskapklaskamers by ’n plaaslike hoërskool. Ek argumenteer dat die toepassing van onderwystegnologie in wetenskapklaskamers die potensiaal het om kritiese onderrig en leer teweeg te bring, en ’n bydrae tot professionele ontwikkeling te maak.

Deur te reflekteer op my eie professionele ontwikkeling as ’n wetenskaponderwyser oor die afgelope drie jaar (2008-2010), dui ek aan hoedat die gebruik van onderwystegnologie krities pedagogiese oomblikke kultiveer wat sterk aanklank vind by reflektiewe onderrig, kritiese denke en transformatiewe leer. Met betrekking tot twee narratiewe dui ek aan hoedat onderwystegnologie reflektiewe onderrig kan bevorder deurdat, eerstens, onderwysers teorieë en kundighede in hulle gebruike ernstig opneem; tweedens, klaskamers organiseer om kritiese leer te fasiliteer; en derdens, breër institusionele en sosiale kwessies aanspreek.

Daarenbowe dui ek aan hoedat onderwystegnologie ook pedagogiese ruimtes vir kritiese denke en transformatiewe leer bied – dit is, waarby leerders kreatief, aktief en betrokke is, en op hulle eie praktyke reflekteer.

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CHAPTER 1

INTRODUCTION AND ORIENTATION TO THE STUDY

1.1 Introduction

Literature about the professional development of science teachers in post-apartheid South Africa abounds. For instance, Johnson, Hodges and Monk (2000: 1) argue that imposing northern / western ideas about teacher change and development on historically disadvantaged schools and teachers is inappropriate for the reason that practices in different physical, social and political contexts differ. I agree. Consequently I shall look at the professional development of my position as a science teacher[1] at the school where I happen to work. Similarly, Reddy (2004: 138) argues that professional teacher development at both pre and in-service levels represents a major challenge for continuous teacher education. He asserts that professional teacher development needs to focus on assisting teachers 'in the process of change' (Reddy, 2004: 138).

Moreover, it is widely recognised that the professional development of teachers is also aimed at improving an education system, and that teachers are 'change agents' in these practices to improve education (Villegas-Reimers, 2003: 12). One of the important tasks of teachers as change agents in post-apartheid (science) classrooms is to develop their 'reflective capabilities' as part of their professional development (Reed, Davis & Nyabanyaba, 2002). This is where I consider my work in post-

[1] For the purposes of this thesis, I shall use 'teacher' instead of the official designation, namely 'educator', which is used by the Western Cape Education Department (WCED).

apartheid science classrooms as potentially contributing to my role as a change agent, particularly with regard to enhancing my reflective ability as a science teacher. This I hope to achieve through the use of appropriate educational technologies in the teaching of science in a high school.[2] For Robinson (2003), the professional development of teachers in South Africa should be linked to increasing their levels of understanding and developing positive attitudes towards teaching. Taking my cue from Robinson, in this thesis I hope to contribute to extending my positive attitude towards science teaching by focusing on how the use of educational technologies can potentially enhance teaching and learning in classrooms, and simultaneously enhance my own professional development. This brings me to a discussion of why the focus on educational technologies in relation to science teaching and learning?

Generally 'technology' refers to the use and knowledge of tools, techniques, crafts, systems or methods with the aim of solving problems or manufacturing something artistic. The word 'technology' is derived from the Greek word *technología* (a combination of *téchnē* (an 'art', 'skill' or 'craft') and *logía* (the study of a branch of knowledge of a specific discipline) (Smeyers & Depaepe, 2007: 1). The term can either be applied generally or to specific areas of which examples include the following: construction technology, medical technology, and information and communication technology (ICT).

ICT consists of all technical means used to handle information and facilitate communication, including computer and network hardware, as well as necessary software. In other words, ICT consists of IT as well as telephony, broadcast media,

[2] Throughout this study I use the plural form ('technologies') rather than the singular form of 'technology'.

and all types of audio and video processing and transmission. A branch of ICT is educational technology which involves the practice of facilitating learning and teaching by using and managing appropriate technological processes and resources (Smeyers & Depaepe, 2007: 1). In a globalised world, the relationship between information and communication technologies (ICTs) has grown closer, with so much expectation from ICTs within the context of educational innovation (Smeyers & Depaepe, 2007: 3). Early educational practices seemed to have been dominated by 'chalk and talk', as well as 'desks and texts', but with the development of ICTs, teaching and learning in schools have gained a new direction, in particular regarding 'the way in which knowledge and understanding (of teaching and learning) have undergone changes due to these recent developments in ICTs' (Smeyers & Depaepe, 2007: 5). Consequently, education dispensations have the responsibility to ensure that learners are able to navigate through such technologically-oriented globalised educational demands (Jeremy, 2000).

In South Africa, the current education dispensation is geared towards promoting the use of educational technologies in classrooms. A project called *Khanya*, an initiative of the Western Cape Education Department (WCED), was established in 2001 to determine the contribution that educational technologies could make to address a teacher shortage in schools. *Khanya's* aim is to determine how educational technologies can augment the professional development of teachers. After I graduated from university with a science degree, I joined the teaching profession a year later after having completed a one-year teaching qualification. As a student in school and at university, I had a particular interest in computer games and computer-based technologies. As most students of my era at schools and on university campuses around the world, I also used social networking utilities, such as MXit and

Facebook, to stay in contact with friends and family. Through my understanding of such computer-related technologies I could see how these technologies can be integrated into lessons and hence, possibly, enhance teaching and learning. In my first year of teaching I knew I had the content knowledge to teach reasonably well, but relied equally on my ICT competences and skills to improve my teaching at school. It was only after one of the lessons I taught to a grade 10 life sciences class was highly acclaimed by an external evaluator from *Khanya* that I realised how effective the use of technologies could possibly be for teaching and learning in public schools. By this I mean that learners can learn better, and that my teaching can hopefully also improve.

In the literature there seems to be some understanding that technologies stimulate the development of high-order skills, such as critical thinking, reflective analysis and scientific (rational) enquiry (Jeremy, 2000). In our current generation, most learners have access to mobile phones, more so than to computers. Today, mobile devices are able to take photographs, film videos and browse the Internet, and have a built-in GPS (global positioning system) that can take you to within a metre of your destination. They can do what desktop computers can do but at a fraction of the cost, and are more accessible. Even though mobile devices are banned from being brought to school by learners, they (learners) still persist in bringing these devices to school. I feel that it would be like trying to stop a tsunami to prevent learners from bringing their mobile devices to schools. My contention is that teachers need to familiarise themselves with these devices and to try to use these technologies (found in these devices) as tools for critically educating learners. Through my own case study (as reported later in this thesis), I would like to illustrate how these mobile devices can be used as a tool in a scientific enquiry process. The case study involves

an environmental assessment of a local wetland area. My interest in pursuing an advanced qualification at the Master's level had been influenced by the use of certain educational technologies in science classrooms. My primary objectives are to examine how the use of these technologies has an impact on the professional development of teachers. I shall relate this and other instances of the use of technologies to my teaching practice where I feel I have hopefully developed professionally as a science teacher.

This brings me to a discussion of professional development (of teachers), and critical teaching and learning in relation to the South African context. After I have undertaken this cursory exploration, I shall show how educational technologies can play a role in advancing critical teaching and learning. South Africa has just recently come out of a deeply divided past. With the introduction of a new national curriculum based on an outcomes-based approach to education (OBE) in South Africa there have been many implications for teachers and learners. The primary shift in the role of the teacher was that (s)he was no longer considered just a conveyer of content, but someone who had to play the role of a curriculum change agent. Teachers thus needed to be prepared to be curriculum change agents, as they were expected to incorporate the National Curriculum Statement through an OBE approach. They were required to be critical despite the fact that some critics argued, and continue to argue, that the new system of education does not encourage one to be critical. Arguments used by some critics involve OBE being associated with predetermined learning, which can stifle the creativity and imagination required in the classroom, and the fact that previously disadvantaged schools do not always have the resources and materials to encourage OBE. Jansen, one such vociferous critic, claims that

> OBE will fail, not because politicians and bureaucrats are misinformed about conditions of South African schooling, but because this policy is being driven in the first instance by political imperatives which have little to do with the realities of classroom life. Rather than spawn innovation, OBE will in fact undermine the already fragile learning environment in schools and classrooms of the new South Africa. First, the language of innovation associated with OBE is too complex, confusing and at times contradictory. A teacher attempting to make sense of OBE will not only have to come to terms with more than 50 different concepts and labels but also keep track of the changes in meaning and priorities afforded to these different labels over time. For example, to understand the concept of 'outcomes' requires understanding of competencies, unit standards, learning programmes, curriculum, assessment criteria, range statements, equivalence, articulation, bands, levels, phases, curriculum frameworks and their relationship to the South African Qualifications Authority (SAQA), the NQF, National Standards Bodies (NSBs), Standards Generating Bodies (SGBs) and Education and Training Qualification Agencies (ETQAs), reconciliation of the 12 SAQA fields with the eight learning areas with the eight phases and the fields of study, and on and on. But it also requires understanding the sudden shift from 'competencies' to 'outcomes' in the official discourse on OBE, what lies behind the change and how the two terms now relate within the new policy. The only certainty about OBE and its predecessor language is that it has constantly changed meaning. This language is quite simply inaccessible (Jansen, 1998: 322).

Moreover, the teacher needs to establish a connection between the classroom and the ‘real world situation’ so as to prepare the learner for the workplace (Genis, in

Carl, Bitzer & Roux 2004: 9) – a situation which points towards being critical. Moreover, teachers are required to adapt or change their teaching as to promote active learner participation and to be reflexive (Jansen, 2001). Following McLean (2006: 185-187), critical teaching and learning implies that teachers have to be self-reflexive, that is, think about their own practices and find ways to improve such practices; engage learners in a dialogical fashion; and connect learning experiences with situations outside the classroom that can lead to the emancipation of the individuals. In a way, critical teaching and learning can lead to the emancipation of individuals and groups (Habermas, 1972). By this is meant that people would be in a position to speak with an authoritative voice and, in the case of teachers, to influence critically what learners are doing in classrooms.

It is my understanding that the afore-mentioned features of critical education, that is teacher self-reflexivity, the dialogical engagement of learners and connecting the learners' classroom experiences with broader societal issues, are at the heart of teachers' professional development initiatives. This view resonates with Reddy's (2004: 146) idea of critical education, which is guided by dialogue, critique, discussion and support. The purpose of my investigation by way of reflection is to find out how educational technologies can be used to engender critical education and thus guide the professional development of teachers, particularly my own. For instance, the use of computers to teach basic scientific concepts can help teachers to be reflective about their practices, to encourage dialogical action with their learners, and to connect learning with broader societal issues, such as climate change, environmental degradation and pollution. Organisations such as *Khanya* provide computers with software that enables learners to do scientific calculations via the computer. Through these scientific solutions, the computers are able to generate

random questions and step-by-step procedures for learners to follow and reflect on. In this way, learners can hopefully become self-reflective in their learning and, in my view, learn in a much better way. This is just one example of how educational technologies can contribute towards critical learning.

In my own case study (with reference to my two narratives in Chapter 5), I wish to show how the technologies I have used with learners in an environmental impact assessment of a wetland area can also promote not only my own self-reflectivity / professional development, but also advance social justice issues in my community, such as making learners aware of poverty, inequality and environmental injustices.

1.2 Problem Statement

From my interactions with grade 10 learners in a science classroom over the past three years (2008-2010), it seems to be that there is an expectation on the part of many learners that science teaching merely involves the teacher giving detailed notes on the subject content, which they (the learners) have to acquire mostly through memorisation. Discussions on the content being taught seem to be considered inappropriate, because learners often have to acquire lots of scientific facts. While socialising learners with facts about science is not inappropriate, the learners have to be initiated into discussion and questioning, which hopefully would help them to make better sense of the knowledge being taught and learnt. Rorty (1988: 45) makes a distinction between socialisation and individuation whereby learners are socialised into an inherited body of knowledge (scientific content) and, at the same time, are encouraged to understand and bring into question what they learn. In this thesis I shall investigate how the application of selected educational

technologies on my part can assist learners to acquire scientific knowledge and, at the same time, develop critical and questioning attitudes about the content being taught. Put in a different way, I want to find out how educational technologies can assist me in becoming a critical teacher who can engender in learners critical attitudes about the content being taught in science classrooms, thus enhancing my own professional development.

The research question for this study can be stated as follows: Can educational technologies enhance the professional development of teachers so that teaching and learning can become critical in a science classroom? The subsidiary questions that will be investigated are:

- Can professional teacher development be attained through critical teaching and learning?
- Can educational technologies assist in achieving critical education for learners?

1.3 Research Approach

For this thesis I intend to apply Sandra Harding's (1987) distinction between methodology and method. Methodology refers to the theoretical framework I shall use, that is interpretive theory, and method is the procedure of inquiry I wish to employ. Both methodology (theoretical framework) and method (procedure) are aspects of the study that make up my research design. In this study, my research design is narrative inquiry. The method that I would like to make use of is that of reflective teaching. Such an educational research design involves me as a story-

telling individual and, hopefully, affords me an opportunity to better convey my personal experiences that I have encountered in the past few years since joining the teaching profession as a science teacher with a profound interest in the use of technologies in my pedagogical practices. This research thesis will be written in the first person, as I will be trying to construct, reconstruct and deconstruct (that is, reflect on) my own experiences in a science classroom with the aim to acquire a better understanding of how technologies can assist the professional development of teachers so as to make them critical in their teaching practices – primarily my own practices. Narrative inquiry sees humans as story-telling organisms that lead storied lives and are characters in their own stories (Connely & Clandinin, 1990: 2). And, as this thesis unfolds, I shall narrate two stories in Chapter 5 that will elucidate some of the positive effects that the use of educational technologies can have on science teaching and learning. Put differently, I want to focus on my own professional development as a science teacher over the past three years. This brings me to a discussion of the outline I shall follow in this thesis.

1.4 Thesis Outline

In Chapter 1 (this chapter) I have introduced the study. I gave a motivation for the study in relation to what constitutes critical teaching and learning. The rationale for this study – investigating the use of educational technologies and its implications for professional development and critical education – was also given, and the research problem was articulated.

Chapter 2 involves a theoretical exploration of the professional development of (science) teachers in relation to the achievement of critical education (pedagogy)[3], specifically teaching and learning.

Chapter 3 involves giving a theoretical account of how educational technologies have had an impact on critical teaching and learning in science classrooms. I also show the multiple uses of technologies and how they advance critical education and professional teacher development.

Chapter 4 explores my research design, methodology and method in examining the research problem at hand.

Chapter 5 involves giving an account of the application of educational technologies with reference to two narratives. I narrate two stories about the use of educational technologies, showing specifically how critical pedagogy can be enhanced in relation to the teaching and learning of life sciences in the local high school where I pursue my profession. My main argument is that educational technologies have the potential to enhance critical teaching and learning in and beyond science classrooms, as well as to contribute to my own professional development as a teacher.

In Chapter 6 I look briefly at some of the limitations of the use of educational technologies in grade 10 science classrooms to bring about critical, transformative

[3] In this thesis I shall use 'critical education' and 'critical pedagogy' interchangeably.

teaching and learning as professional development processes. I then offer some possibilities for future educational research in this area.[4]

[4] For the reason that my research design is narrative inquiry, I am obliged to narrate my story in the first person.

CHAPTER 2

TEACHER PROFESSIONAL DEVELOPMENT, REFLECTIVE PRACTICE AND CRITICAL EDUCATION

2.1 Introduction

There is no doubt that the seminal work of Schön (1983), entitled *The reflective practitioner: How professionals think in action*, has been instrumental in shaping my understanding that a teacher's professional development should be centred on enhancing his or her ability for 'reflection-action' – that is, learning by doing and developing the ability for ongoing learning and problem solving. In Schön's words,

> I begin with the assumption that competent practitioners (teachers) usually know more than they can say. They exhibit a kind of knowing in practice, most of which is tacit … Indeed practitioners themselves often reveal a capacity for reflection on their intuitive knowing in the midst of action and sometimes use this capacity to cope with the unique, uncertain, and conflicted situations of practice (Schön, 1983: 8-9).

By and large, my own teaching has been influenced too by an approach of 'learning by doing', in the sense that my own professional development as a teacher has been guided by trying different things and using different ways of connecting with my learners – an approach that has invariably inspired me to use educational technologies in making the content of life sciences known to learners. Schön (1983: 12-15) distinguishes between different kinds of reflection. On the one hand,

reflection-in-action is considered as the ability of a practitioner to 'think on their feet' – a practice referred to as 'felt-knowing'. It revolves around the idea that within any given moment, when faced with a professional issue, a practitioner usually connects with their feelings, emotions and prior experiences to attend to the situation directly. Whilst engaging with learners, I often had to think on my feet in responding to questions posed. On the other hand, reflection-on-action involves the idea that after the experience a practitioner analyses their reaction to the situation and explores the reasons around, and the consequences of, their actions. This is usually conducted though a documented reflection of the situation. After a lesson has been taught in classroom and after having received feedback from learners and colleagues I would reflect on my teaching as to improve the way I taught. In many ways, this thesis is an instance of reflecting on my practices in science classrooms with the aim to improve my professional development. And, while I engaged my learners I often reflected in the pursuit of performing particular activities. In the next section I want to focus on the professional development of teachers and how, through reflection-in-action, they potentially become more open to critical education.

2.2 Teacher Professional Development and Critical Pedagogy

Drawing on the work of Zeichner (2009: 121), reflective teaching has become a central component of teacher development. He argues that reflective teaching practice can be 'seen as a reaction against a view of teachers as technicians who merely carry out what others, outside the classroom, want them to do' (Zeichner, 2009: 122). In fact, reflective teaching can be seen, Zeichner (2009: 122) argues, as

> … a recognition that teachers are professionals who must play active roles … a recognition that teachers have theories too that can contribute to a knowledge base for teaching … Reflection as a slogan also signifies a recognition that learning to teach is a process that continues throughout a teacher's entire career.

Based on the above-mentioned view of reflective teaching, which I consider as being central to my own teaching practice in science classrooms, one can infer that reflection is ongoing and part and parcel of a teacher's professional development. Like Zeichner (2009: 128), I hold the view that reflective teaching is a way of empowering teachers to 'exercise their professional judgement about both the content of the curriculum and the means of instruction'. Hence, one's professional development as a teacher hinges on the ways in which one embarks upon reflective teaching in classrooms.

Furthermore, Zeichner (2009: 127-128) claims that the importance of reflective teaching to the ongoing professional development of teachers is based on at least four considerations: Firstly, teachers take seriously theories and expertise embedded in their own and other teachers' practices; secondly, reflection does not limit teachers' practice to technical questions of teaching techniques and internal classroom organisation; thirdly, reflective teaching allows teachers to take up broader institutional and social issues beyond their classroom practices; and fourthly, it helps teachers to reflect individually. In a way, reflective teaching helps teachers to acquire and develop professionally some of the key aspects associated with critical education. I shall now elaborate on how reflective teaching connects teachers' professional development to critical education.

Critical education, referred to more appropriately as critical pedagogy, has many meanings. Freire considers critical pedagogy as a practice that gives voice to the oppressed within a framework of dialogue between people (in Gur-Ze'ev, 1998: 467), whereas Giroux's view of critical pedagogy 'is indebted to the politicization of teachers and students and their empowerment as radical intellectuals who change their school as part of a general struggle over essential change' (in Gur-Ze'ev, 1998: 473). For Freire, human activity consists of both action and reflection, that is, praxis that leads to the transformation of the world (Freire, 1993: 125). He relates action-reflection to theory and practice. Praxis is thus taking a critical stance towards one's world of action and reflecting on it for transformative action (Freire, 1993: 126). From this perspective, the most appropriate way to engage the learners' framework of relevance is to allow space for learners to engage critically with the issues, to bring their own insights, culture and different aspects of their multiple subjectivities to bear on the learning process. Critical pedagogy, as articulated by Gur-Ze'ev (1998: 480), seems to be appropriate to encourage reflective teaching in teachers' professional development. Freire argues that critical pedagogy is framed, firstly, by the possibility of developing people's competence, reconstructing human cooperation and realising people's dialogical essence; secondly, by the self-realisation of individuals as part of a collective partnership with other reflective politically-oriented human beings; and thirdly, by striving for conditions under which everyone will become part of a dialogue (Gur-Ze'ev, 1998: 481).

In the same manner, Blake and Masschelein (2003: 47-49) offer three important understandings of critical pedagogy that relate to reflective teaching: Firstly, critical pedagogy values critique as a support for personal autonomy and places critique at

the centre of educational problems; secondly, it recognises reflective processes as important to the production of knowledge; and thirdly, it considers communicative interaction as central to human engagement. Following the afore-mentioned explanations of critical pedagogy, I conclude that reflective teaching practice is important for the professional development of teachers because, firstly, it creates opportunities for teachers to think deeper about their work and to ask questions about what they are doing; secondly, it offers opportunities for teachers and learners to engage in dialogical praxis (action) about their work, that is, doing things together in a critical spirit; and thirdly, it extends what people are doing to improve the lives of others in the broader society, that is, a matter of creating social conditions for the empowerment of individuals and groups.

I now want to focus on two aspects of critical pedagogy that offer possibilities for enhancing reflective teaching on the one hand, and for applying educational technologies on the other hand.

