Appendix A:

Some of the major South African ICT initiatives to provide hardware, software and teacher training

A 2002 audit of the major ICT projects underway in the country reported on 34 different collaborative information and communication technology initiatives between the government and various businesses and/or organisations (WEF Global Digital Divide Initiative Steering Committee on Education, 2002). I have divided the major information and communication technology initiatives undertaken into three groups to facilitate an understanding of their focus.

1. The first group focuses on broad government initiatives, as shown in the table below:

Year	Initiative
1995	"*The need for a technology-enhanced learning initiative (TELI) was identified"* (Howie, 2010, p. 512).
1997	A draft national policy on ICT in education was written (Howie, 2010).
	The TELI strategic plan is completed in April 1997 (Howie, 2010).
2001	President Mbeki announces the founding of the Presidential Establishment of Presidential National Commission on Information Society and Development (PNC on ISAD) and Presidential International Advisory Council on Information Society and Development (PIAC on ISAD) in his State of the Nation address during the opening of parliament in February 2001 ("Gauteng Provincial Government," 2001).
	Telecommunications Act 103 of 1996 amended in 2001 to call for the development of an Educational Network and the implementation of a discounted connectivity rate for schools (Department of Education, 2004).
2002	PIAC on ISAD starts operating in March 2002 ("Presidential National Commission on Information Society & Development," 2005). It identifies three focus areas for developing information and communication technology: education, health and business enterprises (Department of Education, 2004).
	The government, through the Electronic Communications and Transactions Act "*call[ed] for the development of a five-year national e-strategy that aims to enable and facilitate electronic transactions in the public interest, including in the education sector*" (Department of Education, 2004, p. 10). The strategy included the provision of Internet services to public schools and FET institutions at a discounted rate of 50% of the total charge, the so-called "e-rate" (Harris, 2006).
2003	South Africa becomes a signatory to the *World Summit on Information Society*, according to which the country is required develop an ISAD plan (Presidential National Commission on Information Society & Development, 2005).
2004	National policy on ICT in education (White Paper on e-Education) is gazetted, seven years after the draft policy was written (Howie, 2010).
2007	ISAD plan is unveiled, with education identified as one of five "*priority focus areas for ICT application*" ("ISAD PLAN," 2012, p. 13).
2008	The government announces the *Teacher Laptop Initiative* (Mohlala, 2010). According to this initiative teachers should receive a laptop, software, Internet connectivity and insurance for their laptops (Bauer, 2011). Teachers are expected to fund the package, although they would receive a "*taxable monthly allowance of R130*" (Bauer, 2011). Training on how to use the laptops and the software is included in the package (Worst, 2010).
2009	The *Teacher Laptop Initiative* is gazetted and is scheduled to start in July 2009, "*with the aim that all permanently employed teachers have laptops by mid-2011*" (Mohlala, 2010).
2010	The government launches the *Teacher Laptop Initiative* a "*year behind schedule*" (Mohlala, 2010).
2013	A National Economic Development and Labour Council (Nedlac) report was ratified in June 2013. The report stipulates the "*norms and standards for school infrastructure*", which include a fixed telephone line, Internet access and a cellphone for emergency use (Jacobs, 2013).

2. The second group focuses on some of the major national government collaborative initiatives, i.e. initiatives which involve collaborations between government and the private sector, para-statals and non-governmental organisations:

National collaborative initiatives between the South African government and organisations to facilitate ICT integration into schools

Area of development	Initiative	Details of initiative	Achievements to date (2012)
Improved infrastructure and connectivity	*Sentech Ltd*	Undertook to provide 500 schools with computer labs as part of licensing obligations (Department of Education, 2004).	A rural school in KwaZulu-Natal (Myeka) has been connected to the Internet (*Sentech annual report*, 2007). *Sentech* provided broadband connectivity to 2 high schools (Thozamisa, a rural school and Ponelopele High in Midrand) and established the Dipalo School of Information & Technology in Soweto.
	Telkom Internet Project (Supercentres)	*Telkom* undertook to establish Supercentres (with computers, software, Internet connections, monthly subscriptions and rent-free telephone lines) in more than 1,300 schools (Department of Education, 2004).	Supercentres have been established at 200 schools (Kayle, 2009).
Provision of electronic content resources	*Mindset Network*	Provision of content resources via satellite television (Department of Education, 2004). *Sentech* is a founding member of the *Mindset Network* and provides broadcast capacity to the *Mindset Learn* channel (*Sentech annual report*, 2007).	*Mindset* has developed more than 500 hours of video content, as well as interactive multimedia and print content (Busa, 2011).
	Thutong portal	Educational portal for digital content resources established by Department of Education and partners (Department of Education, 2004). Provides access to "*a wide range of curriculum and support material*" (Isaacs, 2007, p. 18).	According to (Isaacs, 2007) *Thutong* had 15,483 registered users and 18,535 content resources by August 2006.
Professional development	SchoolNet SA's *Educator Development Network* (EDN)	The EDN is *SchoolNet SA*'s primary educator ICT development programme ("SchoolNet SA," 2003). The EDN is a CD-based model of training and support involving on-line communities of teachers, (Bialobrzeska & Cohen, 2005; "SchoolNet SA," 2003)). Currently, the EDN consists of 20 modules covering a range of ICT-related topics from *Word processing for Educators* to *Designing Webpages* ("SchoolNet SA," 2003)	*SchoolNet SA* has over 20,000 teachers on the SchoolNet database (Roberts, 2011). Two South African teachers were semi-finalists in the *Microsoft Worldwide Innovative Teachers Awards* held in Hong Kong in 2008. One teacher was the runner-up in the "*Innovation in Community*" category.
	Intel Teach to the Future) http://www.schoolnet.org.za/ttf/index.htm	A global initiative providing training for teachers on integrating information and communication technology. The South African programme started in 2003 and is managed by *SchoolNet SA* (Bialobrzeska & Cohen, 2005; Butcher, 2003).	Under the management of *SchoolNet SA* 28,764 teachers have been trained (Roberts, 2011). *Intel* offers collaborative online courses including *Teach Essentials Online*; *Thinking with technology* and *Skills for success* (ICT literacy for primary school teachers). It also runs workshops known as "*Essentials face-to-face*" which require 40 hours of contact with teachers ("Intel Teach: Essentials," 2009).
	Microsoft Partners in Learning programme	Teacher development and support launched in 2003 as part of a global initiative. *Microsoft* partnered with *SchoolNet SA* and the Department of Education to offer training programmes including basic ICT skills and ICT integration, peer coaching for teachers as well as ICT leadership for education managers (Bialobrzeska & Cohen, 2005).	Latest figures supplied state that 81,264 teachers have been trained in ICT integration and that 800 trainers from the Department of Education have been trained to roll out the *Microsoft Partners in Learning* programme (Roberts, 2011).

3. The third group of initiatives involves government collaborations with the private sector that focused on providing information and communication technology resources in specific provinces (provincial government collaborative initiatives), focusing on two major provincial collaborative initiatives in the country.

Summary of the major provincial collaborative ICT initiatives in schools in South African provinces

Province	Project & business partners	Launch & end dates	Aim	Recent achievements/ progress of initiative
Western Cape	***Khanya Project: Western Cape Education Department Technology in Education Project***	1 April 2001 – 31 March 2012	To supply information and communication technology equipment to schools for the purpose of curriculum delivery (*Khanya annual report for the period March 2007 – April 2008*, 2008).	The Khanya project was completed in March 2012. The latest figures available as of 14 November 2012 are reported below: • Project implemented in 1402 schools. • 89 schools in various stages of preparation for implementation. • 50,824 computers placed in *Khanya* schools • 31,718 educators have been "empowered to use technology for curriculum delivery" • 968,901 learners benefiting from project
Gauteng	***GautengOnline*.** Gauteng Education Department, Accenture, KPMG and Ernst & Young	2002 – 2013	To equip public schools in the province with a 25-workstation computer laboratory and with Internet and e-Mail, to be used for curriculum delivery. In 2004 *Sentech* was appointed by the Gauteng Department of Education and *GautengOnline* to provide connectivity to schools in Gauteng (*Sentech annual report*, 2007).	• Initial goal was placing computers with Internet connectivity in 1,100 of Gauteng's public 2,500 schools by March 2004 (Howie, 2010). This goal had not been met by March 2005 (Sikwane, 2007). R500 million had been allocated to this phase of the project (Mahlong, 2009; Sikwane, 2007). • Deadline extended to 2006 (with additional allocation of R100 million) and later to 2007 (with additional allocation of R200 million) (Mahlong, 2009; Sikwane, 2007). • Project handed over from Gauteng Department of Education to Gauteng Shared Services Centre in March 2007 and extended for another year (Sikwane, 2007). • Deadline to have computers in all public schools in Gauteng by end of 2008 extended to February 2009 and then to April 2009 (Serrao, 2009). • *Sentech* reports that it has provided connectivity and Internet services to 1,180 schools (*Sentech annual report*, 2007).