2.3 Critical Pedagogy, Critical Thinking and Transformative Action

As has been mentioned earlier, critical pedagogy encourages individuals to reflect on their work in relation to others. Bailin and Siegel (2003: 181) make the claim that individuals who reflect deeply about what they are doing are those who are 'appropriately moved by reasons' – they are critical thinkers. To think critically is to have a deep concern for 'the probative strength of reasons' (Bailin & Siegel, 2003: 181). In other words, critical thinking involves 'higher-order thinking', which involves enabling learners to 'judge … matters for themselves' (Bailin & Siegel, 2003: 189). In addition, critical thinking involves preparing learners for 'self-sufficiency and self-

direction', which would enable them to do 'careful analysis, good thinking, and reasoned deliberation in democratic life' (Bailin & Siegel, 2003: 189). In essence, critical thinking as an instance of critical pedagogy is 'an attempt to engage in questioning, criticism, and inquiry (that) proposes the force of reasons' (Bailin & Siegel, 2003: 192). Thus, when teachers are concerned with their professional development, they embark on a kind of reflective practice that harnesses critical thinking. This they do by encouraging themselves and learners to question meanings and to give recognition to the strength of reasons. And when they do so, the possibility exists for learners to do careful analyses in an atmosphere of reasoned deliberation. If this happens, critical pedagogy becomes the order of the day.

Moreover, a reflective practice is considered to be a cyclical activity in which practitioners attend to purposive activities that constitute their practice. Such activities include an examination of the activities planned, critiques of the activities, and suggestions for corrective action (Willis in Reddy & Menkveld, 2000: 178). Likewise, Van Manen (1995: 33) states that a reflective practice refers to a complex array of cognitively and philosophically distinct methods and attitudes, such as perplexity, confusion and doubt due to the situation in which one finds oneself; conjectural anticipation and tentative interpretation of meanings of the situation and possible consequences; examination, exploration and analysis of problems; an elaboration of tentative suggestions; and deciding on a plan of action or doing something about a desired result (Van Manen, 1995: 34). Again, drawing on Reddy and Menkveld (2000: 178-179), at least three levels of reflective practice can be identified in the literature: Firstly, to reflect on an event relying on personal experiences without necessarily understanding the theory that make up practices. Here the emphasis of a teacher would be to reflect on his or her own classroom

competence and effectiveness in relation to measurable outcomes. This level of reflective practice addresses 'the means or procedures for delivering education while leaving the important questions about the purposes, values and goals of schooling unexamined'. Secondly, the level of problem resolution in action in relation to existing theories of teaching and learning is referred to by Van Manen (in Reddy & Menkveld, 2000: 179) as 'the hermeneutic-phenomenological paradigm'. Here, what a teacher does in the practice is related to theories of good practice. Thirdly, the level of critical reflection involves a reference to moral and ethical criteria, such as whether important human needs have been satisfied through practical action. In this regard, 'critical reflection considers the political, ethical and social contexts of teaching, questioning the taken for granted conceptions of teachers' work, and the striving towards the construction of educational communities based on democratic ideals' (Reddy & Menkveld, 2000: 179).

Similarly, critical pedagogy is also aimed at cultivating a deliberative and reflective spirit in learners whereby they listen and respond collectively to ideas that are presented to them, as well as respond critically through talking back to one another and their teachers. Giroux (1988: 27) proposes that teachers can avoid becoming mere technicians by becoming 'transformative intellectuals who develop counter hegemonic pedagogies that not only empower students (learners) by giving them the knowledge and social skills they will need to be able to function in the larger society as critical agents, but also educate them for transformative action'. This means they will be educated to take risks, struggle for institutional change, and fight for democracy in other public spaces outside of schools. It is this idea of transformative action that I want to explore in relation to teaching with the support of educational technologies in schools.

2.4 Transformative Action and Educational Technologies

The question remains: Does the use of educational technologies in teaching create opportunities for transformative action? Teacher professional development nowadays is concerned mainly with the innovative integration of the use of educational technologies in teaching and learning (King, 2002: 285). One of the effects of such integration has been the potential for transformational learning, which 'serves as a comprehensive way to understand the process whereby adult learners critically examine their beliefs, assumptions, and values in light of acquiring new knowledge and correspondingly shift their worldviews to incorporate new ideas, values and expectations' (King, 2002: 293). Stated differently, they embark on reflective practice. The use of educational technologies in classroom practices and the continuing professional development of teachers can create opportunities for teachers to cultivate reflective practice and to encourage the development of learning communities that may lead to (transformative) communities of practice (Wenger in King, 2002: 296). In addition, Foreman (2003: 22) holds that educational technologies such as instructional videogames offer the prospect of learning experiences that can be transformative in the sense of inducing delight and instruction at the same time. Transformative action is attained on the grounds that learning, he argues, requires active discovery, analysis, problem-solving, memory, and physical activity, which game-based educational technologies provide (Foreman, 2003: 12). Likewise, Pearson and Somekh (2006: 520) hold the view that transformative learning involves the following:

- Learning creatively: contributing, experimenting, solving problems;

- Learning as active citizens: acting autonomously, taking responsibility for their own learning;
- Engaging intellectually with powerful ideas: using thinking skills, grappling with ideas / concepts; and
- Reflecting on their own learning: evaluating their own learning through metacognition.

The afore-mentioned views on transformative learning can be achieved through the application of educational technologies such as the search engine Google, directories of Yahoo, and video-recordings that are fully incorporated into group work (Pearson & Somekh, 2006: 524). In the words of Pearson and Somekh (2006: 538),

> The characteristics of transformative learning are observable in young people's experience of using ICT in their own homes, where they have control over how it is used, the ability to explore its affordances and pursue playful activities and the freedom to focus on activities intensively without interruption … enable us to shape new worlds on the basis of imagined constructions … and the extensive experiences of … ICTs.

What follows is that transformative learning is possible with the execution of educational technologies that would ably enhance both the professional development of teachers and the principles of critical pedagogy, including reflective practice.

2.5 Summary

I began this chapter with a defence of reflective teaching practice, which is crucial to the professional development of teachers. Then I developed the argument that teacher professional development (and hence, reflective teaching practice) can be made possible through the implementation of critical pedagogy. In turn, I showed that critical pedagogy has a transformative potential for classroom practice. It is the latter idea of transformative action that can be nurtured through the execution of educational technologies and together improve the professional development of teachers. This thesis is about improving and reporting on my own professional development as a teacher in a high school, responsible for the teaching of life sciences for grades 10 to 12. But first, I need to proceed to the following chapter, where I focus on some of the theoretical understandings that have an impact on the use of educational technologies in classrooms.

CHAPTER 3

THEORETICAL ACCOUNT OF EDUCATIONAL TECHNOLOGIES

3.1 Introduction

In this chapter I shall offer a theoretical account of the application of various educational technologies in school science classrooms. I shall focus specifically on the kinds of educational technologies used, before looking at how these technologies have an impact on teaching and learning in classrooms, including on my own professional development as a science teacher. Thereafter I shall show how critical teaching and learning can be attained through the use of technologies.

3.2 Theories and Educational Technologies: A Literature Review

The promises and pitfalls of information and communications technologies (ICTs) are linked to two motifs of our times: globalisation and the learning society (Lelliot, Pendlebury & Enslin, 2000: 45). On the one hand, globalisation can be considered a process by which societies are connected through rapid, large-scale networks of political, social and economic interaction, whereas, on the other hand, the learning society comprises well-educated communities and individuals through the application of ICTs (Lelliot *et al*., 2000: 46). And, without access to ICTs, societies in Africa are in danger of exclusion from global development, although not immune from the effects of globalisation (Lelliot *et al*., 2000: 47). Of all the African countries, South Africa is the most technologically advanced, and the possibility that schools in the country can promote ICTs is also very high (Lelliot *et al*., 2000: 50). In addition, the growth of a

democratic public sphere can also be linked to the implementation of ICTs. According to Bohman (1998: 213),

> we can expect that under proper conditions and with the support of democratic institutions, a vibrant public sphere will expand and become open to and connected with other public spheres. Members will develop the capacities of public reason to cross and negotiate boundaries and differences between groups, persons and cultures. Certainly the global media may help foster this process.

Considering that schools also make up the public sphere, the potential exists for ICTs to have an impact on schooling, in particular teaching, learning and professional development – the subject of my investigation in this thesis.

In South Africa, some academics consider knowledge advancement as the primary means for resolving societal problems. Education should, therefore, inculcate such an understanding of knowledge and its intent to solve societal problems in the minds of the youth. Certain forms of knowledge transmission are limited in their scope to achieve the goal of knowledge for the sake of resolving societal problems (Scardamalia & Bereiter, 2006: 15). If institutions like schools want to effectively serve the needs of the 21st century, they will have to be attenuated to the use of ICTs. In the words of Peters and Araya (2007: 33), ICTs seem 'to offer strong methodological and epistemological promise across the social sciences, with an apparently easy application to education. This is particularly true with regard to learning networks in the context of *innovation* and a *knowledge economy*'. As

Castells (2004: 224) notes, technological networks, including ICTs, are fundamental to both the challenges we face and the solutions to those challenges:

> Networks matter because they are the underlying structure of our lives. And without understanding their logic we cannot change their programmes to harness their flexibility to our hopes, instead of relentlessly adapting ourselves to the instructions received from their unseen codes. Networks are the Matrix.

Literature on the use of educational technologies in classroom practices abound. Since the 1920s, American schools have gradually implemented educational technologies in the classrooms with varying degrees of support and success (Cuban, 1986: 8). Kent and McNergney (1998: 5), in *Will technology really change education? From blackboard to web*, offer an account of how, on the one hand, technologies will hopefully improve the way educators teach and learners learn. Consequently, there seems to have been a demand to integrate computer and related technologies into the classroom (Kent & McNergney, 1998: 6). On the other hand, there is a growing dissent that questions the efficacy of computers and their related technologies in classrooms, particularly questioning the ability of technologies to deliver quality and affordable education (Kent & McNergney, 1998: 6). Raizen, Selwood, Todd and Vickers (1995: 7-8) argue more in favour of the use of educational technologies which, according to them, would significantly alter the way in which science, mathematics and other subjects are taught. It is the latter view that I share and support, by showing in Chapter 5 of this thesis how educational technologies can improve science teaching and learning in classrooms. More recently, Ashburn and Floden (2006: 8) contend that, despite the evolutionary status of technologies, children need to consider their use in classrooms along with reading, writing and the

acquisition of subject knowledge. For the purposes of this thesis, I want to echo the view of Burbules and Callister (2000: 10-15) who, in *Watch it: The risks and promises of information technologies for education*. argue firstly that educational technologies neither embrace a utopian vision of computers as likely to revolutionise schools, nor join the chorus of those who consider the movement of computers into schools as wasteful and a threat to educational values and processes; secondly, educational technologies offer, according to them, ways to rethink teaching and learning along the lines of critical thinking. It is the latter view that I support and shall argue for later on in the thesis.

Emerging educational technologies hold the key for improving knowledge transmission and teacher quality (Gimbert & Cristol, 2004: 207). Jeremy (2002) suggests that, in addition to technologies improving learning, they may also improve critical thinking, analysis and scientific enquiry. Evidence suggests that there is a measurable difference between learner achievement and teacher quality through the use of educational technologies in the transmission and construction of knowledge. Gimbert and Cristol (2004: 207) suggest that there are five propositions for the integration of technologies into pedagogical practices. Firstly, the use of technologies in the classroom affords learners the opportunity for socialisation and language development. This is dependent on the setup of the learning environment. An example of this at the school where I teach would be that there are classrooms of up to 40 learners and about only 30 computers. So, depending on the lesson, learners are required to work in pairs. This encourages social sharing and cognition (Gimbert & Cristol, 2004: 208). Learners working with technologies in groups would be encouraged to become decision makers, creators and solvers of new problems.

Secondly, Gimbert and Cristol (2004: 208) propose that, by using the appropriate technologies, learners are encouraged to use their imagination and to explore at their own pace, given the nature of the technologies used. This would be useful for learners with learning disabilities. They thus are able to control the pace at which they learn. The software characteristics that are required to assist this type of learner would include software design consisting of open-ended learning tasks with animated routines, and directions that may be paused and resumed so as to nurture students' learning (Gimbert & Cristol, 2004: 209).

Thirdly, what I consider to be considerably important for learners is that the use of technologies enhances learners' attention span. My own account is that learners respond better and pay more attention when technologies are infused into lessons. Guthrie and Richardson (1995: 14) suggest that learners are intrinsically more motivated and that they learn better when technologies are infused into learning in the classroom. Guthrie and Richardson (1995: 15) stress, however, that this only occurs when the appropriate technologies are used, because sometimes the technologies may actually be a hindrance to the learning process, that is, certain technologies may countenance learning (Gimbert & Cristol, 2004: 210). Okolo and Hayes (1996:12) found that learners spend four times more time reading when using technologies infused with animation. However, their research indicates that learners are able to recall knowledge learnt better.

Fourthly, learners (with special needs) benefit from the use of technologies (Behrmann & Lahm, 1994: 105). Technologies such as touch pads and special keyboards magnifying programs can grant learners opportunities to learn effectively despite having physical disabilities, language disabilities and autism (Johanson,

1997: 12). The final proposition for the integration of technologies suggested by Gimbert and Cristol (2004) is that of teacher professional development. Gimbert and Cristol (2004: 211) suggest that teachers should not learn about technologies, but should learn how to teach with technologies. In doing this, their own professional development is taken into consideration. The technologies used should be viable and meaningful (Gimbert & Cristol, 2004: 212). Gimbert and Cristol (2004: 212) claim that there is a need to integrate technologies into teaching, as well as into job-embedded professional development at tertiary institutions. I would argue that technologies can augment teaching and learning effectively, as many teachers who have been in the teaching profession for many years have no experience in the integration of technology into their lessons. These teachers are not able to take advantage of the five propositions of technology-supported education as stated by Gimbert and Cristol (2004: 214).

Although there are many advantages with regard to the integration of technologies into lessons, Gimbert and Cristol (2004: 214) suggest that care needs to be taken when considering integrating technologies into science lessons. Teachers should look at how effective the technologies used are so that they will improve and not impede the teaching and learning process. This may be done through seeking assistance from other teachers who have successfully implemented technologies into their teaching practices.[5]

With regard to the professional development of teachers I feel that there needs to be a support structure in place to assist teachers in their efforts to use technologies to

[5] I have found that, once teachers have been exposed to the use of technologies in their classes, they become enthusiastic to repeat its application in their lessons.

support their classroom practices. As a teacher I see that government is investing money in the implementation of technologies into the classroom. However, I contend that they also need to look at the professional development of teachers so that teachers are able to use the appropriate technologies that government has invested in effectively and so that computer rooms do not become 'white elephants' due to teachers being unaware of or apprehensive to use the various computer-based technologies in their pedagogical practices.

Furthermore, regarding the successful implementation of technologies in the classroom, Gimbert and Cristol (2004: 214) argue that a teacher ought to assist his / her professional development with the aid of professional and collegial support from colleagues, so that teachers can develop themselves to use technologies in their pedagogical practices. In some Western Cape schools, commitments are made by organisations such as *Khanya* (as has been mentioned earlier) that send individuals to schools to train teachers to use technologies in a way that ensures their (teachers') professional development. Having a teacher who is technologically competent when learners are using technologies has been shown to stimulate their (learners') thinking (Gimbert & Cristol, 2004: 214).

Gimbert and Cristol (2004: 214) assert that programmes or workshops on the professional development of teachers tend to use a 'one-size-fits-all' approach. Teachers' technological competences are not all at the same level. I have encountered this situation in workshops that I have attended regarding the use of technologies to augment teaching and learning, where a 'one-size-fits-all' approach seems to be used. As a new teacher I am hopefully quite competent in the use of technologies and I am able to follow well in the workshops, but in my experience

more experienced teachers tend not to follow in these workshops as a result of this blanket approach. As such, professional development opportunities rather need to be designed to allow teachers to determine what best suits their technological needs, instead of them falling into a void where they are unable to grasp the real-life implications (of the use of technologies) for teaching and learning that these workshops should be bringing about. These workshops should afford teachers space and time so that they may see the applications for critical teaching and learning when implementing a curriculum (Scardamalia & Bereiter, 2006: 14). Therefore, there needs to be a collaborative effort between teachers and organisations to drive a professional development process that will result in the meaningful infusion of technologies into teaching in science classrooms.

Jeremy (2000: 76) has done research on the use of technologies in pedagogical practices and has identified four fundamental characteristics that are related to the work of Gimbert and Cristol (2004). The first characteristic described by Jeremy (2000: 77) is that of learning through active engagement. The active engagement involves experience, interpretation and structured interaction with peers and teachers to improve the learning process (Jeremy, 2000: 77). When learners are passive, however, they are not able to apply what they have learned to situations outside of the classroom (Jeremy, 2000: 77). Although active learning can be obtained without the use of technologies, the whole basis for its use (that is, technologies) is that it is guided by active engagement. Therefore, incorporating technologies into classroom practices congruently results in the active engagement of learners. And, if active engagement is absent, then it follows that the use of technologies might not be implemented appropriately. Simply put, the effective application of educational technologies gives rise to active engagement in learning.

Another characteristic that Jeremy (2000: 79) has identified is that the use of technologies in teaching encourages the participation of learners in groups. Jeremy (2000) suggests that social contexts afford learners the opportunity to carry out complex skills that they would otherwise not be able to carry out alone. So, if technologies encourage the active participation of learners, the learning process can only be improved through the creation of a social context in which technologies promote learning in groups.

The next characteristic that I would like to discuss is that of providing frequent interaction and feedback. I was fortunate to study at a tertiary institution that has really embraced the use of educational technologies. This institution made use of an interactive online classroom program called WebCT. The program allowed me to obtain all the PowerPoint notes presented in my lectures, aided me in doing many tutorial exercises designed by the lecturer, and permitted me to do tests. These online tests enabled me to gauge my knowledge of the subject area. The tutorial component of WebCT was particularly relevant to the notion of frequent interaction and feedback. It allowed me to do tutorial questions, on completion of which a detailed memorandum was provided instantly. This is an example of frequent interaction and feedback. If this educational technology was not used then the opportunities for feedback and questions would be relatively slow and this would have impeded the learning process.

The final characteristic that Jeremy (2000: 82) has identified is related to the way that learners learn through connections to real-world contexts. Many learners in classrooms see little relevance in the work they cover in class, or cannot see the real-life applications of the work they do in the classroom. To enable learners to

apply the knowledge they have acquired to real-life applications does not require the memorisation of content, but rather that learners grasp and understand concepts. Jeremy (2000: 82) suggests that traditional exercises do not allow learners to apply their knowledge effectively, due to varying contexts. He claims that, by using educational technologies, learners can effectively apply their knowledge to varying contexts. For example, students have access to many tools that scientists use, such as Google Earth. I have used Google Earth in my teaching practices, and shall elaborate on this in Chapter 5. For example, scientists recently have discovered a new mammalian fossil specimen that is presumed to be the missing link in the evolution of Homo sapiens. The discovery was brought about through the use of Google Earth. In teaching evolution to grade 12 learners, I have to discuss fossil formation with them. Through the use of Google Earth the learners can view the discovery site and, therefore, not consider this section of grade 12 life sciences as arbitrary. A real-life connection is made between what is learnt in class and the latest scientific developments. Research indicates that learners' performances have increased due to the use of educational technologies that link classroom practices and real-life situations (Jeremy, 2000: 82). This brings me to a discussion of the application of different educational technologies in classrooms.

3.3 Application of Educational Technologies in Classrooms

3.3.1 Cellular phones

The first technology I would like to discuss in terms of its relevance to teaching and learning is that of cellular phones. These mobile devices are no longer just used for making calls or texting, but today have ever expanding possibilities, which may

include browsing the Internet and performing GPS (global positioning system) navigation, to mention but a few. These devices are, however, banned from schools as they are seen as a type of distraction. Recently, the untapped potential of these devices for learning have come to light. When using these devices, learners are not just restricted to learning in the classroom. The untapped potential for learning is related to an anywhere, anytime learning possibility. Although laptops and desktop computers have been used for teaching and learning, these mobile devices (cellular phones) have the processing power that many desktop computers had in the late 1990s, making them a more than adequate replacement for the more expensive desktop computers. The fact that they are relatively inexpensive has led to a boom in the number of learners possessing these devices.

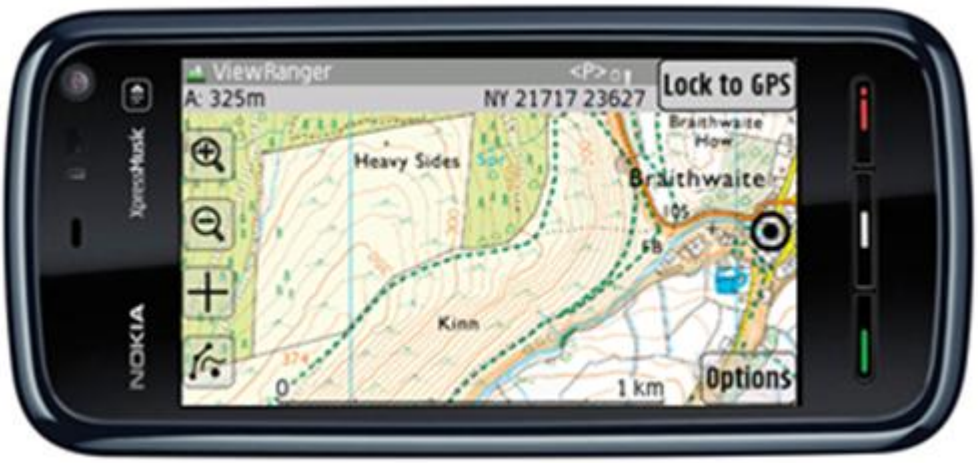

Figure 1: A Nokia mobile device. Devices like these have a vast array of features, such as GPS navigation, which can be used as a tool in scientific investigations.

Digital imaging devices such as video cameras and digital cameras are relatively expensive for schools to obtain. Today's mobile devices have cameras built into them as a standard feature. These devices also have imaging and video-editing capabilities that perform the same functions as desktop computers. These cameras can be used for a wide range of activities, such as the documentation of outings and the use of images for multimedia presentations.

These devices can also be connected to TVs through audio video (AV) inputs. Most data projectors also have these AV inputs, which enable one to connect a cellular device to a data projector. This enables the user to display everything that is on a cellular phone screen onto a data projector. As far as applications go, a teacher can browse the Internet on a cellular phone, for example, to search for an image related to a topic in the work being covered. This picture can be displayed on the data projector for a particular class to see.

Figure 2: Mobile devices are able to be connected to external displays such as monitors and data projectors, enabling them to play the roles of the desktop computers or laptops that are otherwise connected to these displays.

3.3.2 Social networking sites

At many tertiary institutions, when students want to communicate with their lecturers with regard to content covered in the classroom they would contact him / her via

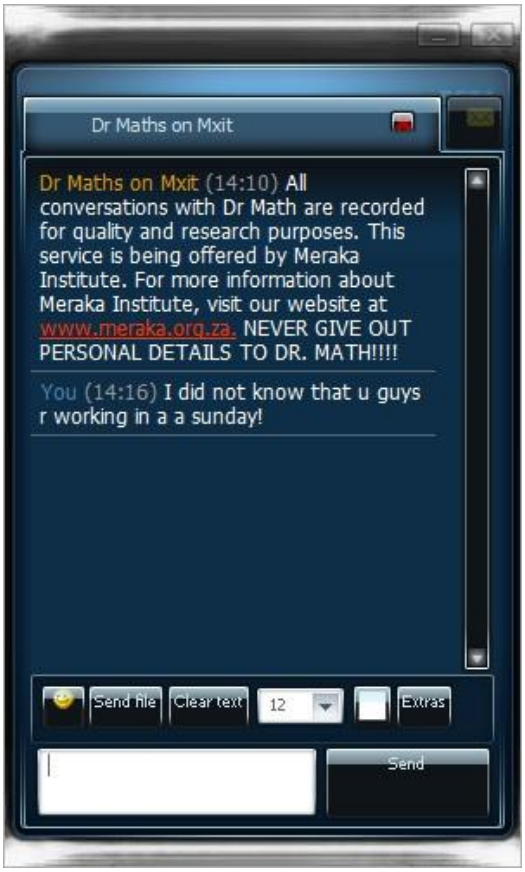

Figure 3: MXit is one of the most popular social networking tools for students. Organisations with a stake in education have already realised its potential.

email. It is easy for students to do this, as these tertiary institutions have many computer laboratories and provide email accounts as well as email addresses and address books to find the lecturers' email addresses. Many schools, however, do not have the facilities to allow this form of communication between teachers and learners, which would definitely enhance learning. Many learners in schools use social networking utilities to communicate, such as Facebook, Twitter, MXit and Blogging. Using these technologies that learners use to communicate with their peers has almost become an everyday practice. A popular social networking utility used by many learners is the instant messaging application called MXit. MXit is a phone application that allows users to communicate with each other via real-time chat. It is inexpensive to use and is freely available to anyone. It is an ideal means for communication between learners and teachers outside of the classroom. There are many pros and cons with regard to the use of MXit. But, as with any technology, the way it is used can determine whether it has advantages or disadvantages. Many teachers already use MXit and Facebook to communicate with one another outside of the classroom. MXit in particular can enable learners to liaise with one another with regard to their understanding of concepts taught in the classroom. Learners can create chat rooms to communicate with each other and to discuss content amongst themselves and

also with teachers. A so-called virtual classroom can be created that will encourage communication amongst all individuals participating.

Another social networking site that has applications for teaching and learning is that of YouTube. YouTube is a video-sharing website that enables users to upload, download, and view video clips. Content found on this site includes video clips covering a variety of subject areas, such as extracts from TV shows, documentaries and amateur videos. For teachers there are many clips that are posted on the website by other teachers and researchers, including illustrations for subjects such as mathematics, physical sciences, life sciences and geography. The YouTube website has a well-designed search function. Teachers can easily search for content related to a section of work they wish to cover with their learners. There also is a mobile application of YouTube for a cellular phone. The fact that many cellular phones can be connected to data projectors enables teachers to display YouTube videos to the classroom via a cellular phone.

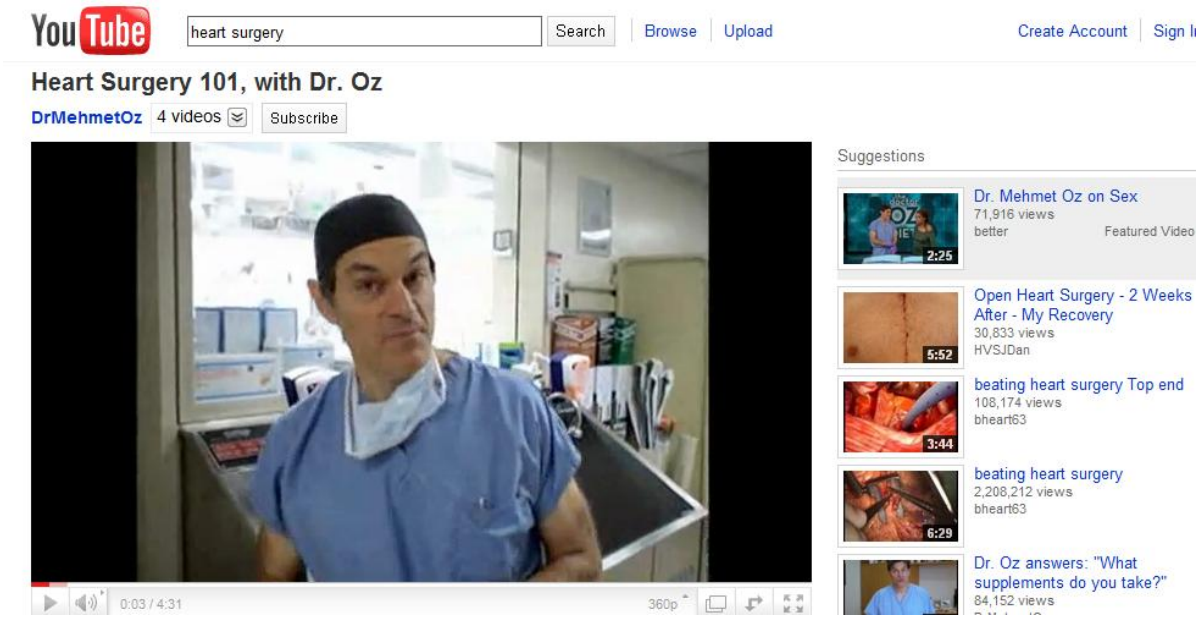

Figure 4: Social networking websites such as YouTube offer a vast array of resources in the form of videos on a wide selection of subject material.

YouTube is a powerful way to spark interest in learners for a section of work to be covered, that is, it can be used as an ‘icebreaker’. Using a YouTube video as an introduction to a lesson can captivate the learners to pay more attention in lessons. Learners show more willingness to follow the elaboration given on the video by teachers. Incorporating a video from YouTube as an introduction does not require much effort by a teacher, as the database of videos on YouTube is vast. It would find particular application in historically disadvantaged schools, many of which are inadequately resourced. Teaching science should be done with experimentation and demonstration, but due to the fact that schools are inadequately resourced means that this is not always possible. YouTube, however, offers a solution to this problem. For example, if teachers cannot do a dissection in class due to problems finding specimens and dissection equipment, they can download a video of a dissection on YouTube’s online database. By using YouTube’s online database of videos, teachers can use a data projector to project an entire dissection of a human heart, or even show how heart surgery is performed. And because YouTube is easily accessible via cellular phones, the learners can go home and revisit any videos presented in the classroom at their own leisure.

Not only does YouTube allow one to download videos, but it also allows one to upload video recordings of lessons. Many universities have already begun to upload their lectures onto the YouTube website. The application of this initiative for schools can be very beneficial. After a teacher has taught a lesson, the lesson can be uploaded onto YouTube, affording the learner another chance to watch a lesson and reflect on content presented in the class.

3.3.3 Smart Boards

In the last five years there has been a buzz with regard to the use of Smart Boards in schools through initiatives of organisations such as *Khanya* providing ICT (information and communication technologies) resources to schools. These technologies are relatively expensive, but provide exciting new potential for teaching and learning. The Smart Board is essentially an interactive whiteboard that makes use of touch inputs, much like a touch-screen monitor. Smart Boards provide input in much the same way as a mouse or keyboard would be used connected to a desktop computer. The picture that appears on a Smart Board is projected with a data projector. This technology functions as a result of the combination and interaction of the following: a data projector, an interactive board and a desktop computer or laptop. Simplified, a Smart Board can be likened to a laptop, where the touchpad of the laptop and the screen are combined into one unit, allowing users to control all the functions of a computer or laptop using a single peripheral known as a Smart Board. Not only does a Smart Board provide touch input, but it is in actual fact a board for writing on in the traditional sense. The Smart Board comes with digital pens and an eraser just like a normal chalk board. Teachers would use these pens to write on this interactive board and the desktop PC would process the touch inputs of the pens on the interactive board as writing, which is then projected via a data projector. Desktop computers attached to Smart Boards can be linked via a network. The rationale for this is that if one were to have several classrooms each containing a Smart Board, then if a teacher writes on one Smart Board the writing will appear on all the other Smart Boards. The classrooms may be next to each other or even in distant locations from each other. The significance of this is that it is ideal for distance learning. Distance learning would entail Smart Boards being set up in classrooms so that

teachers can display their writing on these interactive boards over vast distances. Together with the text displayed there may be sound and even video, which would bring a new dimension to distance teaching and learning.

What I have given here is a description of the hardware capabilities of this type of technology, but what is of actual relevance for teachers in everyday teaching is the software accompanying these interactive boards. These boards are a good teaching resource and contain digital media relating to almost every learning area. Digital media include interactive text, images, sound and videos. The Smart Board works particularly well with flash animation. Flash animations are interactive animated films requiring input. These inputs may include touch input from users using the Smart Board. There are a wide variety of flash animations that have been designed specifically to aid teaching and learning.

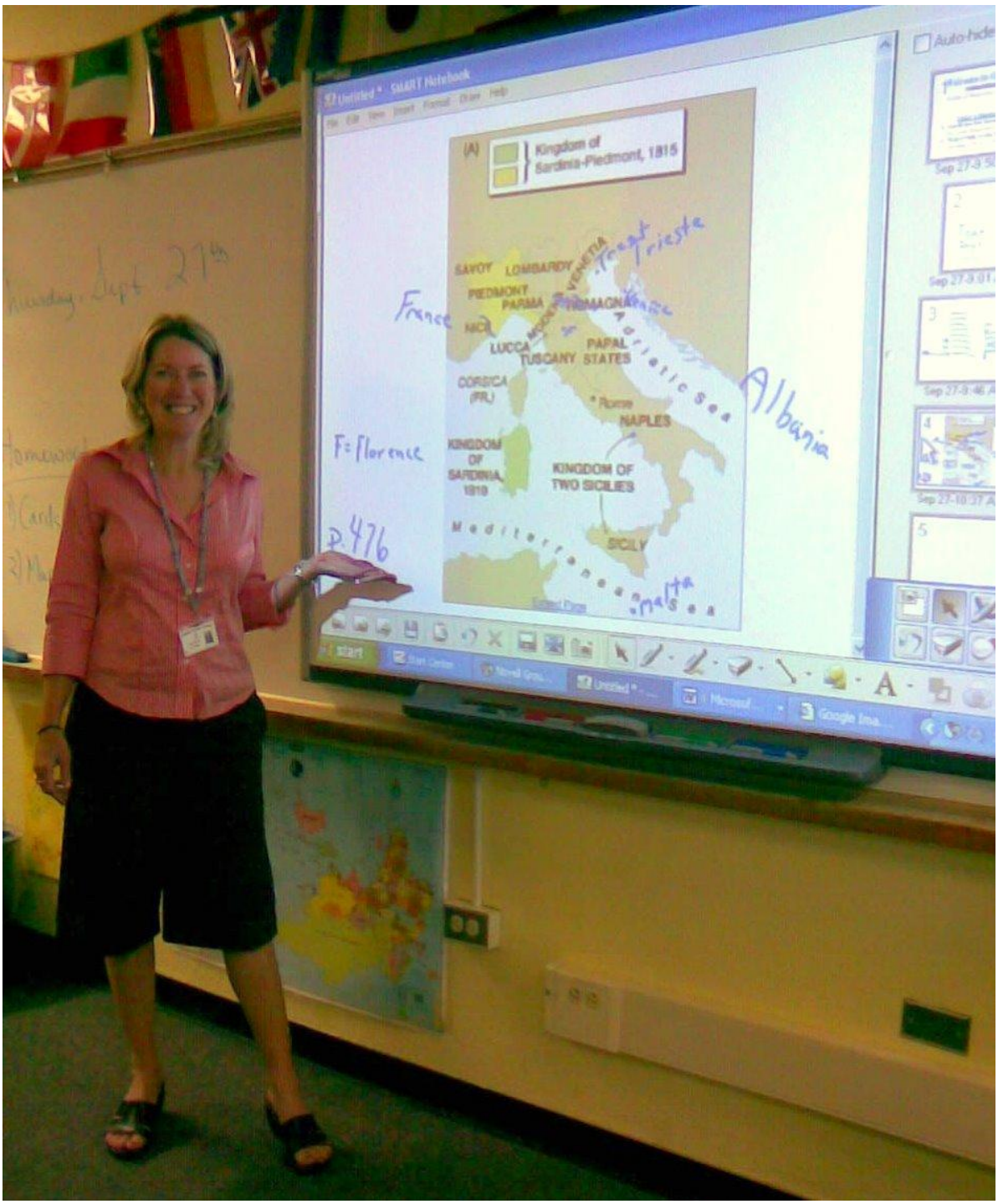

Figure 5: Smart Boards are relatively expensive but have many advantages with regard to teaching and learning.

3.3.4 Edublogs

In education, communication is of paramount importance, whether it is among teachers, learners and / or parents. There are different technologies available to these parties for communication. In the current information age, not being able to use these technologies can effectively result in individual isolation. Blogs are simple to use and include technologies that promote communication between individuals. Blogs are websites run by individuals termed bloggers. Blogs contain regularly updated commentary, event lists and other multimedia content such as videos or audio clips. The content on these websites may be uploaded by bloggers or individuals visiting these websites. What one then has is a website that is easily accessible, which contains a range of content that can easily be uploaded or downloaded, and a communication space in the form of comments in an interactive format. There are different types of blogs, all classified on the basis of their content. Most blogs are primarily textual, although there are blogs that contain content such as photographs (photoblog), videos (video blogging) or music (MP3 blog). The type of blog I want to focus on is the so-called Edublog. Edublogs are blogs created by individuals in the field of education for teachers, learners and parents. Blogs can be used to disseminate information between colleagues, or to learners and parents.

One of the applications for teachers is the enhancement of classroom instruction. Learners and teachers can use a blog website after school from any computer or mobile device with an Internet connection. Therefore, learning is not limited to the classroom. Teachers and learners can alter the content and post comments on the website relating to lessons covered in the classroom, or relating to homework and

projects. The blog can also be used to disseminate information about important events, such as examination dates and project due dates.

More potent are the applications for learners. A blog encourages communication not only between teachers and learners, but also among learners. It encourages collaboration among learners, for example, if a project needs to be done then a discussion among learners can be carried out on the website. Content posted on the website can be reflected on, after which learners can give their thoughts and feelings with regard to these posts. What follows is that conversation is generated that inspires the use of critical and analytical skills (http://www.onlinedegrees.org/top-100-technology-blogs-for-teachers/). Blogs offer shy learners the scope to individually offer views or discernment that they would otherwise not have expressed in the classroom (http://www.onlinedegrees.org/top-100-technology-blogs-for-teachers/). Many schools use blogs as a means of conveying information regarding events or of providing updates to parents. Parents can follow these blogs to monitor learner progression in terms of homework, work covered in the classroom and important test dates.

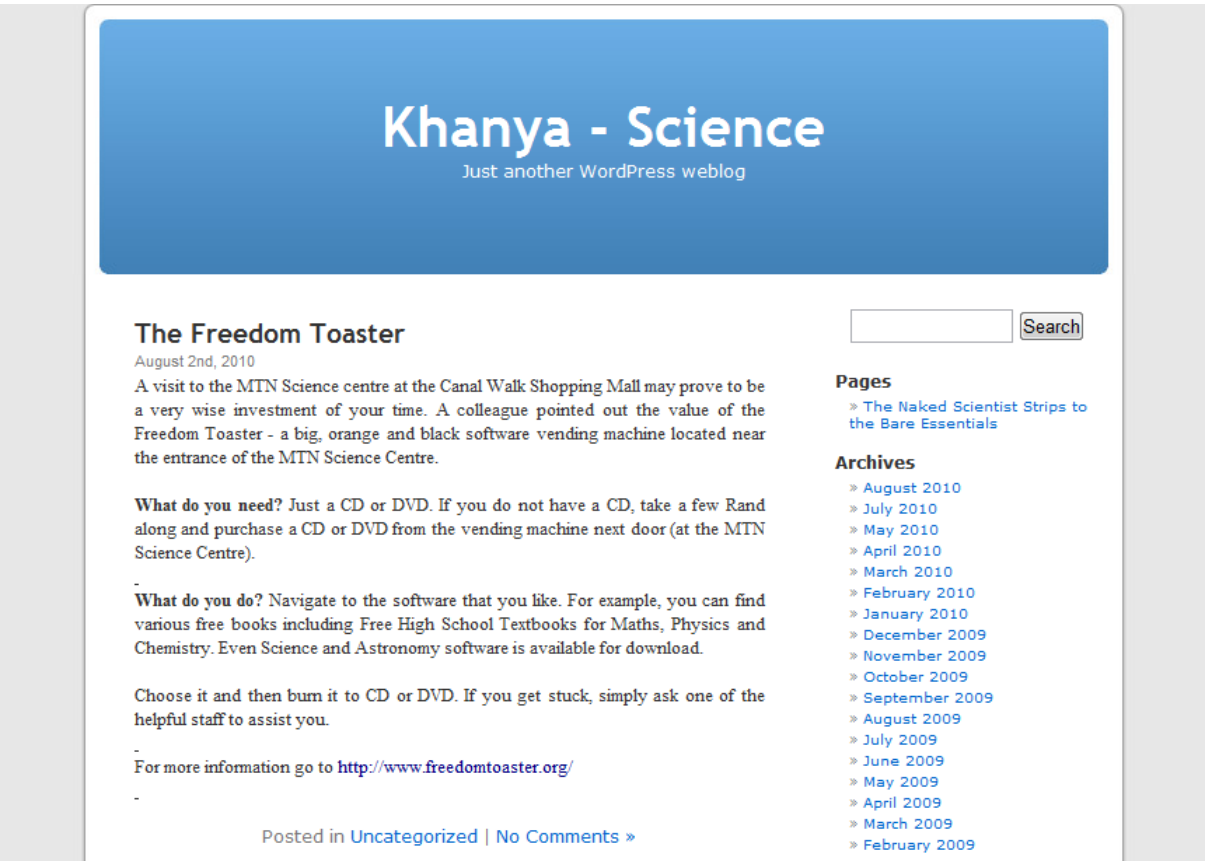

Figure 6: Edublogs are websites that are updated regularly with lots of resources in the form of commentary and media.

3.3.5 Simulation software

Simulation software offers a means to conduct 'virtual experiments'. School laboratories often are inadequately resourced to conduct experiments for the purpose of demonstration for learners. A key component of teaching physical and life sciences is experimentation and demonstration to investigate subject content. With desktop computers or laptops and data projectors, teachers can conduct virtual experiments to display these experiments to learners in a classroom. Simulation software such as Crocodile Clips allows learners to conduct experiments in the subject areas of physics and chemistry. Instead of setting up complex experiments that may be time consuming and not always practical to do in a particular time frame,

especially in the case of teachers often not having classrooms or sharing classes with other teachers, teachers can simply set up experiments beforehand as a means of demonstrating them to learners.[6] For example, if teachers were to teach a chapter on electrical circuits, instead of setting up a circuit board that just a few learners can view due to the small sizes of these circuit boards, they (teachers) can rather set up a virtual experiment with all the components that would be used to demonstrate how electrical circuits work. Pictures representing the components of an electrical circuit, such as cells, switches and bulbs to mention but a few, behave much like they would in an actual experiment. If a virtual circuit is set up in Crocodile Clips with components such as a switch, a cell and bulb, the bulb will glow if the switch is in the 'on' position. Chemistry simulations using Crocodile Clips behave in much the same way. If a virtual experiment is set up using certain reagents, these reagents will behave in much the same way as they would if one were actually to conduct the experiment. For learners, Crocodile Clips can be an important means to learn. This is particularly the case in relation to learners with lower literacy levels, for whom using pictures to show how circuits work, for example, is better than using scientific symbols for the components. This simulation software is easy to use and does not just allow learners to learn at their own pace. Learners obtain instant feedback whenever they put components together in the wrong manner. This software is a powerful tool for teachers as well as for learners.

[6] I am a teacher without a classroom and use this approach.