Appendix B:

The requirements of the South African curriculum and the supporting reasons for these requirements

Curriculum requirement	Implications for teaching practice	Supporting reasons for practice
Education should be outcomes-based.	Teachers should plan their lessons towards achieving outcomes which clearly state what learners should be able to do after the learning experience (M. Sanders & Kasalu, 2004). These outcomes include displaying competency in a wide variety of skills and developing appropriate values in addition to acquiring content knowledge (Department of Education, 1997).	Focusing on the outcomes of lessons provides clear goals for both teachers and learners of what should be aimed towards in terms of learning and what should be assessed (Hattingh et al., 2005).
The curriculum content should be relevant to learners.	Teachers should select lesson content that is relevant to their learners in terms of their background, culture(s) or life-experiences, so that their learning can have an authentic context (National Department of Education, 1997). Content can be made relevant by its application to learners' everyday experiences or by its potential usefulness to the learner in the future (Sanders & Kasalu, 2004).	Learning is believed to be more effective when it takes place in a context that is familiar to the learner (Lave & Wenger, 1991; Vygotsky, 1978). Selecting content that is meaningful to learners promotes their chances of relating the material to their existing knowledge which is an important prerequisite for meaningful learning (Ausubel, Novak, & Hanesian, 1968) and the construction of knowledge (Peers, Diezmann, & Watters, 2003).
Lessons should be activity-based.	A variety of meaningful (purposeful) activities must be used to engage learners both physically and mentally during lessons (Department of Education, 1997; M. Sanders & Kasalu, 2004). These activities should be used to provide the starting point for learners to construct their own knowledge (Sanders & Kasalu, 2004).	Constructivists believe learning involves development and changes in conceptual understanding (Ausubel et al., 1968; Peers et al., 2003). Meaningful engagement of the learner with the material will promote learners relating the material to any existing knowledge they may have and hence enhance conceptual understanding by knowledge construction (Peers et al., 2003; Vygotsky, 1978).
Teaching should be learner-centred.	Teachers must be aware of and take into account individual differences between learners (National Department of Education, 1997; Sanders & Kasalu, 2004).	Because learning is influenced by the culture and context in which it occurs (Lave & Wenger, 1991; Vygotsky, 1978), teachers must make provision for variations in factors like learning styles, languages and backgrounds of their learners.
The teacher should be a facilitator of learning.	Teachers should facilitate learning by creating suitable opportunities for learning to occur, providing the necessary resources, and monitoring learners during the learning process (National Department of Education, 1997; Sanders & Kasalu, 2004).	According to constructivist principles, teachers should foster learning by creating suitable opportunities for learners to actively construct their own knowledge.
Continuous assessment should be applied.	On-going assessment should be applied throughout the year to provide learners with feedback on their progress towards achieving the required outcomes (National Department of Education, 1997; Sanders & Kasalu, 2004).	Providing learners with regular feedback on their progress allows learners to know what they can do and what they still need to improve on.
Teachers should focus on the development of skills.	Teachers should actively teach skills to learners (Harlen, 1996; M. Sanders & Kasalu, 2004).	Teaching should focus on the developing learners' level of competence in various skills (Department of Education, 1997; M. Sanders & Kasalu, 2004; White & Aldous, 2003). The development of a skill involves more than just using the skill, so skills should be actively taught and practiced (Harlen, 1996; M. Sanders & Kasalu, 2004).
Group work should be promoted.	Teachers should plan for some classroom activities to be based on learners working together in groups (National Department of Education, 1997; Sanders & Kasalu, 2004).	Learning is enhanced by social interaction (Peers et al., 2003; Vygotsky, 1978) so collaborating with others should make for better learning.
Content and skills to be learnt should be integrated across learning areas.	Learning programmes should incorporate knowledge from different content areas and skills traditionally associated with different learning areas or subjects (Sanders & Kasalu, 2004).	Integrating learning across different subjects will make learners aware that knowledge is inter-connected and that skills can be applied across subjects. Learning to apply previous knowledge and skills to new contexts requires a great deal of practice (Angelo, 1993). Using knowledge and skills in new and different situations will allow learners to practice applying their knowledge and skills in new situations.

Appendix C:

Research-based evidence for teachers' failure to comply with some practices required by the new curriculum[1]

[1] Much of the research-based evidence presented in Appendix C may appear dated (2000–2005) but this is because of a shift in research focus, with early studies focusing on the implementation of the new curriculum and later studies more on the impact of the changes introduced by the new curriculum.

Teachers' failure to fully implement outcomes-based learning.

One of the requirements of the new curriculum was that education should be based on outcomes[2] which the learner should have achieved by the end of the learning process (Department of Education, 1997). The outcomes for the new curriculum are listed in Appendix D. Some teachers failed to comply with this curriculum requirement for the following reasons:

- **Some teachers appeared not to be focusing sufficiently on the outcomes of lessons.** Matimolane (2004) found that only nine out of the 28 teachers in her study said they based their lesson plans on outcomes. One teacher in a study by Morar (2004) felt that the learning outcomes stipulated in the curriculum documents were unrealistic and difficult for learners to achieve. Morar (2004) reported that this teacher failed to consult the curriculum documents regarding the outcomes, which suggests that the teacher was unlikely to be planning her lessons based on achieving the learning outcomes. The same teacher also felt that "*a content-based curriculum [is] appropriate*", suggesting a lack of focus in her lessons on teaching skills and values as required by the new curriculum outcomes (Morar, 2004, p. 688). Only 16 of the 162 Grade 9 Natural Sciences teachers from one school district in Gauteng said they were recording outcomes for every lesson (Pillay & Sanders, 2002), suggesting that the majority of the teachers in that study were not focusing sufficiently on what they wanted learners to be able to do after lessons.
- **Some teachers appeared not be focusing sufficiently on covering all three of the learning outcomes for the Natural Sciences and Life Sciences.** Learning Outcome 1 of the curriculum statements for both of these subjects focused on the learning of science process skills. Developing learners' skills requires that learners are actively and comprehensively taught how to perform the skills (M. Sanders & Kasalu, 2004). One possible problem with teachers' lack of focus on skills development is that teachers may not have appreciated what is involved in teaching a skill. None of the ten Gauteng teachers interviewed in one study fully understood this curriculum requirement, and while three out of the ten teachers claimed to have carried out some skills development, they did not actively teach any skill (Khoali, 2012). White and Aldous (2003) reported on the lack of process skills (these are skills associated with conducting scientific investigations, such as formulating a hypothesis, performing mathematical calculations and taking measurements) among 53 teachers from government and independent schools. Although this finding does not specifically relate to a lack of understanding of the curriculum requirement on teaching of skills (which is another of the nine curriculum requirements separate from the outcomes), a lack of process skills among teachers suggested that some teachers may have experienced difficulty developing these skills in learners when implementing the new curriculum.

  The following long-term study of the implementation of the new curriculum in 240 Mpumalanga secondary schools, which investigated the amount of time the science teachers spent on practical work, provided evidence of teachers' failure to meet Learning Outcome 1. Teachers were either not carrying out any practical work with their learners, carrying out insufficient practical work, or were not focusing sufficiently on developing learners' process skills. Hattingh

[2] The new curriculum had 12 critical outcomes and developmental outcomes which applied across all subjects and all grades (see Appendix AE). Up to and including 2004, the outcomes for the new curriculum included a set of 'specific outcomes', for each learning area of the General Education and Training band (Grades R-9). There were originally nine 'specific outcomes' for the Natural Sciences. The nine specific outcomes were replaced in 2005, by three 'learning outcomes' for the Natural Sciences (in the General Education and Training band) and Life Sciences (in the Further Education and Training band) (see Appendix AE). In addition to the outcomes specified in various national curriculum statements teachers needed to plan their own lesson outcomes based on what they want learners to be able to do after a particular lesson or unit of work had been taught (Sanders & Kasalu, 2004). With the introduction of CAPS, the outcomes are now referred to as 'aims'.

and Aldous (2004), as part of the long term study, found that 16% of the 240 teachers did not engage their learners in any practical work. Of the 84% who conducted practical work with their learners, 83% allocated 50% or less of their teaching time to practical work. This left only 17% who allocated more than 50% of their teaching time to work where learners could develop some process skills. Another significant finding was that only 6% of the teachers who conducted practical work engaged learners in the type of practical work that would develop higher order cognitive skills through learners being "*given a problem or question and then design[ing] their own experiment*" (Hattingh & Aldous, 2004, p. 353). As part of the same long-term study in Mpumalanga, Rogan and Aldous (2004) conducted interviews with ten teachers from seven of the ten school districts in Mpumalanga about why they were not conducting more practical work. Some of the teachers claimed that a lack of laboratories and science equipment prevented them from carrying out more practical work. However, the researchers could find no evidence of a link between the availability of resources and the amount of practical work. Some schools were found to have well equipped laboratories; the problem was that the laboratories were not being used effectively. Some schools were found to have science equipment that had not even been unpacked.

Many teachers were also failing to teach Learning Outcome 3, which dealt with the application of science knowledge in relation to society and the environment. From the way Learning Outcome 3 was being handled by some teachers, researchers have commented that "*the notion of basing a curriculum on societal issues is very new to South Africa, and does not really appear to have taken root yet*" (Rogan & Aldous, 2004, p. 865). Teachers tended to be focusing mainly on the acquisition of Learning Outcome 2, which deals with the acquisition of content knowledge (Rogan, 2004).

Teachers' failure to fully implement learner-cntred learning.

Chisholm (2005, p. 195) stated that "*the heart of outcomes-based education[3] lies in its learner-centred character*". The concept of learner-centred learning appears to be a difficult one to interpret (Kasanda et al., 2003; Paris & Combs, 2006)**,** and there are a number of different interpretations of 'learner-centred teaching' in the literature (Kasanda et al., 2003; Lea, Stephenson, & Troy, 2003; Paris & Combs, 2006). Schweisfurth found that a number of researchers were using different terms to describe what she identified as the underlying concept of learner-centred education:

> *Few therefore define LCE [learner-centred education] explicitly or concisely. The articles do share a concern for the pedagogical, assessment, or curricular implications of change away from 'teacher centred', 'didactic', 'frontal', 'chalk and talk' teaching focused on rote learning. Some of the studies based in schools refer to 'child-centred learning' (a very close but slightly different tradition), while others refer more generally to 'constructivist' or 'progressivist' principles or other related but more specific terms in local use, such as 'outcomes-based education' (OBE), as found in South Africa. Few of the article titles signal immediately the LCE connection, which is one of the challenges in reviewing the literature in this field.* (Schweisfurth, 2011, p. 426)

As pointed out by Sanders and Kasalu (2004), the new South African curriculum requires that lessons be both activity-based and learner-centred, implying two different requirements. Based on the distinguishing features of this curriculum requirement as defined and validated by Sanders and Kasalu (2004) (in the absence of defining features in the new South African curriculum policy documents) learner-centred learning requires teachers to make provision for differences between learners by

[3] A name commonly used to refer to the original curriculum implemented from 1998.

taking into account variations in factors like learning styles, languages and backgrounds of their learners. The use of activities does not necessarily make classes learner-centred.