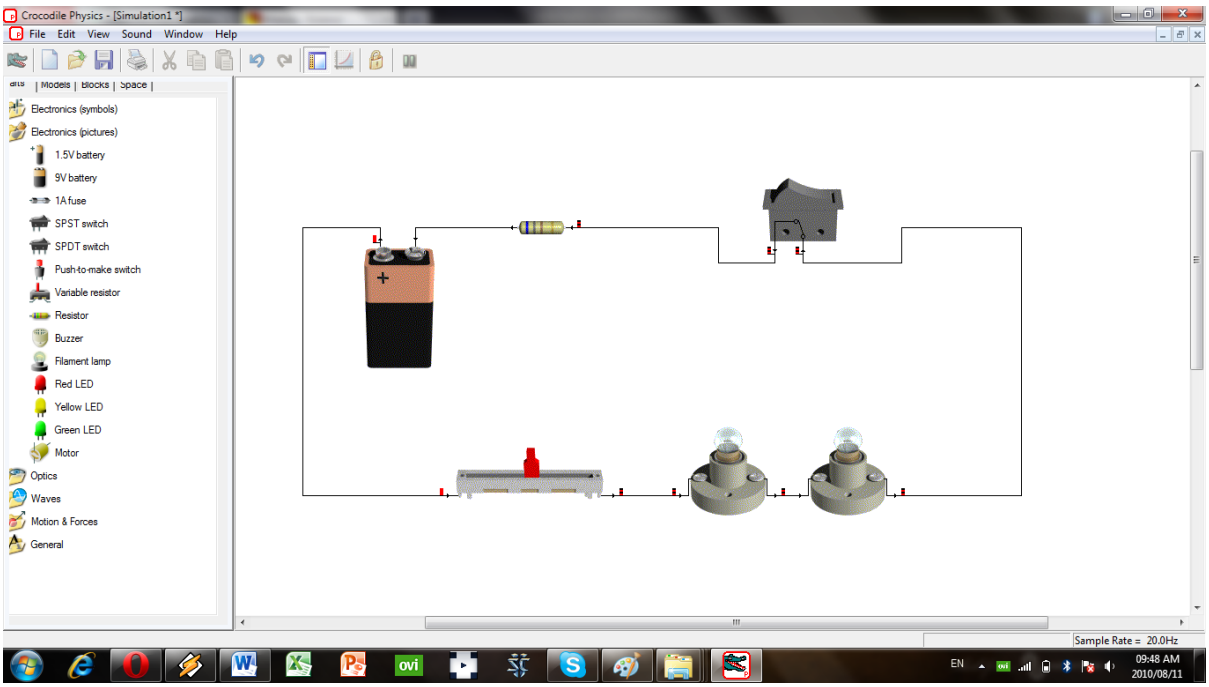

Figure 7: Simulation software such as Crocodile Clips allows learners to control the pace at which they are learning.

Now that I have explored the use of different educational technologies in the classroom (mostly based on my own encounters with these technologies), I shall proceed to a discussion of how critical teaching and learning can be fostered through the use of such technologies.

3.4 Cultivating Critical Teaching and Learning

The primary preoccupation of critical teaching and learning is with social justice and the democracy of social institutions, and the transformation of inequitable, undemocratic or oppressive institutions (Burbules & Berk, 1999: 39). Critical teaching and learning can help people in society who are seen as deficient in their ability to discern inaccuracies, distortions and falsehoods (Burbules & Berk, 1999: 39). Thus, being critical in education can help free learners to see the world for what it is, and therefore to act accordingly (Burbules & Berk, 1999: 39). Thinking critically alludes to

individuals perceptively identifying faulty arguments and generalisations lacking certainty (Burbules & Berk, 1999: 40). As I have mentioned, identifying these inaccuracies, distortions and falsehoods is but part of what critical teaching and learning can do. Critical teaching and learning is emancipatory in its actions (Burbules & Berk, 1999: 41). Having learners who possess the art of explicating, analysing and assessing one another's arguments in classrooms can only lead to improved learning. Critical teaching and learning in classroom practices will hopefully encourage learners to produce arguments that will be looked at by each on an evidentiary basis (Burbules & Berk, 1999: 43).

Technologies serve as a medium for the explication, analysis and assessment of arguments in and beyond the physical boundaries of the classroom. Therefore, with regard to critical teaching and learning, technologies provide a means for teachers and learners to occupy a space for 'communication, community building and the co-construction of knowledge' (Smeyers & Depaepe, 2007: 7). As was mentioned in Chapter 1, 'technologies' and 'networks' are terms that are sometimes used interchangeably (Smeyers & Depaepe, 2007: 4). There are different definitions for the word 'networks'. Traditionally, networks may be seen as entailing telephone networks or mail networks, also termed point-to-point networks. The definition of a network that I want to focus on is described by Burbules (2007: 43) as a space and place for collaboration. Technology and network, which are terms used interchangeably, can be used as a medium and space and place for collaboration for the promotion of critical teaching and learning. Moreover, technologies 'are interpreted in relation to a set of key principles including communication, transparency, knowledge, innovation, regulation, accountability, ownership, citizenship and power' (Smeyers & Depaepe, 2007: 5). I use technology as a practice

that offers a medium or ‘a path of point-to-point communication’, which provides a space where teachers and learners can spend time and collaborate on a shared project (Smeyers & Depaepe, 2007: 7). Technology is thus that medium which offers teachers and learners a space for ‘communication, community building and the co-construction of knowledge’ – a matter of enhancing their (teachers’) professional development (Smeyers & Depaepe, 2007: 7). In this study I want to discover the potential of applying technologies to enhance teacher professional development, that is, how my competence and expertise (skills) as an in-service teacher in a public school can be improved, and how I can better engender critical teaching and learning. Hopefully, I can show how the use of technologies can push my understanding of teaching and learning in the science classroom to unimagined possibilities.

With the advent of various technologies, networks can be described as virtual ‘places’ where people spend time, interact and work in collaboration (Burbules, 2007: 44). For example, with the MXit phenomenon, communication among individuals requires the individuals to be ‘online’. It is this ‘online’ space that represents a virtual ‘place’ enabling individuals to communicate. Moreover, online networked environments support community-building, communication and the sharing of resources (Burbules, 2007: 44). These environments offer spaces for communication, interaction, observation and opportunities to act on (Burbules 2007: 45). For example, blog sites and YouTube (as discussed earlier) are examples of network environments or spaces that provide teachers with vast resources for teaching and learning. On most of these educational websites, resources are not just merely added, as the nature of many of these sites is that there is collaboration and discussion among various professionals in the field of education on what is relevant

to be loaded onto these websites. Content on these websites is added in a critical manner. Therefore, these networks provide a space in which professionals in the field of education can learn from one another. This represents critical learning on the part of teachers, because the space enables them to engage with one another, sharing ideas on which to reflect and asking questions to improve particular understandings. In an online space, new ways of thinking come to the fore (Burbules, 2007: 46) – thus, corroborating the idea that the use of technologies engenders critical thinking. Scriven and Paul (in MacKnight, 2000: 38) view critical thinking as an 'intellectually disciplined process of actively and skillfully conceptualising, applying, analyzing, synthesizing, and / or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action'. Following MacKnight (2000: 38), it is a form of 'intellectual excellence required for full participation in the social, economic and political life of our society'. Learners who acquire critical thinking can exercise 'reasoned judgement', that is, they are capable of examining 'logical relationships among statements of data, construct arguments, respect diverse perspectives, view phenomena from different points of view, and have the flexibility to recast their thinking when reason leads them to do so' (MacKnight, 2000: 38).

Following such an understanding of critical thinking, MacKnight (2000: 39) argues that online communication, for instance, puts emphasis on learners' comprehension and knowledge of an argument and thus how to interact meaningfully with ideas and one another. The latter would invariably involve asking the right questions, listening to one another, sharing work, respecting one another's ideas, and constructing understandings in new ways (MacKnight, 2000: 39). What follows from the afore-mentioned is that critical thinking is possible through the use of educational

technologies – a view I support and find useful to develop in the next chapter. In addition, the creation of a technology-enriched classroom environment is said to have a positive influence on learners' critical thinking skills by establishing opportunities whereby learners construct knowledge rather than passively digesting information. As a result, collaborative interaction unfolds and more complex manipulations take place, rather than just the recall of facts (Hopson, Simms & Knezek, 2001: 110).

What makes these online virtual spaces places for community-building, communication and the sharing of resources is that they expand opportunities and efficacy for people occupying these spaces (Burbules, 2007: 51). Embodied experiences are often limited by disability, infirmity, illness, chronic pain, isolation and physical appearance that may lead to judgement by others (Burbules, 2007: 51). But in an online, virtual space, individuals are not limited by these limitations. In an online environment, individuals explore different identities and perspectives that they otherwise would not have explored in an everyday environment (Burbules, 2007: 52). How this relates to critical teaching and learning is that critical teaching and learning are characterised by discussion and argumentation towards emancipatory action. Therefore, if the use of these networks encourages teachers and learners to articulate provocative opinions just to see where a discussion will go, then it can only lead towards emancipatory action – that is, improving their thinking about and beyond the constraints of distorted situations. For example, learners would be better placed to understand and contribute towards solving real-life problems.

Thus far I have offered an account of the use of educational technologies and their links to critical teaching and learning. I shall now move to an exploration of my

research approach, before looking at the actual application of some of these technologies in Chapter 5, showing how they link to critical teaching and learning.

CHAPTER 4

RESEARCH DESIGN, METHODOLOGY AND METHOD

4.1 Introduction

In the previous chapter I gave an account of the educational technologies used in teaching and learning in classrooms. As further vindication of the appropriateness of using educational technologies in science classrooms, I shall firstly offer some thoughts on the research design of relevance to this thesis, focusing on the use of narratives. I shall thus extend my use of narrative inquiry in Chapter 1. Secondly, as has already been mentioned in the first chapter, this study is located within an interpretive paradigm, that is, I offer some clarification of the understandings, interpretations and explanations that underscore the use of educational technologies in my science classrooms. The primary aim of this research is to inquire, explain and justify, hence my attraction to interpretive inquiry. Thirdly, my production / construction of data (that is, my meaning-making process) is associated mostly with reflections based on my teaching of life sciences with the support of educational technologies. Put differently, reflective teaching would be discussed as a method of research in relation to the use of educational technologies in science classrooms.

4.2 Research Design: A Narratival Account

Drawing on the ideas of Durrheim (1999: 29), a ‘research design is a strategic framework for action that serves as a bridge between research questions and the execution of and implementation of the research’. If one considers that the research

question I want to address is whether the use of educational technologies in science classrooms can result in critical teaching and learning, then the question needs to be asked: What serves as the 'bridge' between the research question (and sub-questions) and the execution (that is, method) of the research? For me, that 'bridge' would be the narrative I am about to tell.

My motivation for using a narratival account as my research design is informed by the following dimensions: Firstly, to embark on some self-reflection, which either would or would not justify my use of educational technologies in the teaching of life sciences, and to discover whether using technologies would in fact enhance critical teaching and learning; secondly, use interpretive inquiry as a methodological paradigm; thirdly, school science classrooms provide the context in which the research unfolds; and fourthly, using the method of reflective teaching, which would assist in the construction of my data. The afore-mentioned dimensions of a strategic framework for action or research design would 'produce a coherent guide for action which will provide valid answers to the research question' (Durrheim, 1999: 33). What follows from the above is that my narratival account can be regarded as my research design, because it holds together four dimensions of the research I envisage to embark upon. These are, '1) the purpose of the research; 2) the theoretical paradigm informing the research; 3) the context or situation within which the research is carried out; and 4) the research techniques employed to collect and analyse data' (Durrheim, 1999: 33). In fact, my narratival account about the use of educational technologies in science classrooms would be informed by the purpose of this research, my methodology or theoretical framework (that is, interpretive inquiry), my method (reflective teaching), and the context of teaching life sciences in science classrooms in a local school.

Mouton (1996: 175) explains research design as ‘an exposition or plan of how the researcher plans to execute the research problem that has been formulated’. He states that the ‘objective of the research design is to plan, structure and execute the relevant project in such a way that the validity of the findings is maximised’ (Mouton, 1996: 175). What I shall attempt in the next chapter is to give a narratival account of the use of educational technologies in science classrooms, and then to reflect upon its implications for critical teaching and learning, and for professional development. To provide a narratival account as an instance of a research design is ably supported by Fay (1996: 197), who identifies narratival inquiry as follows: Firstly, to establish a coherent pattern of thought as a result of interpreting, arranging and making judgements of one’s constructed narratives (1996: 199); secondly, telling stories about the actions one has performed, that is, ‘enlivening’ one’s story (1996: 197). As has been stated previously, the story I intend to construct will be based on my interpretation and arrangement of and judgements on thoughts I had and actions I executed in using educational technologies in science classrooms. These stories or narratives will hopefully contribute towards addressing the question whether the use of educational technologies in teaching life sciences can lead to critical teaching and learning. In support of using narratival research, Hodgson (2009: 559) claims that this kind of research design ‘is often seen as a form of deconstruction that empowers the individual by allowing them to tell their own story; and it is not uncommon to find this accompanied by explicit discussion by the researcher of their own story and positionality in relation to their research participants’.

Other writers who have made an argument for the use of narratival accounts as research design include Griffiths (2003) and Chase (2005). Griffiths (2003: 1) argues that narratival inquiry ‘is a growing genre within educational research concerned

explicitly with social justice'. Chase (2005: 225) cites the establishment of the journal *Narrative Inquiry* as proof that narratival inquiry as a research design is a contemporary development in educational research. Narratival research, following Hodgson (2009: 561), illustrates one way in which poststructuralist thought has influenced educational research 'by displacing assumptions of how an academic text should be structured and of the authority of the author over the reader and research subject'.

In support of the afore-mentioned explanations of narrative research design, Bloom (2002: 310) states that the latter is 'a strand of qualitative research (that) focuses on the self for data collection and data analysis'. For her, narrative research is 'concerned with using narratives of the self as a location from which the researcher can generate social critique and advocacy (and that narrative research) … is concerned with deconstructing the self as a humanist conception' (Bloom, 2002: 310). This brings me to a discussion of the research methodology that I will use in this thesis.

4.3 Methodology: Interpretive Inquiry

The very art of writing a narrative has to be informed by forms of explanation, understanding and judgement. This view is echoed by Bridges (1999: 222), who connects narrative inquiry with the methodological imperative of interpretation. He identifies four intertwined dimensions that make up narrative inquiry and connect the latter with the methodology of interpretive inquiry: firstly, writing a story of one's professional life, in this instance about my teaching practice in science classrooms, requires that I contextualise and reflect upon my actions as a science teacher using

educational technologies in my teaching; secondly, one develops a more communicative mode of conveying a perspective about one's professional practice, in this instance my life sciences teaching; thirdly, one focuses on a literary activity based on real and imagined action, that is, what I observed and creatively thought about in relation to the application of certain technologies in my science classrooms; and fourthly, communicating and justifying one's reasons through the written text, that is, responding to my methodological concern, namely interpretive inquiry.

As my research is located within an interpretive paradigm, the basis for understanding my actions as a science teacher and my relationships with learners in using technologies in my teaching is explanation. Pring (2000: 67) makes the claim that interpretive inquiry is built on the social practice of explaining human actions. In his words, 'to explain human behavior requires not only reference to the intentions of the person acting (as though these were within a purely private and subjective world), but also reference to the social rules and practices within which those intentional actions take place and make sense' (Pring, 2000: 67). Two things emerge from the afore-mentioned understanding of interpretive inquiry: firstly, one has to explain and justify one's actions, in this instance, my use of educational technologies has to be explained and justified in relation to the teaching of life sciences; and secondly, one has to give an account of how others (that is, my learners) interpret one's activities (that is, my science lessons) and to understand the purposes behind them (regard to my use of educational technologies in my teaching). What follows from this is that interpretive inquiry involves understanding 'meaningful social action' (Benton & Craib, 2001: 79). And here, 'meaningful' implies the reasons behind particular actions in pursuing practical purposes in the world (Benton & Craib, 2001: 90).

Of relevance to my research is an understanding of the reasons that prompted me to use educational technologies in my teaching and, in turn, an explanation of the reasons why I have found the use of technologies to be encouraging in critical teaching and learning. Hence, the purpose of interpretive inquiry as my methodological tool when I offer a narratival account of my teaching practice 'is to understand the meanings that people [learners and I] give to their social world (that is, the science classroom)' (Benton & Craib, 2001: 95). Small wonder, Smeyers (2002: 192) considers one of the tasks of educational research to be 'interpretation'.

I now move on to a discussion of reflective teaching as my technique or method of doing educational research.

4.4 Method: Reflective Teaching

As has been argued earlier, I am attracted to the narrative research genre, in which reflection is integral to the approach. As Masschelein (2004: 355) argued:

> ... self-reflective, autonomous life has become the core of any educational theory and been declared as being the general social programme … Autonomy, self-determination, critique, *self-reflection*, independency, are meanwhile expected from all and have become an 'absolute necessity' in order to 'survive' not only for society, but also for every enterprise, institution, organization and so on. (my italics)

My research uses the method of reflection in the form of telling my story by using my own educational experiences to improve my teaching in science classrooms,

particularly through the application of educational technologies. This method of reflective teaching seeks, in some way, to engage my pedagogical practices 'beyond the technical and managerial' (Hodgson, 2009: 565).

As a reflective teacher I tell my story of how using educational technologies enhances critical teaching and learning in science classrooms. This view finds support in the work of Singh (1996: 349), who claims that 'reflective practice is a strategy (method) used by teachers, in cooperation with others, to question their taken-for-granted assumptions so as to improve their teaching and their students' learning'. Reflective teaching practice takes into consideration the following aspects: Firstly, that one becomes aware of what one is doing and aware that what one does influences how learners learn; secondly, that one's actions arise out of one's engagement with the educational context in which one happens to find oneself; thirdly, one's actions serve human interests, that is, one 'is guided by an interest in control and problem-solving, an interest in shared understanding, or the desire to free themselves and their students from the dictates of unquestioned habits and self-deception' (Singh, 1996: 350); fourthly, one reflects on how one's thinking affect learners and their education; and fifthly, it potentially changes a teacher's self-understandings and can in fact transform one's 'experiences into new understandings, commitments and actions' (Singh, 1996: 350). Hence, self-awareness, engagement with context, a problem-solving and sharing interest, impact on learners, and transformation of understanding make up the features that determine a reflective practice. It is this method of educational research that I hope to employ as I seek to determine the impact of technology-assisted teaching on the learning of learners in science classrooms. In essence, embarking on a reflective practice could expand my knowledge base as a teacher in order to improve my

teaching, professionalism, and work situation (Singh, 1996: 352). Drawing on the three levels of reflective practice expounded on in Chapter 2, I wish to focus on my own reflective practice along the lines, firstly, of personal experiences in and about educational technologies and their uses in science classrooms; secondly, to situate my application of educational technologies in relation to science teaching and learning within existing theories of the use of educational technologies in science pedagogy; and thirdly, to reflect critically about the uses of educational technologies and their possible implications for critical teaching and learning. My emphasis on reflective teaching is further supported by Van Manen's (1995: 36) observation that novice teachers (like I) are often well-prepared, have acquired excellent subject matter expertise, have successfully studied theories about learning, have developed critical understanding of philosophical, political and professional educational issues, and upon entering the classroom have introduced the learners to innovative lessons, yet, as he states, 'in spite of this excellent preparation, great frustration is encountered: now facing the students, the new teacher finds, to his or her disillusionment, that all this planning still falls short of what is required by the classroom reality' (Van Manen, 1995: 37). I agree with him that 'the hard-won knowledge base of subject matter, teaching skills, educational theories, and curriculum programs still does not live up to the demands of the pedagogical life in the classroom' (Van Manen, 1995: 36). For this reason I am deeply attracted to reflective teaching in order to respond to the realities in the classroom, such as learner inactivity, restlessness, disinterest, and the flaws of transmission teaching.

4.5 Summary

Having explained my research design (narratival inquiry), methodology (interpretive inquiry) and method (reflective teaching practice), I need to say something about a key issue in educational research traditions, namely generalisability. The issue of the extent to which one's research findings ought to be made generalisable is not in itself

> … an eternal and unquestionable verity (but rather) … the product of historical factors that characterize the period we have come to think of as modernity, including the increasing popularity of measurement as a technology for governing society, and including too the strange shift in which statistics changed its meaning from knowledge of statecraft to the application of mathematical formulae to the understanding of human society. Thus wonderfully, it is not itself universally generalisable (Bridges & Smith, 2007: 7).

Like Bridges and Smith (2007), I do not consider my research as a generalisable study, but rather an assertion of my voice that narrates some of the reasons that guide my teaching practice as I use educational technologies to improve teaching and learning in science classrooms. In fact, giving my narratival account is a means of expressing me, knowing that what I have done in my science classrooms hopefully has value, because through the use of technologies I have made my presence felt – this is to have a voice. In a way I want to give an account of the importance of conviviality (that is, understanding my learners as fellow human beings), reciprocity (that is mutual exchanges between my learners and I), and communicative relationships in progress that are far more meaningful to the validation of my research (Griffiths, 2003: 85-87) than to be concerned solely about generalisability.

CHAPTER 5

NARRATIVAL ACCOUNT OF THE USE OF VARIOUS TECHNOLOGIES IN A SCIENCE CLASSROOM

5.1 History of South Peninsula High School and the Emergence of Technology Education

My narrative account focuses primarily on the school where I am currently employed, namely South Peninsula High. It is a previously disadvantaged school with a rich history that has become a prestigious school and can be seen as influential in attracting learners from previously disadvantaged communities. The school is located in the southern suburbs of Cape Town in the Western Cape province of South Africa. South Peninsula High initially served as a school for the children of farm labourers in the Constantia area whose parents had been displaced by the Group Areas Act. These parents continue to support the school in its endeavour to promote academic excellence (http://www.khanya.co.za/news/). At the time of writing this thesis, the school had 1 089 learners, giving it a 19:1 learner to teacher ratio.

With regard to how technology education began at South Peninsula High School (SPHS), it can be said that the school was selected by the Western Cape Education Department to be one of 11 pilot schools to participate in a *Khanya* Mathematics Project. Through this *Khanya* project and its partner, the DG Murray Trust, it is envisaged that the performance of learners taking mathematics and science can be improved through the use of ICTs (information and communication technologies) (http://www.khanya.co.za/news/). Thus, through *Khanya* a new dimension has

opened for mathematics education to be improved through the integration of ICTs into the mathematics curriculum at SPHS. The school now has an increased mathematics enrolment and, in addition, the introduction of computers has aided teachers in the implementation of the curriculum, as well as in their own computer literacy, and hence in their own professional development (http://www.khanya.co.za/news/).

Through the efforts of the science teachers at SPHS, the school has received funding for ICTs and assistance from an organisation called TRAC (Transportation and Civil Engineering). TRAC is a national, non-profit programme aimed at supporting science and technology education in South African secondary schools (http://trac.sun.ac.za/trac_background.htm). TRAC aims to enable learners to enter careers in science, technology and engineering. They have assisted SPHS to ensure that its learners can enter these career paths by providing equipment such as computers and data loggers, syllabus content, vocational guidance information, and a variety of other material (http://trac.sun.ac.za/trac_background.htm). Through *Khanya* the school also forms part of a pilot project in which data loggers are used to conduct experiments in physical science. These data loggers are used to collect and analyse data to encourage more learners to do science (http://www.khanya.co.za/news/).

SPHS also is part of the *Dinaledi* schools project run by the Department of Education. This project is aimed at increasing access to mathematics and science by learners. The aim of the project is not only to improve mathematics and science results, but also to increase the competence levels of teachers who teach these subjects. Through *Dinaledi*, SPHS has received funds from the Optima Trust, which

is funded by Anglo American in support of the initiative. The Optima Trust has a yearly disbursement of R40 million towards improving mathematics and science education in *Dinaledi* schools. The school has received funds from this trust to improve mathematics and science in the school. These funds may be used for learner bursaries, resources in the form of ICTs, or to employ additional teachers to improve mathematics and science results. It was agreed by many of the staff members of SPHS that the best way to improve the educational resources of the school was to improve mathematics and science teaching and learning in the classroom. Subsequently, the school used some of these funds to purchase ICTs such data projectors, white boards, laptops and desktop computers.

SPHS also has an arts and culture focus. Consequently, it was able to benefit from a pilot project of the Western Cape Education Department (WCED) and Apple Computers in February 2008, which resulted in the installation of Apple technologies in the school that will be used by the learners and teachers for music production and composition (http://www.khanya.co.za/news/). In addition, other ICT resources have been donated to the school by ex-students, as well as by teachers and learners writing to various trusts or companies asking whether they would provide sponsorship in the form of ICT resources for the school.

However, if not used correctly, all this technology in the classroom would result in the classroom with all these technologies becoming a ‘white elephant’. *Khanya* has ensured that their investments in the form of resources to SPHS are used effectively. They do this by employing training coordinators which visit the school regularly. These training coordinators offer workshops to teachers on how to integrate the various educational technologies effectively into their existing classroom practices.

Another teacher and I have it taken upon ourselves to provide teachers with some basic ICT competences in staff development activities on an extramural basis. During these training sessions, we go through things such as how to connect a laptop to a data projector, how to play DVDs, how to scan documents or pictures, and how to use Google as an educational resource.

The Western Cape Education Department (WCED) also arranges training opportunities for teachers. Some teachers and I have been invited to workshops, such as *Thinkquest*. Workshops conducted by this organisation are aimed at supporting teachers to assist learners in constructing websites so that they might be inspired to think, connect, create, and share information (http://www.thinkquest.org.za/). Students work in teams to build innovative and educational websites to share with the world (http://www.thinkquest.org.za/).

Staff development activities at SPHS with regard to the use of ICTs were offered through seminars and training workshops conducted by organisations such as *e-Learning Schools*. Ongoing presentations are run with regard to introducing new technologies to teachers and to holding discussions about the importance of connecting ICTs to teaching and learning. It is thus an opportunity for networking with other teachers and discussing real issues associated with introducing ICTs into lessons, as well as using ICTs as an effective teaching tool. During these sessions, speakers often inspire staff through narrating stories of success and determination, and of ways to overcome the many hurdles of going through the transition of integrating ICTs into the classroom and curriculum. The workshops offer a hands-on approach to the use of ICTs, thus equipping teachers with practical ideas and skills about the possible uses of ICTs (www.conf2010.school.co.za).

What the afore-mentioned discussion indicates is that SPHS's teachers are favourably placed to use educational technologies in their teaching and to inspire learners to use them. It is in this environment that I began to use my technological competence to contribute towards enhancing teaching and learning in the life sciences.

5.2 Life Sciences, Educators, Learners and Educational Technologies

I am one of three life sciences teachers at SPHS. The subject (life sciences) is taught to learners from grades 10 to 12. The life sciences department has a rich history of successful results, obtaining a hundred percent pass in grade 12 in 2009, for example. Content taught in the life sciences varies according to year and complexity, and is offered in various fields of the natural sciences, such as biodiversity, genetics and evolution, to mention but a few. There are about 400 learners on average doing life sciences at the school every year. I am responsible for teaching all the grades in which life sciences is offered – that is, grades 10 to 12. The teachers in the life sciences department have a wealth of experience spanning over 20 years. As a relatively new teacher, I have been mentored by these teachers and have learned a lot from them.[7] Despite their wealth of experience, these teachers are not very proficient in the use of educational technologies to enhance their pedagogical practices. Relationships between my colleagues and I are two-directional, with the result that I can share my expertise in educational technologies with them.

Since the school has received a wealth of resources in the form of ICTs I have taken it upon myself to advise my senior colleagues on how the use of various educational

[7] I also schooled at SPHS and was taught by these two teachers.

technologies can be implemented into their existing teaching practices. For example, these teachers have been teaching certain aspects of the human heart for many of years using an overhead projector (OHP), where the OHP is used to project a static picture of the human heart. From this diagram the teacher would demonstrate to learners through which areas of the heart the blood will pass in sequence. What I have suggested to them is using a flash animation on a computer and projecting an animation that is able to better convey to the learners the pathway of blood through the human heart. A further suggestion to use YouTube to show the learners actual open-heart surgery has added a new dimension to teaching and learning in comparison to the more traditional approach to teaching that they have utilised for many years. These colleagues have shown a willingness to want to learn about how their existing teaching practices can be augmented with the use of technologies. The teachers have now also taken it upon themselves to improve their teaching and learning through the application of technologies. In matric, for example, there is a relatively short window in which to finish the curriculum when one looks at the content to be covered. The life sciences teachers at SPHS have come to the realisation that they can cover a larger amount of work in a shorter period of time through the use of technologies. This is another reason why they have seemed to embrace the use of educational technologies in their teaching practices. An observation I have made through working with these teachers is that they tend to use only certain technologies. Teachers therefore will only use technology if it will improve their teaching. My colleagues often resent using technologies that are difficult to set up prior to lessons.

Implementing educational technologies in the classroom and using these technologies to support learners' learning takes some planning. Certain technologies,

such as Google, can be used instantly to reach a desired outcome. For example, I have encountered many instances in which learners have asked questions that might be related to the work I am teaching, or not, that I am unable to answer. I then use Google to search instantly for an answer to the learners' questions or to search for images by simply using my own mobile device or allowing learners to use their mobile devices to access Google – that is, a matter of establishing conditions for greater learner participation and empowerment. For instance, YouTube is a technology that can provide instant answers to learners' enquiries. By using these technologies there does not seem to be a break in the chain of thought. By this I mean that if I did not use this technology (YouTube) and had told the learners that I would do some research and come back to them at a later time, it would be a break in the learners' chain of thought and even in their interest. I have found that, by using these technologies, the learners' responses have been really positive, as they were not spectators to the learning process but were actually participants and had a joint interest in learning life sciences.

5.3 Reflecting on My Use of Educational Technologies in Teaching Life Sciences

As has been mentioned earlier, I have always had an interest in ICTs. Whether it was for entertainment activities, varying from playing games and watching movies, to surfing the Internet to read up on interesting activities happening around the world, or for social networking such as through YouTube and Facebook, I was always triggered by the application of ICTs. At first glance it might appear as if technologies such as those discussed in Chapter 3 are confined only to fun and play, and that their use might be unrelated to learning. However, through my interest and understanding

of these technologies I wondered and realised how these technologies could be used to augment teaching and learning, and specifically how they could have an impact on critical teaching and learning in the life sciences. Most of these technologies that I have mentioned previously (in Chapter 3) do not actually require extensive learning and, as I have already mentioned before, technologies that are easy to use are attractive. Hence, my affinity for their practical application with learners in science classrooms has been enhanced.

I teach different grades (grades 8, 9, 10, 11 and 12) and my approach to teaching these grades is the same. I use technologies as a resource or tool as much as possible. Not only has the use of technologies improved the effectiveness of how I am able to share content with the learners, but it has also saved me time in preparing work, whether for lessons or the completion of examination papers. The first time I actually used technologies in my teaching was when I was asked to prepare a life sciences examination paper. A colleague recommended that I use an interactive CD called *Focus Exambank*. This program allows a user to set up an examination paper using questions from an existing database. All I needed to do was simply to tick off out of how many marks and which questions from the database I would like to have included in the question paper. In a nutshell, the examination paper would be completed for me, with a corresponding memorandum. For me this was a fantastic technological innovation that helped me and gave me a framework for setting up examination question papers and, as an inexperienced teacher, it aided me tremendously. This brings me to a discussion of my first narrative on using educational technologies to engender critical teaching and learning.

5.3.1 Narrative 1- An Interactive Lesson

Part of my school being involved with *Khanya* is that teachers are required to attend workshops on the use of educational technologies and how these technologies can be used to support teaching and learning. This is done to ensure that the technological investments made in the school are actually used to the benefit of both teachers and learners. Mostly, the use of technologies has been encouraged by *Khanya* to nurture the professional development of teachers. In my first year of teaching, a *Khanya* science training coordinator presented a workshop on the various capabilities of Smart Boards for teaching, as well as their basic application. After this workshop I was asked by the *Khanya* science training coordinator who presented the workshop if he could sit in on one of my classes to observe how I would integrate the Smart Board into one of my life sciences lessons. I agreed to allow him into my classroom to observe my teaching. The lesson was for a grade 10 life sciences class and it focused on the content of the digestive system. In preparation for the lesson I used Google to search for flash animations that I felt worked innovatively with the interactive nature of Smart Boards. I then presented my interactive lesson to the learners with the aid of the Smart Board. The learners were required to give verbal vocal inputs with regard to what I had to select on the animation using the touch inputs of the Smart Board. After my initial demonstration of the flash animation to the learners, they took a keen interest in using the Smart Board, controlling the flash animation by using the touch input of the Smart Board. The learners were thus involved actively and were not just merely spectators. For me, this was a poignant moment in acquiring more learner interest in the life sciences lesson, as well as having encouraged active learner participation (which I actually managed to get right) through the use of the Smart Board technology. Besides participating actively, the

learners articulated their judgements about the ways they understood the content they encountered.

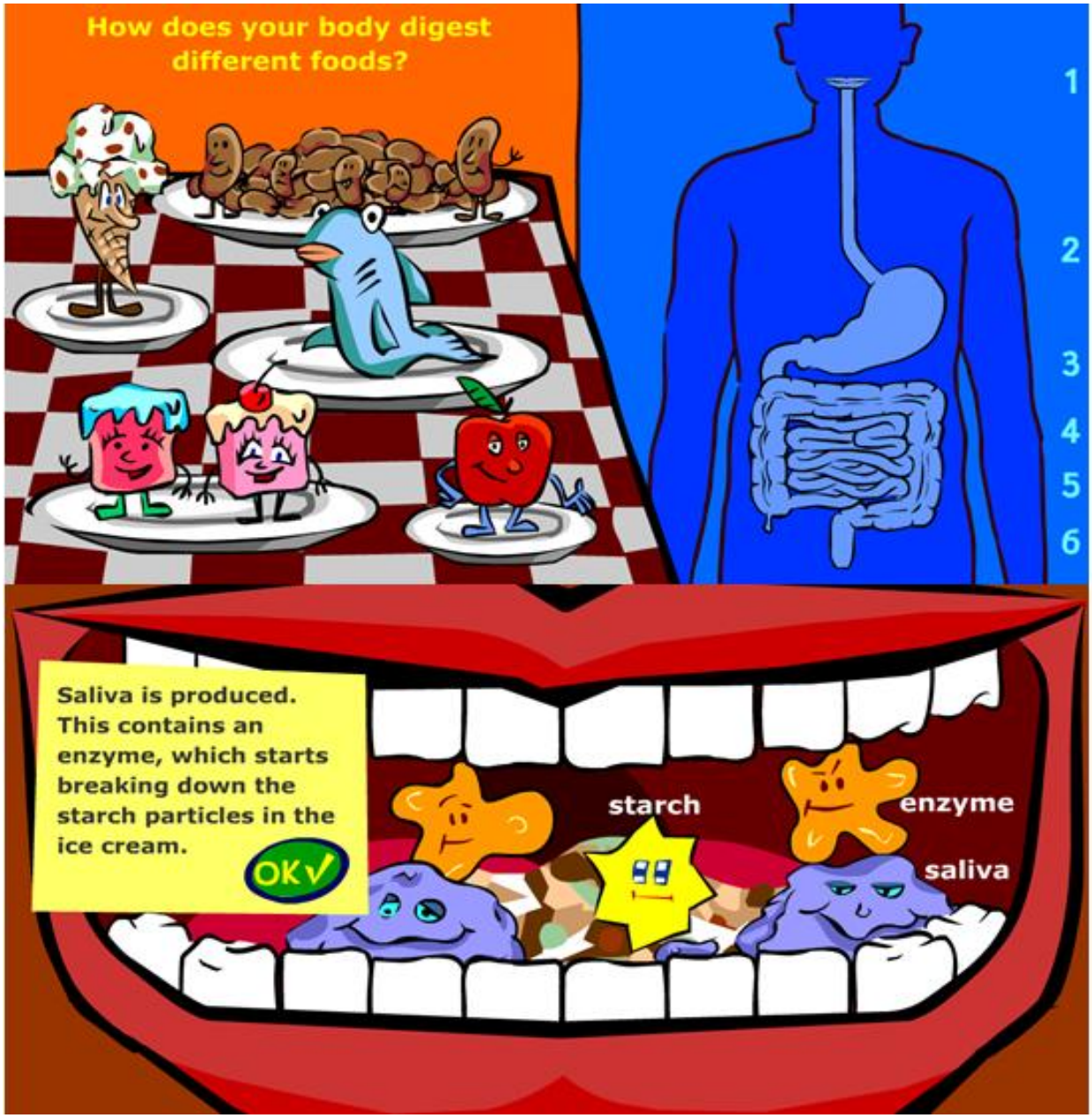

Figure 8: The interactive flash animation that was used. This flash animation was controlled through the touch inputs of the Smart Board. The animation was well received by the learners. It was quite easy to follow and the learners enjoyed being able to control a television cartoon.

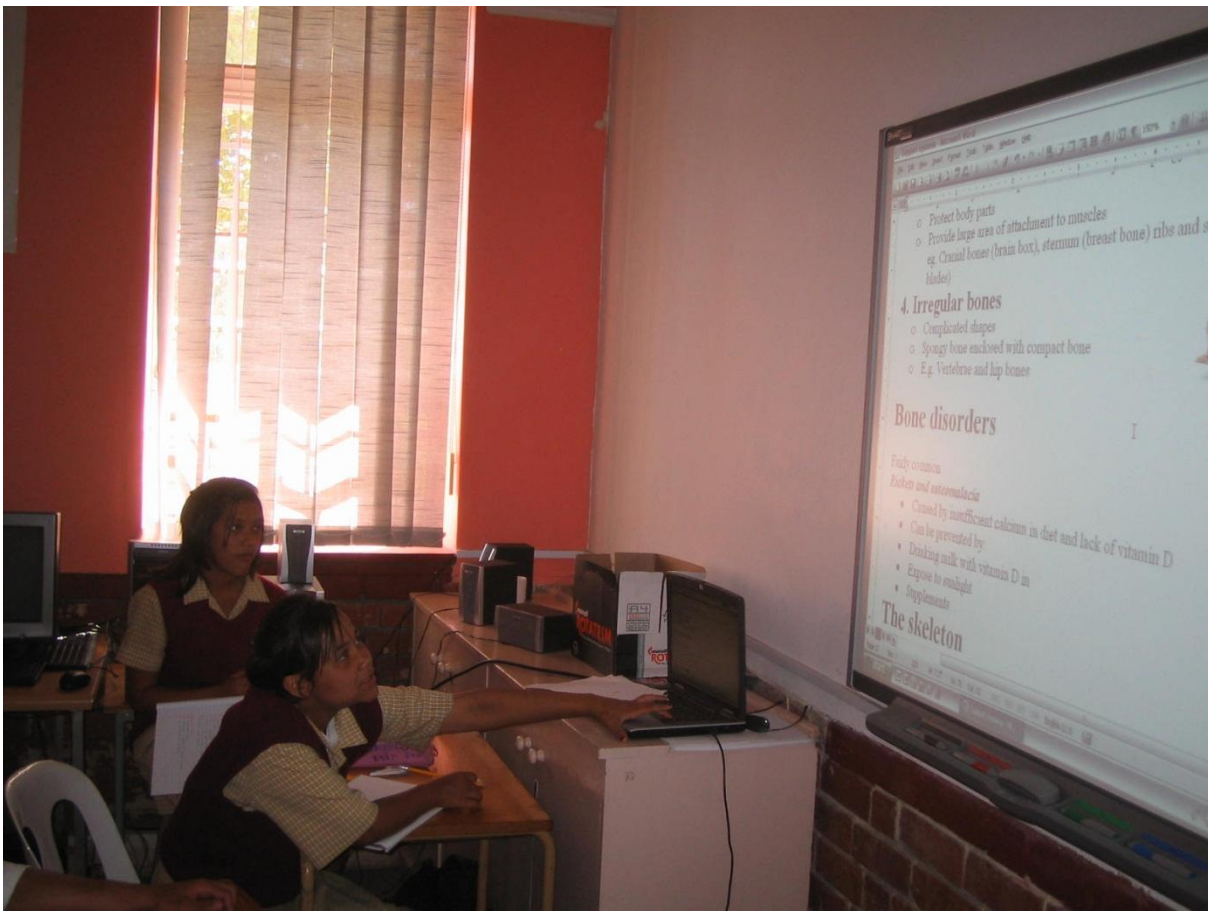

Figure 9: Grade 10 learners who participated in the interactive lesson using the Smart Board.

After the lesson had been presented and observations made by the *Khanya* science teaching coordinator, a review article was posted on *Khanya's* website and Science blog. The article focused primarily on the success of the lesson through the use of educational technology and the positive responses of the learners as assessed by the training coordinator. The training coordinator was very impressed with how ICTs were used to teach a section of the curriculum in an innovative way. The lesson review is shown below and suggests that science learning and teaching can be imaginative, as is evident from the assessment of the independent *Khanya* coordinator.

Figure 10: The review of the grade 10 life sciences lesson as posted on *Khanya's* website and interactive blog.

What can be inferred from the afore-mentioned seems to be in line with the theoretical view that emerging educational technologies hold the key to improving knowledge transmission and teacher quality (Gimbert & Cristol, 2004: 207). The active engagement of learners through using the Smart Board (on the basis of individual manipulation and control) is theoretically linked to gaining experience, interpreting ideas, and encouraging interaction amongst learners, as aptly stated by

Jeremy (2000: 77). To my mind, the learners were not passive both to what they learnt in the classroom and how what they learnt connects with situations outside of the classroom. This observation by both the *Khanya* coordinator and myself finds synergy in the thoughts of Jeremy (2000: 77), who claims that, by using an appropriate technology, one can ensure that learners are not just merely passive participants, but that they are actively involved in an interactive technologically-aided lesson. With reference to the article listed as Figure 10, the observation made by the *Khanya* science teaching coordinator is that, through the use of the appropriate technology, active engagement can occur among learners and teachers. The *Khanya* science teaching coordinator observed the learners' responses to the lesson as engaging and participatory – an idea supported by the literature that says that using educational technologies competently can enhance active learner participation. Thus, it can be argued that the use of educational technologies does not only make learners wonder with amazement, but also promotes active learning. And, when active learning occurs is this way, learning can be said to be critical.

In Chapter 3 I have argued that Gimbert and Cristol (2004: 207) suggest that the use of technology in the classroom affords learners an opportunity for socialisation and language development. This was achieved in the interactive lesson. Learners were actively communicating with other learners who were in front of the classroom what they wanted the learners to select. Simultaneously, using the Smart Board technology served as a medium for socialisation, that is the learners were initiated into the content with the aim of making them think on a higher cognitive level and to offer responses that reflect their connection of what has been learned to the social issues that confront them. Put differently, and as noted by Gimbert and Cristol (2004: 208), the learners (through the use of educational technology) have been

encouraged to use their imagination and to explore at their own pace. The flash animation used in this interactive lesson is dependent on inputs by the user. Therefore the user can control the pace of learning – a practice that connects with critical learning.

And, as noted by Gimbert and Cristol (2004: 208), the learners' concentration span was increased. This was observed by the *Khanya* science teaching coordinator. In the article listed as Figure 10, the *Khanya* science teaching coordinator observed that the learners paid more attention as it was them who were driving lesson. This indicates that the attention span of the learners is enhanced and more time is given to learners to offer their reasonable interpretation of the content matter they have been socialised with – an idea that is in line with what Gimbert and Cristol (2004: 208) propose. Moreover, the use of the flash animation in the interactive lesson gave learners the opportunity for frequent interaction and feedback. Through their inputs, the learners received instant descriptive feedback from the animation. For example, when the learners selected the mouth of the flash animation, seen in Figure 8, it gave feedback in the form of a description telling them the function of the mouth. The learners used this animation to test themselves and subsequently received instantaneous feedback whereby they could judge matters for themselves, thus utilising their critical thinking, as stated by Bailin and Siegel (2003).

In essence, what this narrative foregrounds about critical learning is that the learners not only participate actively when educational technologies were used, but also took responsibility for their own learning. They also engaged powerfully with new ideas and experimented in a creative manner as they embarked on problem solving and critical thinking. They acted as autonomous beings who reflected on their learning at

their own pace. In these ways, they have been active critical learners – an idea that finds support in the work of Pearson and Somekh (2006).