- **Some South African teachers lacked an understanding of what 'learner-centred' means.** A common misconception among South African teachers regarding learner-centredness seems to revolve around the belief that classes are learner-centred if learners are involved in some form of activity, i.e. some teachers think that 'activity-based' and 'learner-centred' mean essentially the same thing. Such a misunderstanding will affect the success of implementing learner-centred lessons. In a study involving 11 Grade 7-9 teachers from eight schools in three school districts in Gauteng, Harris, Mkhomazi, Misser, and Sitsha (2003, p. 105) found that teachers (exact number not given) "*assumed that lessons were learner-centred if learner activity was taking place*". One of the 11 teachers was quoted as saying that "*learners must be actively involved in learning",* which the teacher defined as learners being *"able to follow instructions, do some experiments and to answer questions on their own*" (Harris et al*.,* 2003, p. 105). In a study reported by Sanders and Kasalu (2004) only two of the ten Gauteng teachers interviewed understood learner-centredness, while the remaining eight thought activity-based and learner-centred meant essentially the same thing: learners carrying out activities in class.
- **Some teachers were not attempting to make teaching learner-centred**. Johnson, Scholtz, Hodges and Botha (2002, p. 87) believed that some teachers were not ready to make the changes required to their "*pedagogic strategy*" to make teaching learner-centred. Teachers were failing to make learning learner-centred by not accommodating differences between learners. In an investigation into the practices of 18 teachers from three schools in Gauteng and nine in the Northern Province, who had attended an in-service programme during which they were exposed to a number of strategies which could be used to make their teaching learner-centred, Brodie, Lelliott and Davis (2002) found that the majority of the teachers (11 of the 18) were found to be using methods that that did not fully comply with learner-centred teaching, while four of the 18 did not attempt to employ any of the learner-centred strategies to which they had been exposed. In another study six of the ten teachers interviewed had not made provision to accommodate the differences between the learners in their classes and were therefore not complying with this curriculum requirement (Khoali, 2012).

Teachers' failure to fully implement activity-based learning.

The new curriculum requires the use of a variety of activities during lessons to engage learners (National Department of Education, 1997). Teachers failed to fully implement activity-based learning for the following reasons:

- **Some teachers lacked an understanding of what 'activity-based' learning means.** Researchers have pointed out that to promote meaningful learning the activities used should not just be physical activities, but should be purposefully chosen to engage learners in some mental activity in order to promote the construction of knowledge (Mashalaba & Sanders, 2003; Prince, 2004). Hausfather (2001, p. 18) believes that "*mental activity is of primary importance, and depending on developmental level, physical activity merely leads us to that end*". The new curriculum requires learning to be *'*activity-based'. Many teachers appeared not to have understood this curriculum requirement, many using practical activities to verify facts already taught. One of the teachers in a study about teachers' use of curriculum materials, involving 340 teachers from the Western Cape, admitted that "*she still felt the need to teach*

the lesson before giving out the activities on the topic" (Johnson et al., 2002). Khoali and Sanders, investigating the extent to which ten teachers were using the approaches required by the new curriculum, found that three teachers used activities because they were required by the new curriculum and not because the activities had intrinsic educational value (Khoali, 2004). In the same study it was noted that while three out of the ten teachers used meaningful activities, the activities used by two of the teachers would not have led to any knowledge construction on the part of learners, and seemed not to have any educational value.

- **Some teachers were not attempting to make learning activity-based.** Some teachers appeared to be finding it difficult to relinquish control and allow learners to be actively engaged in learning. One of the four mathematics teachers in the Eastern Cape study by Morar (2004) admitted to using drill methods of teaching despite knowing that he was required to use methods of teaching in which learners would be actively engaged in constructing the own knowledge. This teacher believed that the teacher-centred drill methods he used allowed learners to "*understand some work and keep it in their minds*" (Morar, 2004, p. 688). The teacher cited the large size of his class as the reason why he was not involving learners in activities.

Teachers' failure to fully implement the requirement that teachers be 'facilitators of learning'

Facilitating learning is a complex task, encompassing planning suitable lessons to achieve specific outcomes, creating a suitable learning environment, monitoring learners' progress, and consolidating learners' knowledge (Sanders and Kasalu, 2004). Johnson, Scholtz, Botha and Hodges (2003) described some of the changes the role of facilitator requires teachers to make as follows:

> *The teacher must move away from the blackboard and from a role as dispenser of wisdom. Instead the teacher needs to act as organiser of the learners' discussions and manager of group work and feedback in a way that leads to whole class consensus and closure for the activity.* (Johnson et al., 2003, p. 87)

- **Some teachers did not understand what is meant by teachers being 'facilitators of learning'.** Some teachers appeared not to have fully understood the need to monitor learners' progress. Khoali (2012) reported that not all of the ten teachers interviewed in a study they reported on understood that facilitation incorporates monitoring learning and intervening in the learning process when necessary. In a study investigating the curriculum practices of mathematics teachers from four rural schools in the Eastern Cape, Morar (2004) reported although under the impression that he was acting as a facilitator of learning during lessons, one teacher failed to provide learners with the resources needed to carry out the lesson (Morar, 2004, p. 688). Sanders and Kasalu (2004, p. 922) found that few of the ten Gauteng biology teachers interviewed appreciated the importance of "*setting up a favourable environment for learning, providing the necessary resources to allow learners to learn for themselves or the need to consolidate at the end of a learning session*". All of these are an essential part of teachers facilitating learning.
- **Some teachers were not facilitating learning.** From studies investigating how teachers were implementing this curriculum requirement, it appears that some teachers
  - were not monitoring the work taking place and providing the necessary input where required. Rogan (2003) found that in three of the 18 lessons observed in the study he reported, learners were left to their own devices once they had been given work, meaning that the teachers were not monitoring learners or providing any input.

- were not providing the necessary resources for learning to take place. In one study involving ten teachers from seven schools, Khoali (2012) found that two of the ten teachers did not provide the resources required for the activities learners were meant to carry out. In the study investigating the curriculum practices of mathematics teachers from four rural schools in the Eastern Cape, Morar (2004) reported that one teacher's choice of resources did not support the achievement of the outcomes she had planned for the lesson.
- were not adequately prepared to facilitate lessons. Seven of the ten teachers in the study reported by Khoali (2012) seemed to be inadequately prepared for their lessons. Five of the teachers did not facilitate learning because the teaching approaches they used (general class discussions based on learners' existing knowledge and tasks which did not lead to learning) did not allow a deepening of learners' understanding of science. One of the four mathematics teachers in the study by Morar (2004) failed to fulfil the role of facilitator because she lacked the content knowledge needed for the lesson.
- were not consolidating learners' findings from activities. Four of the ten teachers interviewed by Khoali failed to consolidate learners' findings after group work had been done, thereby not ensuring that the learners' scientific understanding was correct and complete (Khoali, 2012).

Teachers' failure to implement continuous assessment

According to Sanders and Kasalu (2004) one of the purposes of assessment is that it can be used as a strategy to promote learning through making learners aware of the criteria they need to meet and by providing learners with meaningful feedback on their progress.

Some teachers appeared not to have fully grasped how continuous assessment should have implemented, as suggested by the following research evidence:

- Rogan and Aldous (2004) found that the teachers they interviewed in their Mpumalanga study reported problems implementing continuous assessment. The teachers had attended workshops in which they had been exposed to the theory behind the policy, but had not been advised how to implement it. Rogan and Aldous (2004) point out that the workshop facilitators are unlikely to have had much experience of how to implement continuous assessment and were possibly not in a position to advise teachers on how to implement the new assessment policy.
- In another study only one of the ten teachers interviewed fully understood the concept of continuous assessment (Khoali, 2012). Three of the ten teachers in this study appeared to think that regularly conducting informal assessment by asking questions to whole classes without the use of a formal measuring tool (like a rubric) was sufficient. One of the ten teachers in this study misunderstood the concept of assessment within the new curriculum as evident in his belief that learners could never be wrong (Khoali, 2012).

Some teachers had misconceptions related to what they were supposed to be assessing with continuous assessment. While the new curriculum required teachers to assess according to the learning outcomes for a particular subject, some teachers were still focusing only on assessing learners' acquisition of content knowledge without taking into account the learning outcomes dealing with the development of skills and values.

- In the 2007 investigation of six Grade 7 and six Grade 9 teachers' understanding of what continuous assessment required them to do, van Laren and James (2008) reported that all 12

teachers believed that their assessment practices should still be focusing solely on knowledge acquisition by learners. Only one of the Grade 7 teachers mentioned that assessment should also cover skills and values, while another of the Grade 7 teachers mentioned only the need to assess learners' values. Of the Grade 9 teachers interviewed, three referred to assessment as including skills, but none of them made reference to the need to assess values.

- Some teachers seemed not to "*approve of the view that assessment should support learning*" (Vandeyar & Killen, 2007, p. 110). The three urban primary school teachers from "*a large South African city*" (Vandeyar & Killen, 2007, p. 105) in one study held this view. These teachers felt that the aim of assessment was to hold learners accountable for their learning, showing that these teachers did not fully appreciate what continuous assessment entails.