The question arises: What have I learnt from using the Smart Board and how was my own professional development enhanced? I have learnt to become pedagogically tactful. As a novice teacher I could see what goes on with the learners and understand their experiences, that is, sensing what Van Manen (1995: 46) refers to as 'the pedagogical significance of the situation, to know how and what to do, and to actually do something right'. I instantaneously sensed that the learners enjoyed using the mouse and bringing about changes through their manipulations, which they could witness on the Smart Board. Following Van Manen (1995: 46), 'a teacher who is tactful has the sensitive ability to interpret inner thoughts, understandings, feelings, and desires of children from indirect clues such as gestures, demeanor, expression, and body language … (and) the ability to immediately see through motives or cause and effect relations. A good teacher is able to read, as it were, the inner life of the young person'. There were certainly moments when I knew how to interpret, for example, 'the deeper significance of shyness, frustration, interest, difficulty, tenderness, humor, discipline' with the learners as they worked with the Smart Board. Furthermore, I could quite naturally and spontaneously bridge the link between theory and practice. For instance, applying theoretical knowledge to solve a practical problem, such as illustrating to the learners how excess acidity in the stomach can be neutralised. In essence, I have learnt that practical knowledge of teaching resides in the things that surround us: the physical dimensions of the classroom, the learners, and the educational technologies that we used so efficiently in relation to science education. I realised that my practical knowledge is constituted by 'my felt sense of the classroom, my feeling who I am as teacher, my felt understanding of my students

(learners), my felt grasp of the things that I teach, the mood that belongs to my world at school, the hallways, the staffroom, and off course this (my) classroom' (Van Manene, 1999: 47).

5.3.2 Narrative 2 – A Research Project

In 2008 I attended teacher professional development workshops hosted by the South African National Botanical Institute (SANBI). Out of these workshops emerged a three-year project (2008 to 2010) representing a partnership between three organisations: SANBI (The South African National Biodiversity Institute), situated at The Gold Fields Environmental Education Centre in the Kirstenbosch National Botanical Gardens, the Botanical Society of South Africa (BotSoc), and the Western Cape Education Department (WCED). These workshops were hosted as in- and outreach initiatives to help teachers to teach environmental education through a scientific enquiry process of reflection and action. The workshops were linked to the BotSoc-funded 'Biodiversity, Sustainable Development and Climate Change in the Further Education and Training' project. The aim of this project was to assist teachers in identifying various opportunities for environmental education within the National Curriculum Statement; to build teachers' knowledge around certain topics and their capacity to conduct environmental education lessons relating to their local context; to develop communities of teachers; and to build support structures that allow them to become critically reflexive environmental education practitioners (http://www.sanbi.co.za). The teachers were given a course on what biodiversity is and how it relates to the curriculum and learners' everyday lives. They were also guided through the scientific enquiry process and how this process can be taught effectively. In using the scientific enquiry process, the teachers were initiated into

using the ‘Active Learning Framework’. The framework serves as a guideline for teachers to follow so as to allow learners to adhere to the pedagogical procedures of a scientific enquiry as they embark on research projects.

I was inspired by the ‘Active Learning Framework’ and the idea of using it in an eclectic way. I contemplated how this framework would augment my existing teaching pedagogy, which involves the use of educational technologies. I started off using the most appropriate technology during the suggested phases of the ‘Active Learning Framework’. The framework is a method that teachers can follow to help them in their application of scientific inquiry in classrooms. It consists of various interrelated phases. These phases include, firstly, that learners undergo a process of gathering information, reporting ideas, seeking and creating enquiry encounters, and some form of taking action.

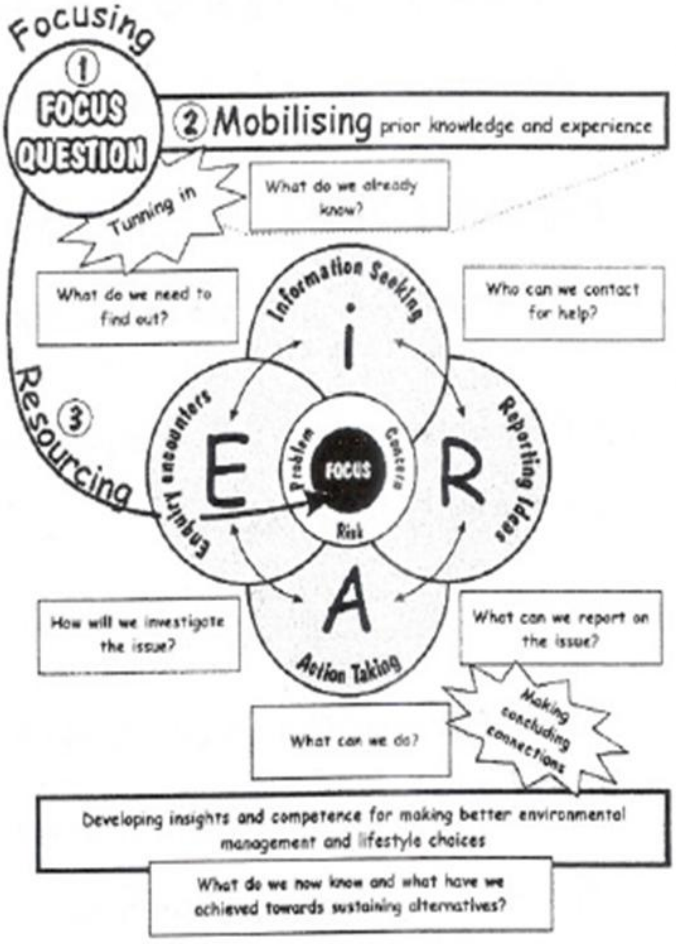

Figure 11: The Active Learning Framework (ALF), with its interrelated phases.

The research project that I embarked on involved using the ALF with a group of grade 10 learners. The learners were asked to investigate water pollution in a nearby wetland area called Zeekoevlei. This wetland consists of two water masses. The one water mass is in a nature reserve called Rondevlei, and the other water mass is influenced by a residential impact, called Zeekoevlei. The learners were to investigate which of these two water masses were more polluted and how the biodiversity was affected due to the pollution that may exist. Their hypothesis was that the water mass that was impacted by the residents would be more polluted and that the biodiversity would be affected due to this pollution. The learners could collect data that would verify their hypothesis for the investigation.

Figure 12: A snapshot of the wetland area using Google Earth. The large water mass on the right is under the influence of a residential impact. The smaller water mass on the left is in a nature reserve that is fenced off from residents in the area. It was hypothesised that the smaller water mass would be much less polluted than the larger water mass on the right handside.

The rationale for doing this study in the Zeekoevlei wetland area was due to the fact that most of SPHS's learners come from the area and that it would be of relevance to them if they conducted this scientific investigation in the area in which they reside. Before the learners went to the actual study site, the first phase of the ALF was followed, namely creating information-seeking opportunities. The learners had no background about what a wetland is and its role in the environment. During this initial stage of the information-seeking opportunity, educational technologies such as Wikipedia, Google and Google Earth were used. The learners were given an opportunity to use the Internet as a resource to determine what a wetland is and to discover the importance of wetlands. The school's library is inadequately resourced, so it would not have been possible for them to use it to determine what a wetland is. Some learners even used Google mobile, which is the search engine designed to work on a mobile device. Google was thus the perfect software tool to ensure that an information-seeking opportunity was created.

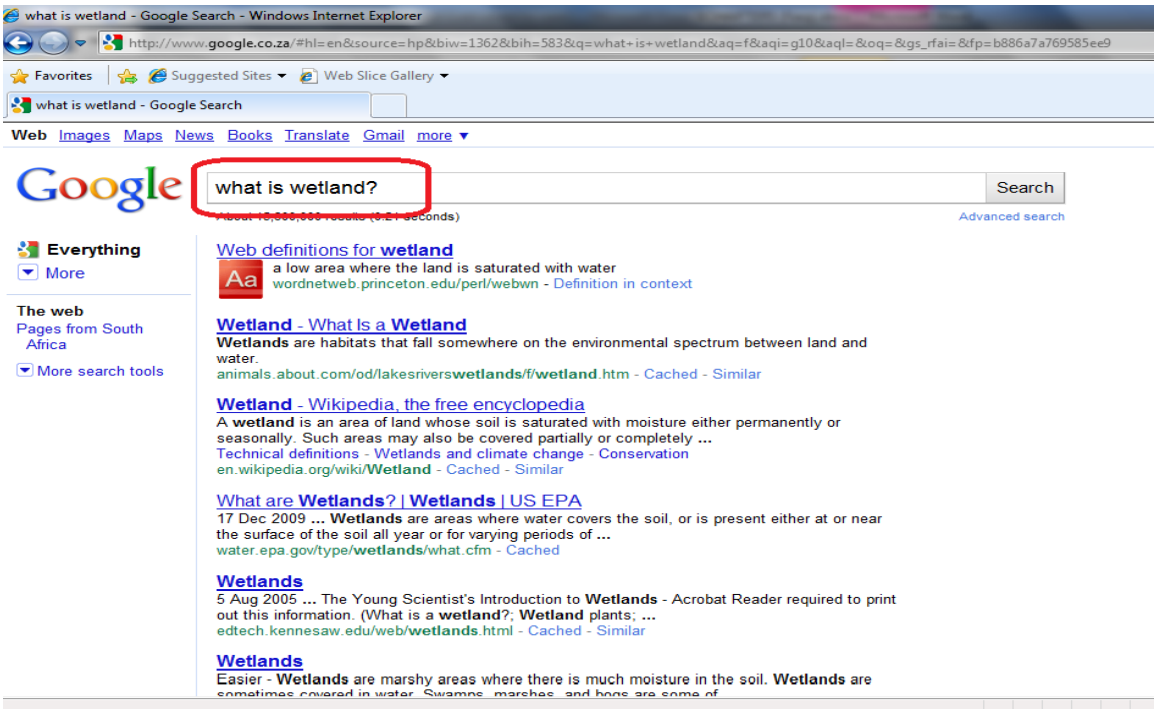

Figure 13: The first phase of the ALF for conducting a research project was to create information-seeking opportunities for the learners. This was the first phase in which I took advantage of using technology to aid me in helping learners to conduct a research project.

The use of Google Earth on the learners' desktop computers as well as on their mobile devices was an important tool for this research project. Google Earth mobile is much like the desktop version of Google. However, it requires an Internet connection to work, which the learners do not always have on their desktop computers. This Internet connection is easily obtained on a cellular device. The learners used Google Earth from their computers and mobile devices in order to identify where the two water masses for the study are found. Using Google Earth allowed them to identify the areas where they could conduct water testing in the field. The areas where water testing were eventually conducted were mapped via Google Earth, and a GPS coordinate was also obtained. The use of Google Earth was an innovative scientific tool, as it allowed the learners to accurately map water-testing sites without the use of complex GPS devices, which are expensive to maintain and are not as user friendly for learners. These technologies were ideal for fostering the learners' interest and, through the use of these educational technologies, which are used by many researchers in tertiary institutions, the learners felt that they were potentially making a contribution towards knowledge in the field of biodiversity.

Figure 14: In the first phase of the ALF (Active Learning Framework), cellular phones and desktop computers loaded with Google Earth were used. The learners could therefore get a scope of the area in which the research project was being conducted.

The second phase of the ALF was the creation of enquiry encounters for learners. This involved taking the learners to the nature reserve where they were investigating the human impact on the wetland. Fortunately the nature reserve had an environmental education officer who guided the learners through the reserve and answered questions posed to her. After the learners were briefed and were able to ask questions relating to their study of the wetlands, they were required to gather data to test their hypothesis.

Figure 15: The second phase of the ALF was for the learners to be exposed to enquiry encounters. The enquiry encounter was with the environmental education officer at Rondevlei bird sanctuary, as shown above.

The data that they collected to verify or reject the hypothesis for this project included photographs, water readings obtained through water-testing kits supplied by the Stellenbosch University Environmental Education Programme (EEPUS), and mapped GPS coordinates of where the photographs were taken. The photographs were taken

at both water masses using digital cameras as well as cellular phones with cameras embedded in them.

Figure 16: A learner collecting data in the form of photographs for the research project. Learners used digital cameras as well as cellular phones with integrated cameras for this form of data collection.

The use of a cell phone for this scientific investigation was crucial, as it pinpointed GPS locations as well as being used to take photographs. The water-testing kits that were used for the determination of pH and nitrate levels were another form of data collection. These variables are important, as they allow learners to gauge the water quality levels of the respective water masses. The verification or rejection of the hypothesis was done through visual (photos) and empirical (determination of pH and nitrate level) data collection. During the data collection, the use of various technologies aided learners to act more scientifically.

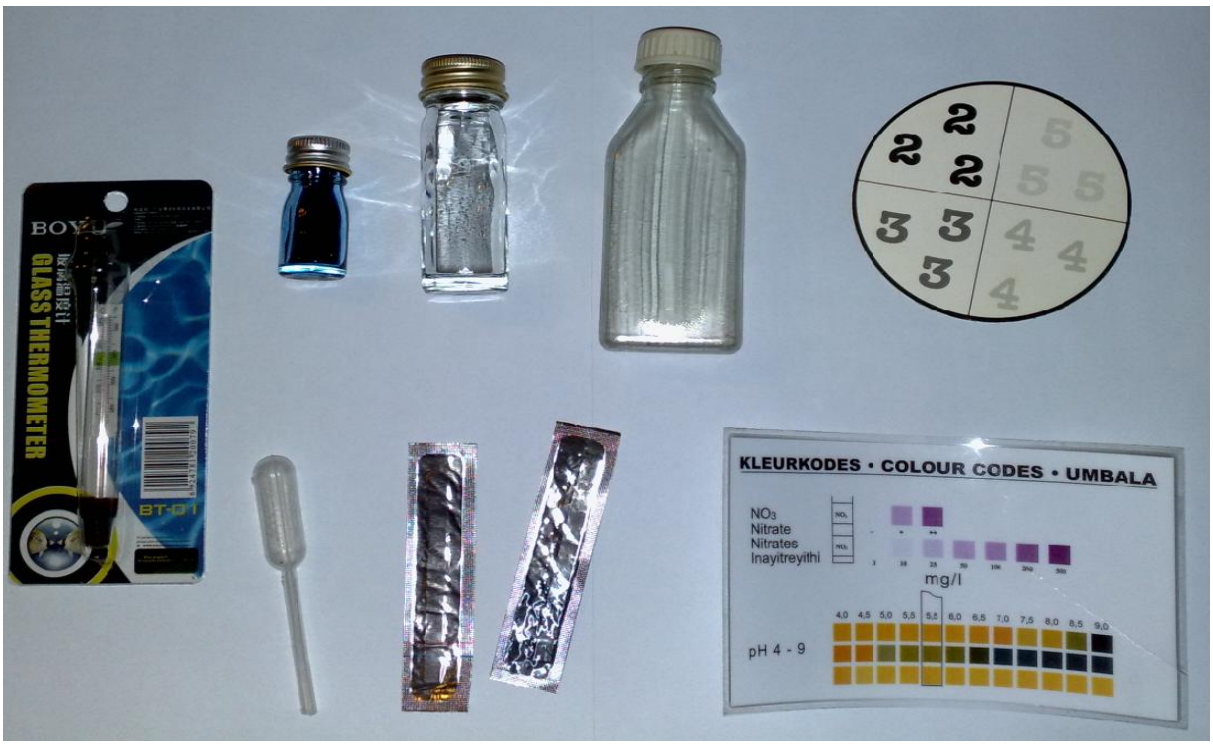

Figure 17: The water-testing kit that was used for empirical data collection.

After this data collection phase, a data analysis was required. At this stage of the research project, the learners were able to reflect on what had been done and what the data actually meant. This was the third stage of the ALF, whereby the learners reflected critically on ideas. At this point in the research project, technology was again used. The learners used Microsoft Office for their data analysis to determine which water mass was more polluted. Graphs and tables were constructed and the learners reflected on what these graphs meant. Theses graphs would later be used on scientific posters that were also constructed using Microsoft Office, and that either accepted or rejected the hypothesis for the scientific investigation of the wetland area.

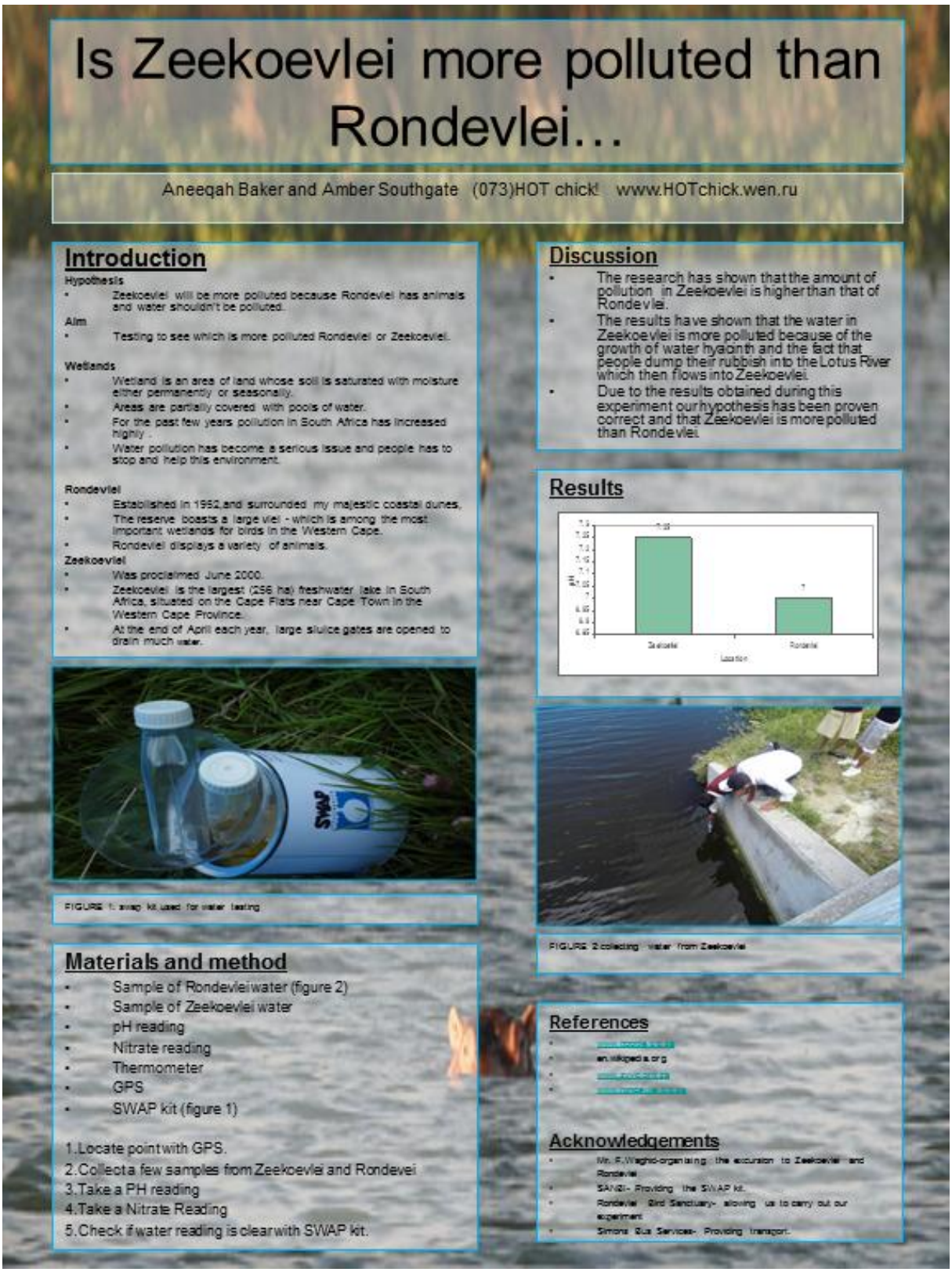

Figure 18: A sample of one of the learner's research posters that was compiled using Microsoft Office. The graphs that were constructed in the data analysis phase gave an indication as to which water mass was more polluted in order either to accept or reject the hypothesis made.

The final stage of the ALF involved taking action. Action taking allowed the learners to inquire whether the work they had done in this research was of value and significance to the local community. The form of action agreed upon by the learners was for them to create awareness of the problems that affect the wetland area and of the importance of wetlands and wetland biodiversity. To create awareness for this scientific research, photographs taken at the wetland site were loaded onto the school's website. As the school's website already had over 10 000 visits it seemed a logical means to inform potential visitors to the website about the ongoing study and thus to create awareness.

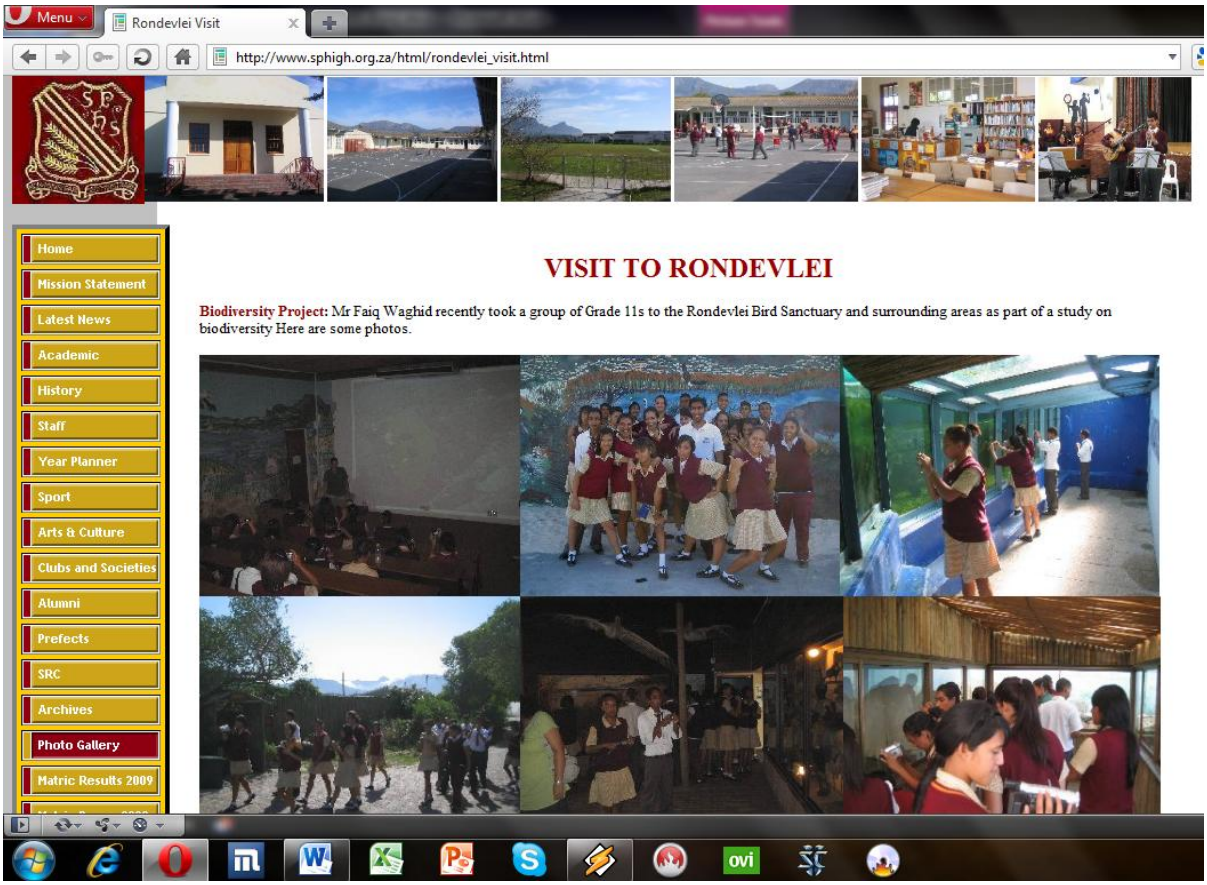

Figure 19: Photos of the research activities were loaded onto the school's website. The site has many visitors every day, making it an ideal way to highlight the research conducted and the findings.

Another form of action taken that was related to promoting awareness of this project was to create a Facebook group where photographs were loaded and a brief

description was provided of what the project was attempting do achieve. The Facebook phenomenon has reached many schoolchildren. Almost all the learners at SPHS are on Facebook. So the 40 students who were involved in this reach project invited learners via Facebook in order to increase awareness of the project's findings.

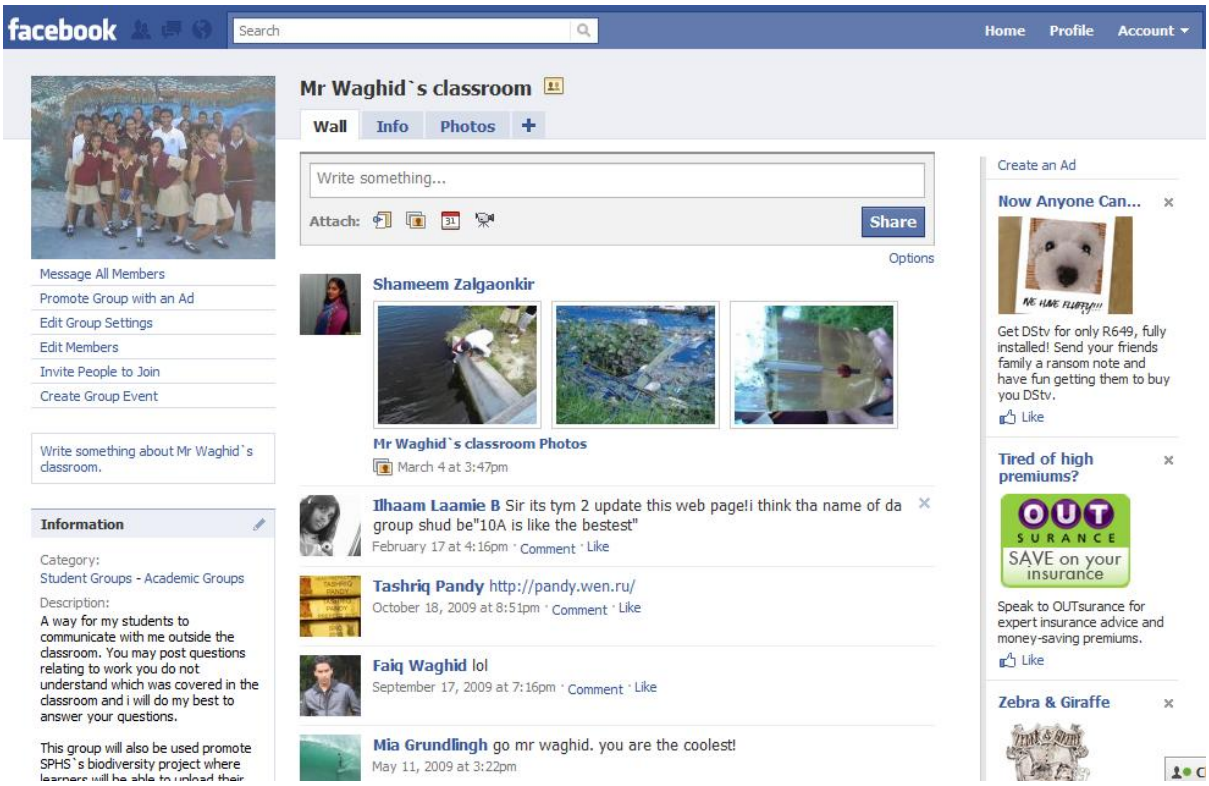

Figure 20: The Facebook group that was created. It allowed learners the opportunity to load their photographs and it was also a place for discussion and deliberation among learners with regard to the research that was conducted.

One learner took it upon himself to create a video of the research activities. Although this was not part of the action taken as proposed by the learners, he felt inspired by what we had done through this research project. He loaded the video onto YouTube, thus creating an additional form of action taking. This learner usually displays a keen interest in the educational technologies I used (and continue to use) in the classroom. He also advises me on information about new technologies that are produced, whether they are related to education or not.

Figure 21: A video of the research activities in the wetland area created by the one of learners and loaded onto YouTube.

In planning this research project using technologies with the learners, I have tried to incorporate as many as possible of the theories pertaining to how educational technologies can improve teaching and learning that were mentioned in Chapter 3 of this thesis. Instances worth noting are the following: The use of educational technologies to improve knowledge construction and teacher performance, as put forward by Gimbert and Cristol (2004: 207); Jeremy's (2000) ideas on how the use of technologies can improving learning; and Pearson and Somekh's (2006) view that critical thinking, analysis and enquiry can be improved through the use of educational technologies. Through the use of educational technologies in the wetland research project, I contend that critical thinking, analysis and scientific enquiry processes have been enhanced. Learners deliberating with one another with regard to why they hypothesised that certain water masses were more polluted indicates the extensive

application of critical thinking skills that have been enhanced through having used technologies as a medium for communication among them. Technologies such as Facebook, YouTube and the Internet were competently used by the learners to improve their analysis of the data. They were able to construct graphs that could adequately elucidate the differences between the two water masses of the wetland, and this is proof that their higher cognitive skills came into play. Throughout the application of the various phases of the ALF, the use of educational technologies featured prominently. The fact that a learner assumed the initiative to make a video of our research project (which he subsequently posted on YouTube) supports the view that autonomous and imaginative learning occurred. Also, there is ample evidence that societal awareness as an instance of action taking is a definitive corollary of this research project, particularly through the creation of a Facebook group, which enhances the view that transformative learning (Pearson & Somekh, 2006) unfolded.

I am even more persuaded that Guthrie and Richardson (1995: 14) are right when they argue that learners are intrinsically more motivated and that they learn better when technologies are infused into classroom pedagogy. When the learners constructed scientific posters of the research project it became more and more evident that (judging from the quality of the posters that were produced) they were even more motivated – that is, as indicated in Figure 17, their levels of creativity, presentation and engagement were quite remarkable. In short, the learners deliberated more willingly and openly, having been prepared to listen to one another more attentively (Behrmann and Lahm, 1994: 105).

It would not be an exaggeration to claim that the learners participated actively on the basis of having used highly complex cognitive skills, as suggested by Jeremy (2000: 79) when he defends the view that the use of educational technologies encourages interactive group work. For instance, the learners were encouraged to work in groups, as not every learner had a cellular phone with GPS and a camera. They worked freely in these groups which they themselves formed. It also happened that some learners 'mastered' the use of the various technologies much quicker than others. Learners therefore were actively involved in the learning process by unselfishly supporting one another in the use of these technologies, as discussed by Foreman (2003).

The fact that the learners embarked on action that connected their learning to real-life situations is evidence that the use of technologies enhances critical societal awareness, as claimed by Jeremy (2000: 82). The learners saw more relevance in the work they did in my classes when they connected their learning to real-life applications. Using technologies such as Google Earth brought about a connection between what they learned in class and what they experienced through this project – that is, the learners used Google Earth to observe and analyse the areas in which they reside; they could see how various inputs from the areas that were close to them affected the quality of the water mass; they became more enthusiastic to investigate what was having an impact on the water masses as it related to the context in which they found themselves; and they wanted to do something (such as taking action on Facebook) to conscientise others.

Hence, through the use of educational technologies they constructed ideas and opened their minds to new ones. In fact, through their collaboration in this project

they became a learning community intent on changing a situation in society – practices that seem to be in harmony with King's (2002) findings.

This brings me to a discussion of whether critical teaching and learning unfolded in and beyond my science classroom through the use of educational technologies.

5.4 Cultivating Critical Teaching and Learning in a Science Classroom through the Application of Educational Technologies

In Chapter 2 I developed the view that reflective teaching as a practice is an integral component of a teacher's professional development. I then argued that professional development can be made possible through critical pedagogy, which in turn can bring about transformative actions. Transformative actions, as I have shown earlier, can be attained through the use of educational technologies in science teaching and learning. I now want to link these interrelated theories of transformative action, critical pedagogy, and professional development through reflective teaching to the two narratives in this chapter.

Earlier I showed how Zeichner (2009: 121) makes an argument for reflective teaching being linked to the ongoing professional development of teachers. Firstly, the view that reflective teachers take into consideration theories embedded in their own and other teachers' practices is of relevance to my own professional development. For instance, as the narratives indicate, I took into consideration various theories, such as the use of technologies and their implications for critical, transformative learning. This suggests that I also gained professional grounds in terms of connecting my practices with practices that can bring about changes in learners' attitudes, their

commitment to learn, and their motivation to find out on their own and to actuate societal change. Likewise, I have been inspired to create conditions for the learners and me to think more critically, to try to get more persuasive answers to pertinent issues in the real world, and to be deliberative and attentive to the learners' opinions. The fact that I consulted with my two science colleagues and collaborated on what teaching works 'best' in particular lessons, indicates that I have also been moved by reasons – a matter of having become more critical. Secondly, following Zeichner, technologies were not used simply as technical instruments, but rather as pedagogical tools that can engender in myself a critical spirit to ask why, and to search for better ways of teaching science. Thirdly, as a reflective teacher I am even more aware of wanting to take up issues in society that can enhance improved living conditions for humanity. The wetland project and the collaboration with learners made me more environmentally aware of my own surroundings as a resident in Zeekoevlei, as well as having been encouraged through this project to link up with community organisations that care about the environment and society. I am even more aware of the negative effects of drug abuse, for instance, considering that on occasion I witnessed with concern how people walk around in the area without jobs and perhaps even without food. Similarly, I am also deeply concerned about why some people (vagrants) sleep in the wetland areas – perhaps they do not have any housing. These are societal issues with which I am seriously beginning to grapple. And as I reflect individually about teaching and learning, I begin to wonder whether educational technologies do not have other functions, such as alleviating the crisis of social injustices in our communities. For example, I thought about how xenophobia can perhaps be troubled through the use of a Facebook group at school. I became an empowered teacher deeply guided by a critical and transformative agenda that I hope to pursue in my science classrooms and beyond.

For me, by far the most important finding emanating from my narratives is the fact that critical pedagogy cannot be delinked from my science teaching. My teaching encouraged learners to make their own judgements – that is, as suggested by Bailin and Siegel (2003: 181), to become more critical in their thinking. The learners made various judgements related to the action-taking component of the ALF. Likewise, the learners were required to judge which forms of action taking would be most effective for the water research projects, and these judgements manifested in the creation of a Facebook group. They embarked on more careful analyses as they conducted their research. The use of technology to construct graphs aided these careful analyses on the part of the learners. The learners deliberated with one another and constructed meanings for the implications of their analyses for their learning. In the main, the learners became (I think) very critical thinkers.

This brings me to a discussion of my own professional development. Drawing on the ideas of Guskey (2002), and in particular his five levels of evaluating teachers' professional development, I shall once again reflect on my own practices in relation to the following aspects: the learners' reactions towards my teaching; the learners' learning (on which I have reflected extensively so far); organisational support and change; the learners' application of the new knowledge and skills acquired; and the learners' learning outcomes. I have to mention that my own professional development also increased through my workshop attendances, where other teachers and I reflected together on our practices through the use of educational technologies in life sciences. Firstly, the learners' reactions relate to the initial satisfaction they had with my professional development opportunity (Guskey, 2002) – that is, my use of educational technologies to support my teaching practices. I am reasonably satisfied with my own performances through the use of educational

technologies in life sciences. I am also at ease regarding my research on how educational technologies can be used and how these technologies support my teaching in science classrooms. Secondly, following Guskey (2002), the learners' levels of knowledge of and skills in life sciences in relation to the application of technologies expanded in an autonomous way. Thirdly, as indicated by Guskey (2002), with the support from *Khanya* and my two life sciences colleagues, my own problem-solving capabilities improved, especially through the aid of troubleshooting guides and mentorship discussions with my colleagues. Fourthly, as also noted by Guskey (2002), there exists sufficient evidence through the photographs taken and evaluative reports of *Khanya* that I used technologies quite competently and efficiently. Fifthly, the learners' attitudes towards the life sciences improved through their active participation in classes and in the research project.

In sum, I have argued that the use of educational technologies in and beyond the practices of my science classroom open up spaces for critical teaching and learning to occur. And, as the learners' critical thinking gained momentum, they, as did I, became more consciously aware of the societal issues that affect our daily lives. In this way, our pedagogy (teaching and learning) has been critical, transformative, and reflective.

How did learners demonstrate critical learning at the micro (classroom), meso (school) and macro (community) levels? Firstly, at the micro level, they deliberated about issues and often challenged one another's view points. They listened to other learners' views before their own views were raised. Sometimes, I noticed that learners would even change their ill-conceived or undeveloped views. Secondly, at the meso level, they became more interested in extracurricular activities and even

joined the environmental education society in order to engage with other learners and teachers. I have learnt that many of the learners in my classes often came up with innovative ideas to make SPHS an ‘eco-friendly’ environment. Another learner also introduced a newsletter on eco-issues for the school. Some learners also participated in the annual EXPO Competition for Young Scientists held in Pretoria where they were awarded a bronze medal for their project. I would like to believe that their exposure to technology and the manner in which they constructed their posters contributed towards their success. At the macro level, some learners have joined community organisations to be part of civil society that discusses matters of social and political concern for the community. Although it would be too premature to claim that learners had been transformed into critical social beings concerned about remedying poverty and crime in their communities, they have nevertheless been initiated into such a discourse at school level, particularly in the life sciences.

CHAPTER 6

SUMMARY OF INTERPRETATIONS, CONSTRAINTS AND POSSIBILITIES FOR FUTURE EDUCATIONAL RESEARCH

6.1 Introduction: Summary of Findings

What I have found thus far in relation to science education, and more specifically the teaching and learning of life sciences for grades 10 to 12, can be summarised as follows: Firstly, if learners are initiated into a discourse of learning through the use of educational technologies, the possibilities exist for them to become critical. This involves learners being engaged in active participation, deep questioning, listening, deliberation, and moments whereby they take responsibility for their own learning. In a way, they creatively connect their newly acquired ideas with existing concepts, and they develop a heightened sense of discovery, problem solving and critical thinking. Through the use of educational technologies they, as autonomous beings who can reflect on their learning at their own pace, learn concepts in the life sciences. Secondly, through the use of educational technologies the learners can construct ideas in the life sciences and are open-minded and receptive towards new thoughts. The chances that they collaborate as a learning community intent on changing a situation in society are also high. Thirdly, through the use of educational technologies, learners have the potential to make their own judgements – that is, to become critical in their thinking. Fourthly, the use of educational technologies in science classrooms and beyond can also enhance a teacher's reflective capability. The teacher's teaching can be linked to his or her ongoing professional development. By this is meant that the use of technologies creates pedagogical opportunities for

teachers to become transformative, critical, deliberative and concerned about social injustices – a matter of gaining more professional competences linked to moments of individual and social empowerment.

6.2 Advantages and Limitations of the Application of Educational Technologies in Science Classrooms

As is evident from my use of educational technologies as depicted in the narratives in the previous chapter, the learners and I have been fascinated with their application in and beyond the science classroom. My use of technologies evokes a sense of astonishment in what they (educational technologies) have to offer critical teaching and learning in science classrooms. So, it would be difficult to repudiate the value of using educational technologies in improving critical teaching and learning in the life sciences. Firstly, as I have shown, technologies help teachers to teach more critically in science classrooms. Secondly, both the learners and I added a few new practices to our educational repertoire, like Google Earth for doing science projects. Thirdly, the use of educational technologies introduces new forms of interpersonal communication between teachers and learners, and 'new ways of manipulating imagery, both visual and auditory' (Blake & Standish, 2000: 7). All the afore-mentioned make the use of educational technologies in the life sciences hardly irrelevant to critical teaching and learning. The learners and I realised that the use of technologies in life sciences added 'electronic glamour and glitz' (Blake & Standish, 2000: 6) to our teaching and learning together.

However, despite the positive contributions that educational technologies have made in enhancing critical teaching and learning in my life sciences classes, I do not want

to dismiss scepticism about the educational worthiness of technologies too quickly. Jean-Francois Lyotard offers the most developed critique of the use of educational technologies to date, by arguing that technologies merely enhance the economic goal of performativity (Lyotard, 1984: 11). In other words, educational technologies, following Lyotard, have predominantly a market-oriented function to prepare learners to fit into the work environment like technicians and machines that can be controlled in order to increase output or productivity (Lyotard, 1984: 13). I agree partially with Lyotard in the sense that the learners and I emphasised how the use of technologies would enhance opportunities in the job market and how adept one will become in fitting into the world of work.

In addition, the use of educational technologies also created new relations among the learners through which issues of inequality and social injustice surfaced in a different way. The learners compared cell phones and, at times, became too embroiled in conversations about the latest state-of-the-art technology, rather than focusing on what makes up critical learning or even how their learning can begin to connect meaningfully with issues of social injustice in their communities. By implication, the use of technologies at times distracted critical pedagogy rather than enhanced it.

Nevertheless, the learners and I cannot deny that the use of educational technologies in life sciences opened up exciting potential for teaching and learning. Thus, I remain upbeat about its use in the teaching of life sciences for grades 10 to 12. Yet, if one desires to deepen debate we cannot begin to look uncritically at its use. This study, however, wanted to focus more on the positive contributions that the use of educational technologies could make to science teaching and learning in schools.

Although I have argued mostly in defence of the use of educational technology in relation to science classroom pedagogy, learners and I also encountered several challenges in relation to pedagogy as discussed below:

Firstly, although learners' analytical and problem solving capacities increased through the application of educational technology in relation to the life sciences, they desired that every lesson had to be tied to the use of technology. This was not always possible and my interactive classroom atmosphere was challenged by instances of learner disinterest and indiscipline. Although learners gained the confidence to independently explore other opinions and to voice their personal viewpoints, at times they became too judgemental towards others who might not have acquired the skills to use technology effectively. Although learners now acquired the confidence to use educational technology as a useful research and information gathering resource, many learners abused the opportunity to do other Internet searches for instance, often unrelated to life sciences lessons. This situation often worked against learners collectively discussing, debating and deciding on particular matters in the life sciences classroom. Thus the use of educational technology seemed to have undermined effective classroom pedagogy.

Secondly, learners relied too much on technology to come up with responses to their assignment and projects which often resulted in serious cases of plagiarism, especially from the often unreliable and scientifically unsubstantiated Wikepedia website. Their linguistic abilities suffered which one could infer from their poor construction of sentences. They became uncritical towards the use of technology which in a way contradicts the very practice of criticism I wanted to cultivate in them.

Thirdly, evident from their performances in class tests and assignments it seemed as if the use of educational technology in teaching the life sciences transformed classroom practices back towards task-oriented approaches as opposed to increasing learners' understanding about the life sciences. Some learners might even have been turned further into technocratic 'junkies'.

6.3 Reflective Teaching and Professional Development

My own professional development has been greatly enhanced by engaging in a reflective practice, more specifically teaching. In this thesis, the notion of reflective practice not only guided my professional development as a science teacher, but also influenced my lived experiences in the classroom. In other words, reflective practice extended 'layers of action and mutual understanding that are instantly and often unreflectively realised in everything teachers [such as I] do in constantly changing situations (my technologically informed classroom)' (Van Manen, 1999: 3). In fact, all the things that I did with the learners in relation to teaching science through educational technologies had a positive pedagogical significance. My professional development as a teacher was informed by what Van Manen (1999: 4) refers to as 'knowledge in practice' – that is, knowledge resides in my teaching style, in my gestures and demeanour, in my classroom, and in the relations of trust and intimacy with the learners. Moreover, through reflective teaching I was also struck by how eloquent learners can be if we are prepared to listen to them attentively and to speak about their learning experiences. I hopefully became smarter in my relations with the learners I taught. In this regard, Van Manen (1999: 6) makes the point that 'much of knowing what to do, ensues from the complex dimensions of practice: one's body,

actions, relations, and the things of one's world'. In a way, my professional development as a teacher became 'embodied' in the context of my encounters with learners in a science classroom and the ways in which we used educational technologies.