Some teachers were not using assessment practices as required by the new curriculum. Khoza (2004), on investigating the assessment practices of five Grade 9 mathematics teachers from a secondary school in Gauteng, found that the teachers were not addressing the learning outcomes for this subject adequately in assessment tasks they set for learners. The degree to which the learning outcomes were reflected in assessment tasks differed greatly from the recommendations stated in the curriculum statement for mathematics (Khoza, 2004). Morar (2004) found that two of the four Eastern Cape teachers from rural secondary schools were still conducting only summative assessments in the form of tests and examinations instead of the ongoing assessment involving a variety of forms of assessment required when carrying out continuous assessment.

Teachers' failure to comply with the requirement for group work to be used

One curriculum requirement was that group work should feature prominently as a teaching approach. Some teachers lacked an understanding of the role and use of group work, suggested by the following evidence:

- One of the ten teachers interviewed by Khoali (2012) believed that all learning had to take place in groups, revealing a misunderstanding of the requirement for group work to feature prominently, but only where appropriate. For group work to be constructive, teachers should monitor the work taking place to ensure that learners are participating equally and proceeding with the task at hand. Few of the ten Gauteng biology teachers interviewed by Sanders and Kasalu (2004) understood the teachers' role in ensuring that group work was constructive.
- Some teachers were not using group work in the way it was intended to be used within the new curriculum, which is allowing social interactions to enhance learning through collaborative work. Some teachers seemed to think that seating learners in groups or assigning tasks to groups of learners satisfied this curriculum requirement, but this did not comply with the curriculum requirement as learners sitting together does not mean that collaboration is taking place, let alone collaborative learning. Evidence for teachers' failure to use group work correctly is provided below:
- In his Mpumalanga study, Rogan (2004) found little evidence of meaningful group work occurring despite learners being seated in groups or being assigned tasks in groups. Further evidence of the failure to use group work properly was supplied by Harris et al. (2003). These researchers reported that some Gauteng teachers in their study (exact number not given) believed that seating learners in groups meant that group work was taking place, even though the researchers observed that learners seated in clusters often worked on their own. Group

work is meant to enhance learning through its collaborative nature, but one teacher in the study by Khoali (2012) used group work in a manner unlikely to promote meaningful learning.

Some teachers lacked an understanding of how curriculum content can be made relevant to learners.

There are different ways in which lesson content can be made relevant to learners (Sanders & Kasalu, 2004). One of the ways content can be made relevant is by virtue of its relationship to learners' life experiences, or based on potential future significance to learners, or because learners might find it interesting (Sanders & Kasalu, 2004). In six of the seven schools in their study Khoali (2012) found that teachers were merely tagging social issues onto the end of their lessons in an attempt to meet the curriculum requirement that content must be relevant. These researchers point out that merely adding on some relevant examples at the end of lessons does not adequately meet the curriculum requirement.

Appendix D:

Summary of 48 studies investigating teachers' use of computers

Name	Country	Sample	Aim	Method
Zammit, S. (1992)	Australia	102 teachers who used computers and 250 teachers who did not use computers in lessons from 7 secondary schools.	To develop a hierarchy of factors facilitating or hindering the use of computers.	Surveyed teachers who use computers and those who don't using a questionnaire with a rating scale.
Marcinkiewicz, H.R. (1993)	United States	149 teachers, 8% who had integrated computers into their teaching, 47% who used computers for purposes other than teaching and 45% who did not use computers.	Study investigated the effect of the personal variables of primary school teachers' use of their use of ICT in the classroom.	Teachers self-reported on their levels of innovativeness, self-competence and their perceived relevance of computers using a 7-point rating scales (1 = strongly disagree to 7 = strongly agree).
Chiero, R. (1997)	United States	36 teachers (70.6% primary school, 11.8% middle school and 16.6% high school)	To investigate 14 teaching-related tasks including teachers' use and their attitudes towards computers and obstacles to using computers.	Survey using a 48-item questionnaire. For frequency of computer use a Likert scale ranging from 'never' to 'more than once a week' was used.
Russell, G. and Bradley, G. (1997)	Australia	350 primary and secondary school teachers in government schools in rural and urban Queensland.	To investigate sources of computer anxiety for teachers. Teacher computer anxiety is believed to hinder use of computers.	Survey using a ranking scale where 1 = most effective/ appealing and 6 = least effective/ appealing for some factors. Supporting data not always supplied.
Drenoyianni, H. and Selwood, I. (1998)	United Kingdom	37 teachers from six primary schools in Birmingham.	To investigate problems and constraints regarding teachers' computer use.	Questionnaire was administered to 30 teachers. Eleven teachers were interviewed (four of whom had answered the questionnaire) and classroom observations were carried out for six of the 11 teachers.
Cox, M., Preston, C. and Cox, K. (1999)	United Kingdom	Literature review of findings from a 1992 project to promote use of technology and a survey of 82 teachers.	To investigate factors affecting teachers' use of computers.	Literature review and questionnaire based on teachers' use of ICT.
Ertmer, P.A. and Hruskocy, C. (1999)	United States	Thirteen teachers from one primary school.	To investigate the impact of support for technology integration on teachers' attitudes towards using technology	Survey with follow-up interviews.
Quick, D. and Davies, T.G. (1999)	United States	18 faculty members from a community college.	To investigate the instructional needs and wants of faculty members.	18 formal interviews of which 10 were analysed and followed up with tutoring sessions. No quantitative results were reported.
Selwyn, N. (1999)	United Kingdom	96 students and 20 teachers from 5 school-based sixth forms, 1 sixth form college and 5 further education and training colleges.	To investigate the extent to which subject culture influenced the use of computers for teaching and learning.	Used focus groups and interviews with students; conducted semi-structured interviews with teachers; also interviewed one IT coordinator from each school (semi-structured).
Wellington, J. (1999)	United Kingdom and Singapore	47 schools and colleges in United Kingdom and 3 in Singapore.	To investigate factors affecting teachers' use of computers.	Survey of schools participating in a project which provided teachers with a CD-ROM, lesson plans and worksheets and a website for on-line support. Six in-depth case studies were also conducted. .
Becker, J. (2000)	United States	More than 4000 teachers from more than 1100 schools.	To investigate teachers' use of computers for instructional purposes, the characteristics of teachers who use computers and the conditions under which teachers would use computers.	Survey.
Williams, D., Coles, L., Wilson, K., Richardson, A., and Tuson, J. (2000)	Scotland	Survey: 352 primary and 329 secondary school teachers. Interviews with 23 secondary school teachers and 13 primary school teachers.	To investigate the factors affecting teachers' uptake of ICT in the classroom.	Survey of teachers' current ICT usage, their level of ICT training and their perception of their ICT knowledge and skills needs. Scenario interviews were conducted where teachers had talk through how they would respond to a particular situation.

Name	Country	Sample	Aim	Method
Cuban, L., Kirkpatrick, H. and Peck, C. (2001)	United States	21 teachers and 26 learners from 2 high schools.	To investigate whether teachers were using computers and possible barriers to computer usage	Data collection techniques included interviews with teachers and learners, classroom observations, teacher and learner surveys. No figures reported for barriers to usage.
Nisan-Nelson, P. (2001)	United States	Three teachers from different high schools who participated in a technology workshop.	To investigate the effect of teachers' learning styles and their problem-solving ability on their use of technology.	Teachers' learning styles were determined using a 12-item test. Their problem-solving ability was measured using 35-item instrument with a 6-point Likert scale. Questionnaires were also administered to investigate the teachers' technology experience and their technology use. A document analysis of lesson plans and emails was also conducted.
Pelgrum, W. J. (2001)	24 countries including SA	Representative samples of schools at primary and secondary schools. Exact numbers not supplied.	Investigated obstacles to computer use at lower secondary level.	Teachers were surveyed to find out what they regarded as major obstacles to computer use in the school. The results were presented as a list of 38 obstacles sorted by average percentage respondents across countries.
van Braak, J. (2001)	Brussels	51 teachers who used networked computers and 182 teachers who used stand-alone computers from public and private secondary schools.	To investigate factors influencing teachers' use of networked computers.	Standardised questionnaire with investigating factors including teachers' computer experience, attitudes towards using networked computers, innovativeness, evaluation of the attributes of networked computers, and the organisational constraints to the use of technology. Mean scores for the two groups were calculated.
Baylor, A. and Ritchie, D. (2002)	United States	94 teachers from 12 highly technology-integrative schools (5 primary, 5 middle and 2 high) across 5 states.	To investigate the factors influencing a variety of outcomes including technology integration.	Survey with a 5-point Likert scale and structured teacher interviews.
Butler, D. and Sellblom, M. (2002)	United States	125 lecturers from a University in Indiana.	To investigate lecturers' use of technology and the barriers to lecturers' use of computers.	Questionnaires.
Dori, Y. J., Tal, R.T., and Peled, Y. (2002)	Israel	67 science teachers from 9 junior secondary schools.	To investigate teachers' willingness to use web-based teaching after receiving training.	Qualitative study. No figures supplied.
Zhao, Y., Pugh, K., Sheldon, S., and Byers, J. (2002)	United States	10 teachers who were recipients of a state technology innovation grant.	To investigate the implementation of projects involving technology in relation to teacher knowledge, how innovative the project was and how well the project fitted into the school context.	Multi-level study including 10 case studies. No figures supplied. Figures used in Tables 2.2 and 2.3 are those inferred from findings of study.
Russell, M., Bebell, D., O'Dwyer, L., and O'Connor, K. (2003)	United States	2894 teachers from Massachusetts schools participating in a technology study.	To investigate teachers' beliefs about technology and use of technology.	Survey.
Shannon, S. and Doube, L. (2003)	Australia	156 academic staff members from the University of Adelaide.	To investigate factors affecting teachers' decisions to use technology in their teaching.	Survey. Also conducted 12 face-to face semi-structured interviews.
Zhao, Y. and Frank, K.A. (2003)	United States	Teachers from 19 elementary schools from a Midwestern state. Schools were selected on the basis of ready access to technology.	To investigate factors that affect teachers' use of computers.	Survey and semi-structured interviews with 3-5 teachers and the school principal in 1 focal school in each district. Interviews focused on technological infrastructure, policy, investment and teacher beliefs about technology. Observations of technological