I shall now reflect in more detail on my own professional development in relation to the use of educational technologies as I endeavoured to make science teaching and learning more critical. Firstly, as a novice teacher with just under three years of teaching experience, my life sciences colleagues had confidence in me to teach the content of the curriculum well. This I know because both of them (senior teachers at SPHS) consulted me on several occasions to teach lessons on genetics and evolution, and were highly impressed with my level of competence and teaching strategies in making the content known. But it was when I demonstrated to them how one could use a cell phone to teach a lesson via Microsoft Power Point, that they became more interested in my skills to teach the life sciences. So, my professional development was greatly enhanced by the better pedagogical relationships that ensued as a result of using educational technologies in my science classrooms. However, there were also moments that I felt that my colleagues were not entirely happy (so it seemed) with the fact that I could do things in my teaching that they were perhaps not capable of doing. And it also happened that my life sciences question papers were over-zealously scrutinised, and one of my colleagues actually tried to humiliate me for what, according to him, appeared to have been sloppy work. I soon learnt that as a teacher there would arise moments of professional jealousy among colleagues that I might not have anticipated. For instance, another senior teacher who returned from leave made me feel incompetent because, according to her, I had neglected the TRAC laboratory at school. This all happened, I think, as a result of the

fact that I introduced some new ways of teaching the life sciences at school. I realised that my innovative efforts to improve the teaching of life sciences possibly affronted others or perhaps exposed their lack of use of such forms of innovation. Instead, I became more confident to the extent that I had more reason to complete this study.

Secondly, my reflective approach to teaching life sciences also brought me in close contact with the management of SPHS. I am aware that the management is very intent on ensuring 'discipline' in the classrooms because (as I was told) a school environment has to be conducive to successful learner performance. But having used my reflective approach to teaching life sciences, I often 'disrupted' the quietude of the classroom, perhaps to the disappointment of some of my colleagues. Also, the fact that I took learners on excursions (with them perhaps missing out on other lessons) soon brought me into partial conflict with some of my senior colleagues, who experienced my teaching approach as somewhat 'disruptive'. Fortunately I could liaise with the principal, who not only encouraged innovative teaching in relation to the sciences (he also is a life sciences teacher), but also supported my own professional development, partly because was pursuing doctoral studies.

Thirdly, the fact that I confidently co-operated with the learners meant I could also deal more professionally with their parents during meetings and often shared my reflective approach to teaching life sciences with some of them. I also realised that learner performance was not just about scoring good marks, but also about becoming a better person – that is, how learners relate and communicate with others, and how they conduct themselves ethically. Through such a critical approach I, in a sense, entered the life spaces of learners – being attenuated to them, I experienced

them. In addition, I would also regularly share my initial successes in using educational technologies in the classroom with family members, who often commented and offered sound advice. In a way my own professional development was extended to the private sphere of my home.

Fourthly, I am always trying out new ways of teaching science through the use of educational technologies. So, my research skills have also improved. Even the writing of this thesis can be considered as an extension of my professional development into the public sphere. Likewise, I also developed professionally by having been asked by my supervisor to present my initial findings to a group of science teachers at Stellenbosch University's Faculty of Education, in particular the findings related to how educational technologies can be integrated into science teaching and learning.

Finally, by far the most important shift I have made in my own professional development is to connect my science teaching in school to the epistemological advances made at university level. I became involved in a project that included other science teachers in the Western Cape, teachers from Wisconsin (United States), WCED officials and academics from Stellenbosch University. My engagement with others contributed towards my professional growth. I realised that life sciences can be better taught and learnt at school level in deliberation with others, because our potentialities are continuously evoked during discussions with others. I now consider myself to be a legitimate member of a community of practice.

6.4 Possibilities for Future Educational Research

As I mentioned earlier, I think there is scope to embark on real critical studies about the potential dangers of using educational technologies in schools. I have briefly touched on some issues, but contend that there is ample intellectual space to pursue projects that give consideration to more critical studies that highlight both the philosophical and pragmatic problems of educational technologies. By more critical studies, I have in mind contributions that not only spell out the use of educational technologies in schools in more detail, but, more importantly, spell out the quality of learning they make possible. This is necessary because simply to reduce knowledge in the science classroom to technologies might, as stated by Oakeshott (1989: 30), erode critical teaching and learning.

Also, further investigation of how the use of educational technologies modifies our views of identity and community is also required, particularly of how the use of ICTs shapes our understandings of education for democracy in and beyond science classrooms. Likewise, as noted by Lelliot *et al*. (2000: 45), a lot of educational research needs to be done about the use of educational technologies in accomplishing inclusive education and a sustainable civil society in most African countries so as to foreground the dilemmas of justice that have to be addressed.

Finally, science teachers intent on using educational technologies are required to gain a wider and deeper understanding of how to initiate genuine dialogues and appropriate educational moments when they initiate learners into this new discourse in relation to critical classroom pedagogy. In this regard, I have not encountered notable contributions in South Africa that are concerned with the practice of ‘learners

caring for themselves' (Marshall, 2000: 164) through the use of educational technologies.

6.5 Summary

In this thesis, I have argued that the use of educational technologies in science classrooms can engender spaces for critical teaching and learning. Critical teaching and learning as moments in my own professional development can be realised in several ways. One of the ways I have chosen (and that has been inspired by my personal affinity for computer games) is through the application of educational technologies. I acknowledge there are many pitfalls and unexplored areas that require further attention. But I have shared, in a positive way, my excitement and sense of wonder at its application throughout my first three years of teaching life sciences to grades 10 to 12 at a local high school. Thus far, it seems as if, in relation to my own science teaching, educational technologies have, firstly, engendered moments of critical learning; and secondly, hopefully improved my own professional development along a critical path.

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APPENDICES

Appendix 1

Detailed History of South Peninsula High School

South Peninsula High was established in January 1950. It was established as a new high school for disadvantaged communities of the southern suburbs of Cape Town in the Western Cape province of South Africa. The school was initially housed in a church hall in Southfield, which is also situated in the southern suburbs of Cape Town. Initially it was called Southfield Secondary. It later developed into the highly esteemed school that was rebranded South Peninsula High School (SPHS). The first principal of South Peninsula High School was Mr F. Hendricks, who was the retired principal of Battswood Teacher Training College, which was also situated in the southern suburbs of Cape Town. Battswood Training College was one of a few educational institutions responsible for teacher training at that particular time. The first staff members of South Peninsula High were Mr P. Swiegelaar (who remained at SPHS until his retirement in 1970), Miss Fuchs, Mr F.P. Joshua and Mr Lochner (http://www.sphigh.org.za). When the school started in 1950, 124 grade 9 learners were enrolled and divided into four classes. All four classes were housed in the church hall and were partitioned from one another by means of curtains. Teaching instruction took place under very difficult conditions (http://www.sphigh.org.za). July 1950 saw the beginning of a new phase in the history of SPHS. Having completed all the preliminaries and formalities of starting the new school, Mr Hendricks left (as did Miss Fuchs) to start the Harold Cressy High School in Cape Town, which is also a high school well known for academic success. Mr Joshua left to become the first

principal of Alexander Sinton High School in Athlone (http://www.sphigh.org.za). In July 1950, Mr A.G. de Villiers was appointed as Principal and he remained principal until his retirement due to ill health in 1967. Mr de Villiers employed two new teachers to replace the two that left. These teachers were Mr A. Daniels and Mr R.C. Hepburn, who studied with Mr AG de Villiers at Genadendal Teacher Training College (http://www.sphigh.org.za). Mr de Villiers was known to be a strict disciplinarian, dedicated to the academic advancement of the underprivileged (http://www.sphigh.org.za).

The first students of SPHS received instruction in adverse conditions in Southfield church hall, before respite came in the form of the school obtaining a vacant building situated in Kendal Road, Diep River, which had been set aside for a primary school. As a result of the primary school not materialising, the Cape Education Department agreed that SPHS should occupy the vacant premises (http://www.sphigh.org.za).

As SPHS was developing into the school it is today, emphasis was on discipline and academic success. Students were expected to have a book with them for studying purposes even during breaks. Control over the students was so strict that SPHS was referred to by many as ‘The Concentration Camp’. The year 1954 was the year of change. In that year, the first grade 8s, totalling 81 students, were enrolled. They were divided into two classes. Two teachers, Ms E. Haggis and Mr D. Thebus, were appointed for these new classes (http://www.sphigh.org.za).

Appendix 2

Smart Board

Smart Board with interactive flash animation

Appendix 3

Edublog

Science blogs such as these provide teachers with invaluable ICT resources

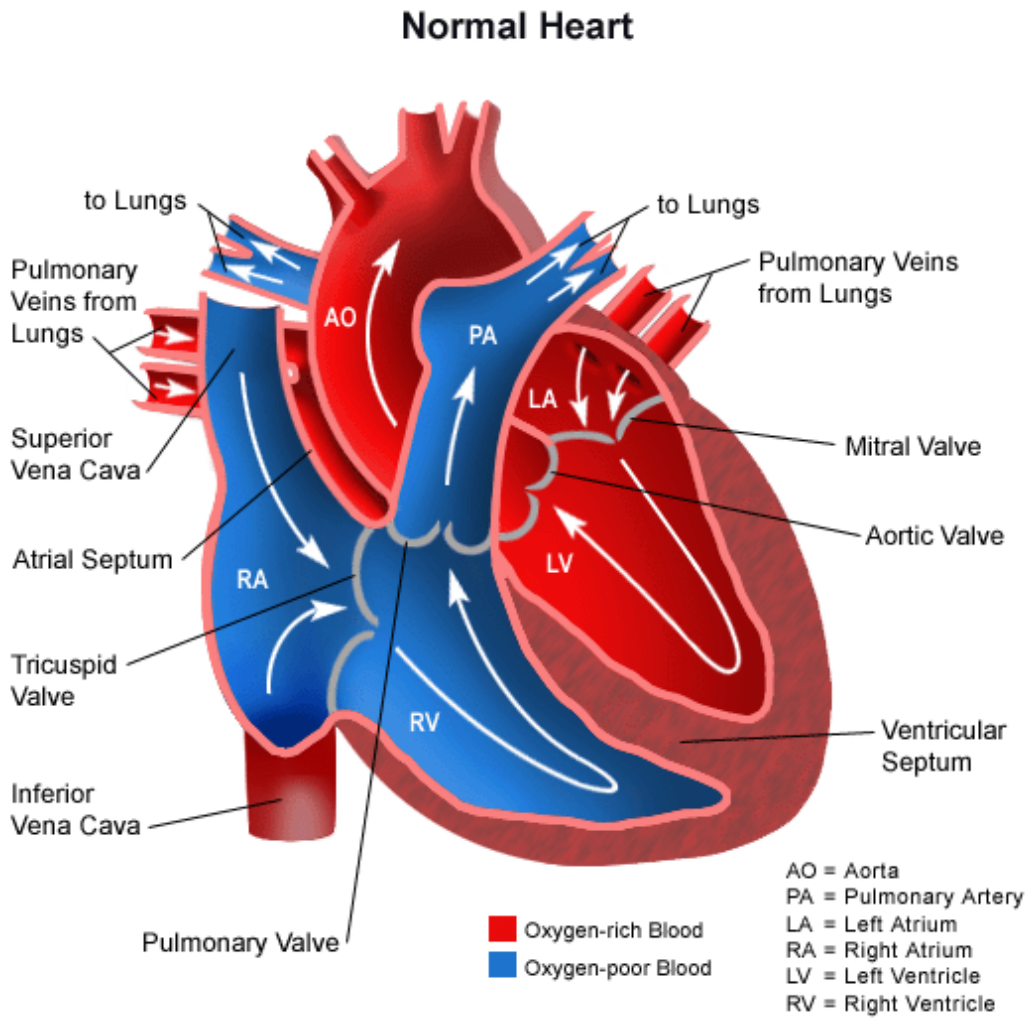
Appendix 4

Mobile device

Mobile device such as these can be connected to data projectors and televisions, giving these devices the same functionality as that of a laptop or desktop PC

Appendix 5

Interactive Flash Animation



Interactive flash animations such as this can aid teachers in conveying concepts much more effectively than static images would

Appendix 6

Learners in Action with Digital Cameras

I

Digital cameras are a good way to spur the interest of learners to do environmental projects

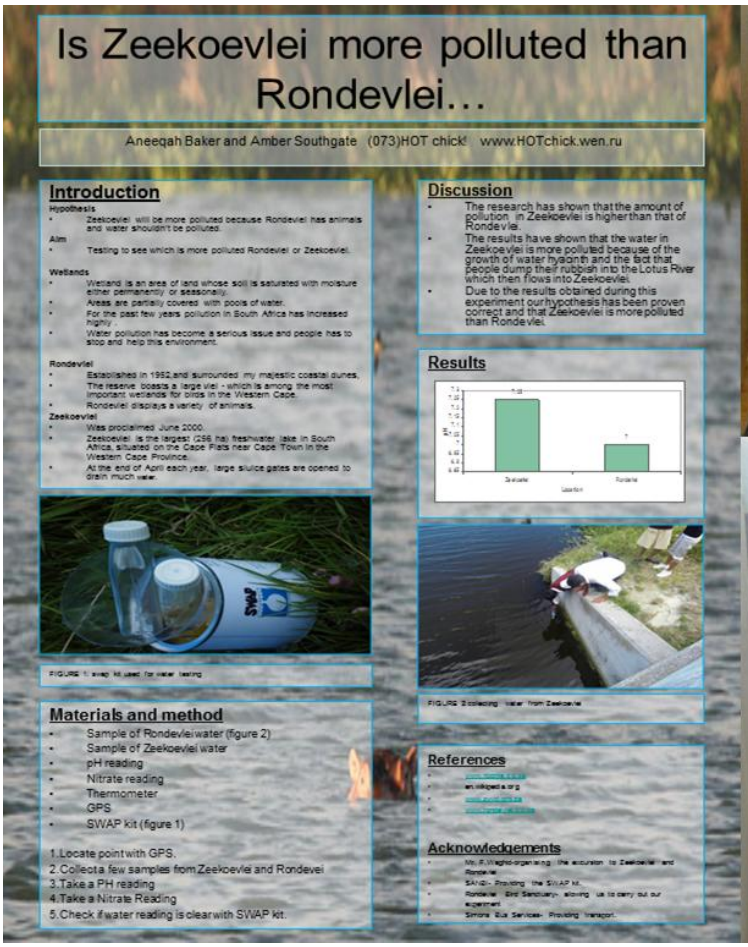
Appendix 7

Mobile Devices with Google Earth

Mobile devices loaded with Google Earth are able to view 3D views of many locations all around the world

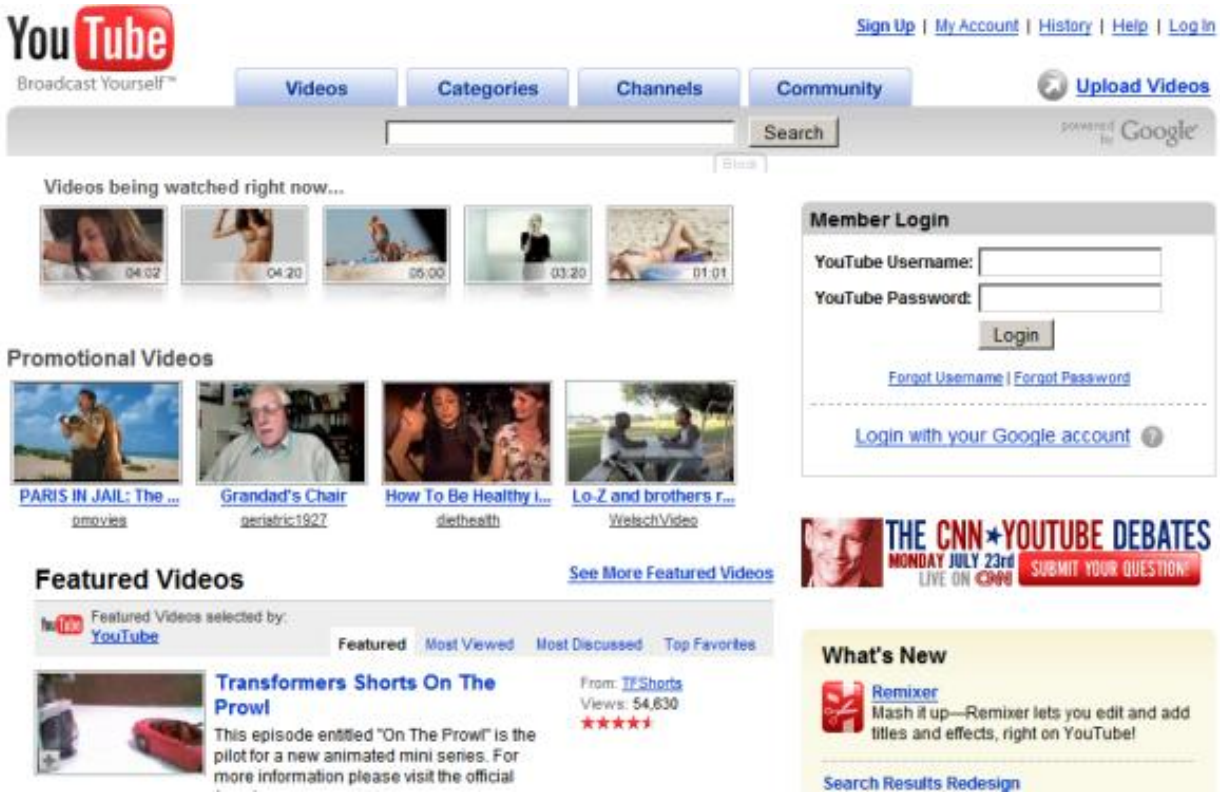
Appendix 8

Samples of Learner Posters for Research Project



Appendix 9

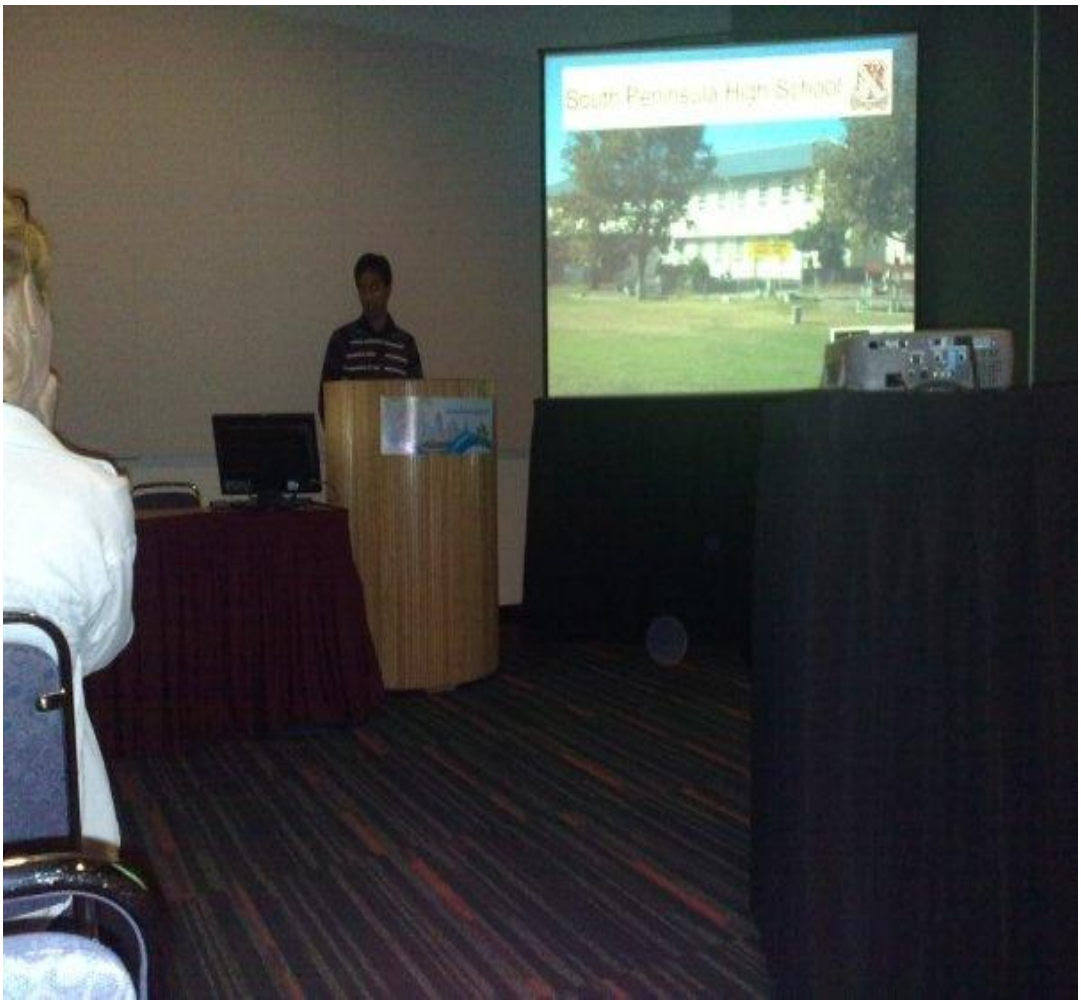
Application of YouTube



YouTube is an invaluable resource, with video documentation of almost every aspect that is covered in the classroom

Appendix 10

Conference Presentation at 11th World Environmental Education Conference in Montreal in 2009



Appendix 11

Global Education Teachers: Partnership between the WCED, SANBI and Wisconsin-Madison in 2009