Name	Country	Sample	Aim	Method
				infrastructure in same focal school from each district.
Lai, K. and Pratt, K. (2004)	New Zealand	Survey: 21 computer co-ordinators, 22 principals and 207 teachers from 22 of the 26 secondary schools. Interviews: 14 computer co-ordinators.	To evaluate the use of ICT in secondary schools with a focus on the role of computer co-ordinators in the integration of ICT.	Questionnaires on use of and access to ICT, professional development, ICT support and the level of skills. Follow-up interviews were conducted with 14 computer co-ordinators about their roles, responsibilities and beliefs regarding the use of ICT in their schools.
McCarney, J. (2004)	Scotland	40 teachers from 40 primary schools.	To investigate the impact of the types of knowledge and skills gained by teachers from ICT staff development	Questionnaire on the effectiveness of different types and models of staff development in ICT.
Priest, J., Coe. R., Evershed, B., and Bush, N. (2004)	United Kingdom	83 learners and 28 parents of a primary school in Greenwich.	To investigate teachers' use of technology.	Multi-level study. No figures reported for teacher beliefs.
Vannatta, R. and Fordham, N. (2004)	United States	170 teachers from 6 Northwest Ohio schools (4 primary and 2 secondary).	To investigate the factors that would influence teachers' use of computers in the classroom.	Survey.
Bauer, J. and Kenton, J. (2005)	United States	30 technologically-savvy teachers from four schools (two primary, one middle and one secondary) in one US state.	To investigate factors affecting teachers' use of computers.	Survey with a 5-point Likert scale. Observation and informal interviews.
Kanaya, T., Light, D., and McMillan Culp, K. (2005)	United States	237 teachers from 130 school districts across 15 regions of the US who had enrolled in a teacher development programme (Intel Teach to the Future).	To investigate the factors affecting teachers' use of computers after attending a training programme.	Two surveys: one just after the training was completed and one at the end of the school year subsequent to the training.
Selwood I. and Pilkington, R. (2005)	England and Wales	Sample numbers varied depending on the number of teachers who responded to different questions.	To investigate factors influencing teachers' use of ICT.	2003 survey data relating to ICT use from a government project were analysed and compared to changes from a 2002 survey. The project included supplying new hardware, software and teacher training. Interviews were also carried out.
Wood, E., Mueller, J., Willoughby, T., Specht, J., and Deyoung, T. (2005)	Canada	54 teachers (37 primary and 17 secondary) form a Canadian city.	To investigate factors affecting teachers' use of computers.	Survey. Focus groups.
Sahin, I. and Thompson, A. (2006)	Turkey	117 faculty members on one College of Education at an Anatolian University	To investigate the level of use of computers among the faculty members and the factors affecting their use	Questionnaire with a 5-point Likert scale
Castro, M. and Alves, L. (2007)	Brazil	Science teachers from public schools (34 state-funded and 11 municipal-funded) in Niterói city, Rio de Janeiro.	To investigate factors affecting teachers' use of computers.	Survey.
Ng, W. and Gunstone, R. (2007)	Australia	79 teachers from 47 government secondary schools in Southern Metropolitan Region of Victoria.	To investigate teacher attitudes towards use of ICT, perceived benefits of ICT, and support for their ICT use.	Survey. A subset of 22 teachers from 16 schools was interviewed.
Al-Fudail, M. and Mellar, H. (2008)	United Kingdom	9 teachers and 32 hours of teaching time.	To investigate the amount of teacher stress induced by various activities associated with ICT use.	Direct observation, video-logging and recordings of galvanic skin responses were recorded to establish the amount of teacher stress. The stress-causing activities

Name	Country	Sample	Aim	Method
				can be viewed as obstacles to ICT integration. No figures were supplied.
Drent, M. and Meelissen, M. (2008)	Netherlands	Secondary analysis of data for 210 3rd and 4th year primary education teacher educators collected through a large scale national study (ICT monitor 1991-2000).	To identify the factors which affect teachers' use of ICT.	Questionnaires and semi-structured interviews with four teachers.
Hermans, R., Tondeur, J., van Braak, J., and Valcke, M. (2008)	Belgium	525 primary school teachers from 68 schools in Flanders.	To identify the factors which affect teachers' use of ICT.	Survey with a 5-point Likert scale.
Hossain, S. and Brooks, L. (2008)	United Kingdom	16 staff members from 3 secondary schools.	To investigate the factors affecting the adoption of educational software.	Questionnaires with close-ended questions and semi-structured interviews.
Tondeür, J., van Keer, H., van Braak, J., and Valcke, M. (2008)	Belgium	574 teachers from 60 schools (minimum of 6 teachers per school).	Investigated teachers' use of computers and the factors affecting their use of computers in the classroom.	Survey with multi-level analysis of findings.
Blignaut, A., Hinostroza, J., Els, C., and Brun, M. (2010)	Chile and South Africa (SITES 2006[4])	1400 Grade 8 mathematics and science teachers from 504 South African schools and 596 Chilean schools.	Investigation of factors affecting Chilean and South African teachers' use of computers (secondary analysis of SITES 2006 data)	Analysed selected questions from the SITES 2006 teacher questionnaire.
Chen R-J. (2010)	United States	206 preservice teachers from one university in California.	To develop an SEM model of the factors influencing preservice teachers' use of technology for learner-centred teaching.	Questionnaire.
Chigona, A. and Chigona, W. (2010)	South Africa	14 teachers from 4 secondary schools which had been supplied with a 25-computer lab as part of the Khanya project.	To investigate the factors affecting the use of ICT for teaching.	Semi-structured interviews; no figures supplied.
Voogt, J. (2010)	22 countries (SITES 2006[1])	3027 Grade 8 science teachers (1754 who used ICT extensively and 1273 who used ICT, but not extensively).	To investigate the factors affecting teachers' innovative pedagogical use of ICT.	Analysed selected questions from the SITES 2006 teacher questionnaire.
Ward, L. and Parr, J.M. (2010)	New Zealand	199 teachers from 4 secondary schools with sound ICT infrastructure.	To investigate the extent and level of teachers' usage of computers and what factors affect their computer usage.	Survey with 30 sections and 185 items. Some sections used a 4-point Likert scale and others a 5-point Likert scales. Section relevant to this study looked at factors affecting particular types of use, e.g. teacher use vs. learner use.
Donnelly, D. , McGarr, O., and O'Reilly, J. (2011)	Ireland	Initial study: 7 science teachers Final study: 5 chemistry teachers from 5 different towns and cities across Ireland	To investigate factors affecting teacher's uptake of a virtual chemistry lab.	Initial interviews with 7 science teachers; Observations and semi-structured interviews with 5 chemistry teachers; focus groups with students.

[4] The Second Information Technology in Education Study (SITES) is a study conducted between 1999 and 2006. The study consists of three modules, each of which focused on a different aspect of ICT in education. SITES 2006 refers to the third module implemented in 2006 which collected data from 22 countries (20 from the northern hemisphere and 2 from the southern hemisphere). The study focused on teachers' pedagogical practices and the use of ICT in teaching and learning.

Name	Country	Sample	Aim	Method
Ertmer, P., Ottenbreit-Leftwich, A., Sadik, O., Sendurur, E., and Sendurur, P. (2012)	United States	12 teachers who had won awards for their technology practices.	To examine alignment between teachers' pedagogical beliefs and their classroom practices.	Document analyses of teachers' websites; semi-structured interviews with teachers and survey using a 5-point Likert scale.
Vanderlinde, R., van Braak, J, and Dexter, S. (2012)	Belgium	62 primary school teachers from Flanders.	To investigate factors affecting teachers' use of computers.	Survey.

Appendix E:

Frequency counts for factors from 48 papers reviewed

	Category	Factor	Al-Fudail and Mellar (2008)	Bauer and Kenton (2003)	Baylor and Ritchie (2002)	Becker (2000)	Blignaut et al. (2010)	Butler and Sellblom (2002)	Castro and Alves (2007)	Chen (2010)	Chiero (1997)	Chigona and Chigona (2010)	Cox et al. (1999)	Cuban et al. (2001)	Donnelly et al. (2011)	Dori et al. (2002)	Drenoyianni and Selwood (2003)	Drent and Meelissen (2008)	Ertmer and Hruskocy (2009)	Ertmer et al. (2012)	Hermans et al. (2008)	Hossain and Brooks (2008)	Kanaya et al. (2005)	Lai and Pratt (2004)	Marcinkiewicz (1993)	McCarney (2004)	Mueller et al. (2010)	Ng and Gunstone (2003)	Nisan-Nelson (2001)	Pelgrum (2001)	Priest et al. (2004)	Quick and Davies (1999)	Russell and Bradley (1997)	Russell et al. (2003)	Sahin and Thompson (2006)	Selwood and Pilkington (2005)	Selwyn (1999)	Shannon and Doube (2009)	Tondeur et al. (2008)	van Braak (2001)	Vanderlinde et al. (2012)	Vannatta and Fordham (2004)	Voogt (2010)	Ward and Parr (2010)	Wellington (1999)	Williams et al. (2000)	Wood et al. (2005)	Zammit (1992)	Zhao and Frank (2003)	Zhao et al. (2002)	**Grand Total**
Institutional-level	Finance (13)	Finance		•									•		•					•				•				•									•						•				**13**
	Hardware-related (67)	Availability of ICT hardware		•			•					•	•	•						•		•						•	•	•	•			•			•	•	•			•	•	•	•	**23**
		Accessibility of equipments		•		•		•	•	•	•	•	•	•	•							•						•	•	•	•			•			•	•	•			•	•	•	•	**28**
		Functionality of equipment	•	•				•	•		•			•						•		•						•		•		•	•					•					•				•	**16**
	Software-related (22)	Availability of software for use in teaching		•			•		•																					•								•	•			•			•	•			**11**
		Quality & suitability of software						•							•														•		•	•							•							•				**7**
		Ease of use of software						•			•																		•		•																				**4**
	In-service training (43)	Extent of training provided	•		•		•		•		•	•		•		•	•			•			•	•		•				•	•	•	•		•	•		•	•	•	•			•	•	•	•	**27**
		Nature of training provided			•							•				•	•						•	•		•				•	•			•	•											•	•	**16**
	Support-related (112)	School policy & guidelines for integrating ICT																		•				•						•			•																	**10**
		ICT culture in school & leadership			•		•	•		•						•		•		•		•		•								•			•		•	•	•	•	•				•	•	•	•	**21**
		Level of technical support	•	•			•	•	•	•	•	•	•	•			•		•	•		•		•						•		•			•		•	•	•	•			•	•		•	•	**28**
		Having an ICT coordinator					•		•									•						•											•		•		•								•	**9**
		Having a pedagogical advisor					•			•														•						•			•				•		•			•							**10**
		Support from other teachers	•							•	•				•	•				•				•		•				•			•				•	•				•	•		•	•	•	**18**
		Level of administrative support																																	•										•				•	**3**
		Need for teaching assistants								•									•															•							•	•	•	•	•				**9**
		Support from learners												•					•																									•	•				**4**
	Time (41)	Time to prepare lessons						•			•									•				•						•	•	•		•								•	•	•	•	•			**14**
		Time for computer use in lessons	•	•						•				•	•		•							•				•		•	•	•				•						•				•		**15**
		Time to learn to use ICT	•	•		•		•		•			•	•			•			•				•											•			•						•					**12**
			6	**8**	**3**	**2**	**7**	**8**	**6**	**8**	**7**	**5**	**5**	**8**	**5**	**4**	**5**	**2**	**3**	**10**	**0**	**5**	**2**	**11**	**0**	**3**	**0**	**8**	**2**	**14**	**6**	**8**	**10**	**3**	**12**	**4**	**3**	**7**	**8**	**10**	**8**	**0**	**0**	**8**	**9**	**10**	**15**	**12**	**7**	**11**	**298**

	Category	Factor	Al-Fudail and Mellar (2008)	Bauer and Kenton (2003)	Baylor and Ritchie (2002)	Becker (2000)	Blignaut et al. (2010)	Butler and Sellblom (2002)	Castro and Alves (2007)	Chen (2010)	Chiero (1997)	Chigona and Chigona (2010)	Cox et al. (1999)	Cuban et al. (2001)	Donnelly et al. (2011)	Dori et al. (2002)	Drenoyianni and Selwood (1998)	Drent and Meelissen (2008)	Ertmer and Hruskocy (1999)	Ertmer et al. (2012)	Hermans et al. (2008)	Hossain and Brooks (2008)	Kanaya et al. (2005)	Lai and Pratt (2004)	Marcinkiewicz (1993)	McCarney (2004)	Mueller et al. (2010)	Ng and Gunstone (2003)	Nisan-Nelson (2001)	Pelgrum (2001)	Priest et al. (2004)	Quick and Davies (1999)	Russell and Bradley (1997)	Russell et al. (2003)	Sahin and Thompson (2006)	Selwood and Pilkington (2005)	Selwyn (1999)	Shannon and Doube (2003)	Tondeur et al. (2008)	van Braak (2001)	Vanderlinde et al. (2012)	Vannatta and Fordham (2004)	Voogt (2010)	Ward and Parr (2010)	Wellington (1999)	Williams et al. (2000)	Wood et al. (2005)	Zammit (1992)	Zhao and Frank (2003)	Zhao et al. (2002)	**Grand Total**
Teacher-level	Teaching profile (15)	Subject culture				•						•		•						•									•		•		•							•	•		•		**13**
		Teaching experience																															•	•													**2**
	Social proficiency (1)	Interpersonal skills																																												•	**1**
	Beliefs about ICT (58)	Teaching philosophy			•	•	•			•				•	•		•	•	•	•	•		•				•	•	•			•		•		•	•				•	•	•		•	**25**
		Perceived relevance of ICT to teaching				•	•	•		•			•	•	•		•	•		•			•	•			•	•						•	•	•	•	•			•	•	•	•		**28**
		Locus of control								•			•												•				•																	•	**5**
	Attitudes towards ICT (68)	Level of innovativeness		•	•										•	•		•		•				•	•				•	•				•		•		•	•	•				•	•		**18**
		Level of confidence	•	•			•			•		•	•						•	•						•		•				•	•		•							•	•	•			**19**
		Enthusiasm for using ICT											•		•			•		•	•			•		•	•		•					•		•	•	•					•		•		•	**16**
		Teachers' preferred learning style											•				•											•																				**3**
		Fear of embarrassment	•																													•				•												**3**
		Fear of loss of status																																			•						•						**2**
		Fears about managing learners in lessons											•				•											•	•								•						•	•					**7**
	ICT profile (83)	ICT training		•	•					•		•			•				•			•	•	•		•						•				•	•						•		•	**19**
		Length of ICT experience													•			•			•		•	•								•						•					•					**8**
		ICT use outside of teaching			•	•							•	•				•		•	•	•	•	•			•					•			•			•					•		•			**18**
		ICT competence	•	•	•	•	•	•		•	•	•	•		•		•	•	•	•		•	•	•	•			•		•		•		•	•		•		•		•	•	•	•	•	•	**34**
		Positive experiences using ICT																	•								•																					**2**
		Difficulty integrating ICT into instruction	•																										•																				**2**
			4	**4**	**5**	**5**	**4**	**2**	**0**	**6**	**1**	**4**	**8**	**4**	**7**	**1**	**5**	**7**	**5**	**8**	**4**	**3**	**6**	**7**	**3**	**0**	**7**	**5**	**6**	**4**	**1**	**2**	**7**	**4**	**6**	**4**	**9**	**5**	**6**	**3**	**4**	**3**	**4**	**7**	**4**	**7**	**7**	**7**	**4**	**6**	**225**

	Category	Factor	Al-Fudail and Mellar (2008)	Bauer and Kenton (2003)	Baylor and Ritchie (2002)	Becker (2000)	Blignaut et al. (2010)	Butler and Sellblom (2002)	Castro and Alves (2007)	Chen (2010)	Chiero (1997)	Chigona and Chigona (2010)	Cox et al. (1999)	Cuban et al. (2001)	Donnelly et al. (2011)	Dori et al. (2002)	Drenoyianni and Selwood (1998)	Drent and Meelissen (2008)	Ertmer and Hruskocy (1999)	Ertmer et al. (2012)	Hermans et al. (2008)	Hossain and Brooks (2008)	Kanaya et al. (2005)	Lai and Pratt (2004)	Marcinkiewicz (1993)	McCarney (2004)	Mueller et al. (2010)	Ng and Gunstone (2003)	Nisan-Nelson (2001)	Pelgrum (2001)	Priest et al. (2004)	Quick and Davies (1999)	Russell and Bradley (1997)	Russell et al. (2003)	Sahin and Thompson (2006)	Selwood and Pilkington (2005)	Selwyn (1999)	Shannon and Doube (2003)	Tondeur et al. (2008)	van Braak (2001)	Vanderlinde et al. (2012)	Vannatta and Fordham (2004)	Voogt (2010)	Ward and Parr (2010)	Wellington (1999)	Williams et al. (2000)	Wood et al. (2005)	Zammit (1992)	Zhao and Frank (2003)	Zhao et al. (2002)	**Grand Total**
Learner-related	Access to ICT resources (3)	Access to computer hardware												•																															•		•				**3**
	Attitudes to use of ICT (10)	Level of learner interest in ICT use in lessons													•				•	•								•									•			•				•	•	•	•				**10**
	Learner ICT profile (10)	Level of learner ICT competence	•	•															•	•										•							•				•				•		•	•			**10**
			1	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**3**	**1**	**3**	**1**	**0**	**0**	**23**

Appendix F:

Institution-level factors affecting teachers' use of ICT, summarised from 48 studies reviewed

	Factor	Empirical evidence for sub-factor affecting ICT use in the classroom[5]
Finance	Adequacy of finances to supply needs: *Availability of finances for costs associated with the provision of ICT resources, e.g. the initial outlay for equipment.*	1. Some of the 30 tech-savvy teachers in the study by Bauer and Kenton (2005) cited insufficient funds to buy the type of software they wanted to use in their lessons as an obstacle to their computer use. 2. Cox et al. (1999): More than 65% of the 82 respondents in this study wanted more ICT equipment, but understood that technological equipment is expensive to supply. 3. The 21 secondary school principals in the study by Lai and Pratt (2004) saw the cost of equipment as the major factor affecting the use of ICT. 4. Ng and Gunstone (2003): Science teachers in this study were unable to purchase the technological equipment they required because their departmental budgets would not be able to cover the costs of such items. 5. Quick and Davies (1999): A lack of funding restricted the types of hardware and software that could be purchased by the 18 faculty members in this study. 6. Russell and Bradley (1997): Teachers in this study strongly resisted paying for their own ICT training, because they felt it was the school's responsibility to fund training. 7. Shannon and Doube (2003): Eighty-five percent of the respondents in this study cited the availability of funding for resources as impacting on their use of a learning management system. 8. van Braak (2001) reported insufficient funds to purchase ICT equipment as the major obstacle to teachers' use of computers. 9. Williams et al. (2000): Up to 7% of primary school teachers and 10% of non-computing teachers (both primary and secondary) identified the cost of buying software applications as a factor discouraging their use of ICT. 10. Wood et al. (2005): Teachers in this study were concerned that due to insufficient funds, money that should be used for textbooks would be used to buy ICT equipment. Teachers also mentioned that funds were not available for professional development. 11. Zammit (1992): Teachers who were non-class users of computers cited the lack of money to buy software as the 7th out of 12 factors preventing them from using computers for teaching. 12. Donnelly et al. (2011): In the Irish study, one of the five teachers felt the cost of acquiring new equipment was the biggest barrier to using ICT. 13. Ertmer et al. (2012) reported a lack of funding to buy resources as the fourth (out of 15) most significant barrier to teachers' computer use.
Hardware-related factors	Availability of ICT hardware: *The machines and associated equipment provided (e.g. keyboard, mouse, speakers) as well as computer infrastructure like Internet connectivity.*	1. Zammit (1992): A lack of hardware resources was ranked 2nd out of 7 factors hindering teachers' use of technology by teachers who use computers and 5th by teachers who do not use computers. Teachers who do not use computers identified increased availability of computers as the major factor that would encourage them to start using computers. 2. Russell and Bradley (1997): Computers were found not to be equally available to all teachers. Where not available, teachers could obviously not use them. 3. Cox et al. (1999): More than 65% of the 82 respondents in this study felt they needed more ICT equipment. 4. Wellington (1999): Lack of computer resources was identified as the most important barrier to computer use by most respondents. 5. Williams et al. (2000): Primary school teachers cited the lack of availability of resources as the main reason for not using ICT (e.g. 67% of primary teachers did not have access to the Internet). 6. Cuban et al. (2001) found that despite the two Californian schools in their study being 'technology-rich' by both Californian and national standards, about ¾ of the teachers who taught academic subjects were non-users of technology. 7. Pelgrum (2001): 70% of the teachers surveyed ranked insufficient computers as the main obstacle to computer use, while 57% of the teachers ranked insufficient peripheral hardware as a major obstacle. 8. Nisan-Nelson (2001) found that one of the three teachers in that study was discouraged from using computers for teaching and learning by the limited number of computers in the computer lab. 9. van Braak (2001): Teachers who used network computers reported that a lack of equipment hindered their use of technology.

[5] Figures have been supplied for those studies for which they were available.

		10. Zhao (2002) found that the lack of availability of resources negatively affected the success of 2 out of 10 projects involving technology. 11. Russell et al. (2003): The availability of ICT resources was found to be the 2nd most important indicator of technology use for instruction. 12. Priest et al. (2004) reported that the provision of hardware to teachers resulted in increased levels of ICT integration. 13. In the 2005 study by Bauer and Kenton, 4 out of 30 teachers reported significant difficulties getting enough computers to use for teaching. Two of the 30 teachers (7%) said that even when they could schedule time for classes to work in the computer lab, there were insufficient computers for their large classes. 14. Wood et al. (2005): Teachers cited the lack of sufficient computers for student use as the most significant barrier to their use of computers for teaching and learning. 15. Sahin and Thompson (2006): A lack of availability of computers was identified as a barrier to teachers' computer use. 16. Ng and Gunstone (2003): 55% of teachers reported that a lack of computers in their classrooms prevented them from using technology in their teaching, while 35% felt the number of computers in their classrooms (4 or less) was insufficient. 17. Hossain and Brooks (2008) found the availability of hardware to be one of the major factors affecting ICT usage. 18. Tondeur et al. (2008): A lack of hardware (as reflected by a higher pupil/pc ratio in the classroom) had a significantly negative effect ($p<0.001$) on ICT use. 19. In their secondary analysis of SITES 2006[6] data for South Africa and Chile, Blignaut et al. (2010) reported a lack of computer infrastructure as a major obstacle hindering the use of computers in teaching, especially in South Africa. 20. Chigona and Chigona (2010) reported insufficient computers (25 computers per computer lab compared to class sizes of about 40 learners) at the Khanya project schools for adequate learner use. One teacher expressed a need for computers in the classrooms. 21. Ward and Parr (2010) found the extent to which ICT resources are available for learner use to be a significant factor affecting the ICT use for learning ($p < 0.1$). 22. Vanderlinde et al. (2012) identified the availability of ICT infrastructure as an important factor affecting teachers' use of computers in their study. Two of the three case study schools, which displayed high levels of ICT usage for teaching and learning, were ranked 4th and 5th out of 62 schools surveyed with respect to their ICT infrastructure. 23. Ertmer et al. (2012) reported the lack of availability of resources as the 5th (out of 15) most significant barrier to teachers' computer use.
	Accessibility of equipment: *The extent to which computer equipment can be accessed for use during lessons when required by teachers and learners.*	1. Zammit (1992): The accessibility of computers was ranked 1st out of 7 factors hindering teachers' use of technology by teachers who use computers in the classroom and 4th by teachers who do not. 2. Chiero (1997): Lack of easy accessibility to computers was rated as a significant obstacle to computer use by 26.5% of teachers and as a moderate obstacle by 29.4%. 3. Russell and Bradley (1997): Teachers in this study blamed a lack of computers in classrooms for the limited use of technology for teaching and learning. 4. Cox et al. (1999): More than 65% of the 82 respondents in this study felt they needed access to more ICT equipment in the classroom for teaching. 5. Selwyn (1999): Teachers in this study expressed a need for computers in their classrooms as well as reporting that some subjects (regarded as 'non-IT subjects') experienced difficulty gaining access to the computer labs. 6. Wellington (1999) identified a number of factors related to the accessibility of equipment as barriers to computer use: lack of access to facilities, implications of using a booking system for facilities (lack of spontaneity, planning required) and distance to computer room. 7. Becker (2000) reported that subject teachers with between 5 and 8 computers in their classrooms (62%) are twice as likely to use computers in lessons than teachers whose classes used computers in a central location (32%).

[6] The Second Information Technology in Education Study (SITES) is a study conducted between 1999 and 2006. The study consists of three modules, each of which focused on a different aspect of ICT in education. SITES 2006 refers to the third module implemented in 2006 which collected data from 22 countries (20 from the northern hemisphere and 2 from the southern hemisphere). The study focused on teachers' pedagogical practices and the use of ICT in teaching and learning.

		8. Williams et al. (2000): Secondary teachers reported not having access to ICT resources like the Internet (16%) or digital scanners (8%) when needed. 9. Cuban et al. (2001) found that despite having computers available in labs, classrooms and libraries, there was low technology usage at the two 'technology-rich' Californian schools where they conducted their study. 10. Nisan-Nelson (2001): One of the three teachers in this study expressed frustration at having limited access to library computers and changes to the scheduled times when she was meant to be using the computers. The same teacher used technology at a high level of integration when she had access to the proper technological equipment in her classroom. 11. Pelgrum (2001): The need to book computers for use during lessons prevented 58% of respondents from using computers. 12. Butler and Sellblom (2002): Six out of 125 faculty members (4.8%) mentioned difficulties with scheduling access to computers for use with classes as an obstacle. 13. Zhao et al. (2002) found that 2/10 technology-based projects reviewed were negatively affected by limited access to a computer lab. 14. Russell et al. (2003) found the availability of ICT equipment to be an important predictor of technology use for instruction. 15. Shannon and Doube (2003): Faculty members cited a lack of access to ICT facilities for students as a barrier to their use of computers for instruction. 16. Zhao and Frank (2003) found that teachers used computers more in classrooms than in computer labs. 17. Priest et al. (2004) reported that the provision of laptops to teachers increased levels of ICT integration. 18. Bauer and Kenton (2005) reported that five of the 30 teachers (17%) in their study encountered scheduling difficulties accessing computers in computer labs for use with their classes. 19. Selwood and Pilkington (2005): Teachers in this study reported that technology access at school influenced their use of ICT for instruction. 20. Wood et al. (2005): The lack of accessibility of computers in classrooms was the third major barrier to elementary teachers' use of computers and the fourth major barrier for secondary teachers. 21. Sahin and Thompson (2006): Participants indicated a need for access to computers in classrooms. 22. Castro and Alves (2007) found that less than a third (32%) of the secondary schools in Rio de Janeiro had computer laboratories compared to 82% of the primary schools. However, only information technology teachers had regular access to the computer lab (once a week), while teachers of other subjects could only schedule time in the computer lab during one week of each month. 23. Ng and Gunstone (2003): Many teachers interviewed identified insufficient access to computers due to the location of the computers and timetabling restrictions as major obstacles to ICT integration. 24. Hossain and Brooks (2008) found the accessibility of hardware to be one of the major factors affecting ICT usage. 25. Chen (2010) found teachers' perceived ease of access to ICT resources had a significant effect ($p < 0.01$) on their use of computers for student-centred learning. 26. Chigona and Chigona (2010) reported very limited access to computers at the Khanya project schools. Only maths and science teachers had access to the computer labs for lessons. 27. Ward and Parr (2010) found the extent to which ICT resources are accessible to learners significantly affected their use of ICT for learning ($p < 0.1$). 28. Donnelly et al. (2011): Some teachers in the Irish study cited difficulties in arranging access to the computer room as a barrier to their use of ICT.
	Functionality of equipment: The functionality of the computer equipment provided:	1. Chiero (1997): 70.1% of respondents rated outdated equipment as an obstacle to computer use. 2. Quick and Davies (1999): Participants were discouraged from using computers by the age of the equipment. They also mentioned that their outdated equipment was incompatible with the software their students were using. 3. Wellington (1999): A lack of compatibility of available resources was identified as a barrier to computer use. 4. Russell and Bradley (1997): Teachers described outdated and damaged equipment as obstacles to computer use. 5. Teachers at the two 'technology-rich' Californian schools where Cuban et al. (2001) conducted their study cited a number of problems including unreliable

	includes issues like compatibility, age and state of repair.	equipment and obsolete hardware and software, which could account for their low technology usage. 6. Pelgrum (2001): 49% of teachers identified an outdated local school network and 32% cited a poor telecommunications infrastructure as obstacles to ICT use. 7. van Braak (2001): Teachers who use networked computers were more convinced than teachers who did not use networked computers that the school computers were not properly maintained ($p < 0.01$). 8. Unreliable equipment was the most important factor hindering the use of computers amongst the 125 faculty members surveyed by Butler and Sellblom (2002). Eleven of the 125 faculty members (8.8%) also mentioned the lack of compatible equipment across classrooms as another problem that discouraged them from using computers. 9. Zhao (2002) reported on the negative effect of incompatible resources on the use of technology: 1/10 projects reviewed failed due to a lack of compatibility of the operating system required by the project with the available computers. 10. Four of the 30 teachers (13%) in the study by Bauer and Kenton (2005) mentioned problems with outdated computers while other teachers referred to incompatible hardware and software and technical breakdowns. 11. Wood et al. (2005): 7.9% of elementary teachers and 9.7% of secondary teachers cited computer malfunctions, compatibility issues and outdated equipment as a barrier to their computer use. 12. Castro and Alves (2007): Only 1 out of 11 state (secondary) schools with computer labs had maintenance while all the municipal schools had access to maintenance. 13. Ng and Gunstone (2003): Some teachers in this study mentioned unreliable machines as an obstacle to their computer use. 14. Al-Fudail and Mellar (2008) reported that problems with compatibility and reliability of equipment hindered computer use. 15. Hossain and Brooks (2008) found the functionality of hardware to be one of the major factors affecting ICT usage. 16. Ertmer et al. (2012): The functionality of equipment was reported as the 8th out of 13 external barriers to computer use. One of the 12 teachers reported network instability as a major barrier limiting their computer use.
Software-related factors	Availability of software for use in teaching: *The educational software made available in school which covers both the depth and breadth of subjects across the curriculum.*	1. Zammit (1992): Teachers in this study who did not use computers indicated a need for more software as the 7th most important factor out of 12 that would encourage them to use computers for teaching. 2. Quick and Davies (1999): Participants did not have the type of software available they wanted to use in their teaching. They expressed a need for the latest software. 3. Pelgrum (2001): 54% of teachers reported insufficient copies of software for use in teaching. 4. van Braak (2001): Teachers who use networked computers were more convinced than teachers who did not that insufficient software was available ($p < 0.05$). 5. Four out of the 30 teachers in the study by Bauer and Kenton (2005) mentioned difficulties finding suitable software they could use in their teaching as an obstacle to their use of computers. 6. Wood et al. (2005): Teachers reported a lack of up-to-date software hindered their use of computers for teaching. 7. Sahin and Thompson (2006): A lack of software was cited as the third major barrier to faculty members' use of computers for instruction. 8. Castro and Alves (2007): 45.5% of state teachers and 78% of municipal teachers reported insufficient instructional software available for use. 9. Blignaut et al. (2010) reported that the availability of suitable software to use impacted on teachers' computer use (more South African teachers than Chilean teachers indicated a need for a variety of types of software, e.g. word processing and communication software). 10. Ward and Parr (2010) found software availability to be a significant factor affecting their ICT use for administrative tasks and lesson preparation ($p < 0.1$). 11. Vanderlinde et al. (2012) identified the availability of ICT infrastructure as an important factor affecting teachers' use of computers in their study. Two of the 3 schools in this study, which displayed high levels of ICT usage for teaching and learning, were ranked 4th and 5th out of 62 schools surveyed with respect to their ICT infrastructure, which includes providing software for teachers to use.

	Quality and suitability of software: *'Suitability' refers to how well subject-specific software addresses the curriculum requirements (e.g. content coverage for a particular educational level). 'Quality' refers to how well the programme's design features (e.g. the level of interactivity) support learning.*	1. Zammit (1992): Poor quality of software was ranked 4th out of 7 factors preventing computer use by teachers who used computer and 6th by teachers who did not. 2. Pelgrum (2001): Teachers reported a number of problems with the quality of software available: a lack of information about software (38%); software not suitable (29%); software not compatible with curriculum (19%); software not in language of instruction (18%); software not culturally compatible (12%). 3. van Braak (2001): Available software was thought to be unsuitable for use in teaching by teachers who used networked computers and those who did not. 4. In their study at one US university, Butler and Sellblom (2002) reported that 10 out of 125 faculty members (8%) reported that the software available to them was out of date. Another 6 faculty members (4.8%) cited issues with software that was incompatible as a problem. 5. Priest et al. (2004) reported that the availability of high-quality software was a factor that had increased levels of ICT integration. 6. Ng and Gunstone (2003): Lack of suitable software was identified as an obstacle to ICT integration. 7. Donnelly et al. (2011): Three of the five teachers in the Irish study were discouraged from using a particular software application because the software was not suitable. The other teachers felt that the software catered for different levels of student ability and that the interface was "*quite intuitive*" (Donnelly et al., 2011, p. 1476).
	Ease of use of software: *The level of difficulty involved with using a software package (e.g. how icons are presented).*	1. Chiero (1997): 58.8% of teachers reported software that is too difficult to use as an obstacle to their computer use. 2. Pelgrum (2001): Teachers reported problems with software being too complicated to use (10%). 3. Butler and Sellblom (2002) reported difficulties with learning to use new software as the 7th most significant factor affecting faculty members' use of technology among the 125 faculty members at a US university. 4. Ng and Gunstone (2003): Teachers were discouraged from using software that was too complicated and not user-friendly.
In-service training	Provision of training: *The number and duration of opportunities provided by an institution for staff to improve their computer*	1. Zammit (1992): Teachers who did not use computers rated the need for more in-service training as the 3rd of 12 factors that would encourage them to use computers for teaching. 2. Chiero (1997): 78% of teachers reported a lack of computer training as the second major factor limiting their computer use. 3. Russell and Bradley (1997): Teachers felt the institution had not provided sufficient ICT training, as they lacked the basic skills required to use computers for teaching. Also, teachers reported that they would prefer to have training conducted on school grounds. 4. Drenoyianni and Selwood (1998): 47.5% of the teachers in this study expressed a need for more school-based training. 5. Quick and Davies (1999): In this qualitative study, several teachers mentioned a huge need for training. 6. Williams et al. (2000): Both primary (32%) and secondary (22%) teachers reported a need to develop their technical skills and knowledge in terms of their

	skills	classroom practice as their main priority for training. 7. Cuban et al. (2001): Teachers found that training was not offered at times convenient to them. 8. Pelgrum (2001): 43% of teachers reported insufficient opportunities for training. 9. van Braak (2001): Lack of in-service training was found to hinder ICT integration. 10. Baylor and Ritchie (2002) found that providing teachers with in-service training has a significant positive effect ($p < 0.001$) on teacher morale, which, in turn, "*influences all aspects of the teaching and learning environment*" (Baylor & Ritchie, 2002, p. 410). 11. Dori et al. (2002) found that the provision of professional development and ongoing support improved teachers' ability to develop learner-directed ICT tasks and to assess learners' work. 12. Shannon and Doube (2003): More than 75% of faculty members indicated a need for training on using ICT for instruction. 13. Zhao and Frank (2003) found that one of the four districts in their study offered more ICT training than the other three districts. 14. The secondary school teachers in the study by Lai and Pratt (2004) expressed a need for more professional development on integrating ICT into their teaching. 15. McCarney (2004) reported that the majority of the teachers in this study (90%) preferred in-service training with a tutor (78%). 16. Priest et al. (2004) reported that the provision of training had improved teachers' levels of ICT integration. 17. Kanaya et al (2005) found that 78% of the teachers who received technology training used technology in their lessons. 18. Selwood and Pilkington (2005): Teachers in this study reported that the provision of training influenced their use of ICT for instruction. Some teachers reported not having received any training on a number of software applications while others had only received informal training from colleagues on the use of some common applications, e.g. word processing. 19. Wood et al. (2005) found that the provision of ICT training impacted on teachers' use of computers for teaching and learning. 20. Sahin and Thompson (2006): A lack of training on how to use the existing equipment was identified as the second major barrier to teachers' computer use. 21. Castro and Alves (2007) found inequitable access to training across state and municipal schools to affect ICT use. All municipal teachers received initial training in ICT use and continued professional development, compared to 19% of state teachers. 22. Al-Fudail and Mellar (2008): Teachers identified a lack of training as an obstacle to computer use. 23. Tondeur et al. (2008): The amount of training teachers have had was found to have a significant positive effect ($p < 0.01$) on their ICT use in the classroom. 24. In their secondary analysis of SITES 2006[3] data for South Africa and Chile, Blignaut et al. (2010) found a lack of teacher training impacted negatively on ICT integration, since few teachers knew how to integrate computers into their teaching. 25. Chigona and Chigona (2010) reported that teachers in their study had had insufficient training to allow them to use computers confidently in their lessons. 26. Ertmer et al. (2012): One of the 12 teachers in this study reported a lack of training as a barrier limiting his computer use. 27. Vanderlinde et al. (2012) reported that one of the schools in their study, which was ranked 7/62 in an initial survey for their use of ICT for learning, and 8/62 for use of basic ICT skills in classroom, provided school-based training courses for teachers to improve their competencies.
	Nature of training provided: *The type of staff development opportunities provided by the institution (e.g. developing ICT*	1. Russell and Bradley (1997): Most teachers in this study expressed a preference for learning ICT skills from other more skilled teachers. 2. Drenoyianni and Selwood (1998): 76% of the teachers in this study expressed a need for training aimed at teaching them to use software properly, while 36.8% expressed a need for training focusing on how to integrate software into their subject. 3. Quick and Davies (1999): In this qualitative study, teachers requested training that fits their specific needs. 4. Williams et al. (2000): Both primary and secondary teachers expressed a need for training that allowed them to use ICT in the classroom more effectively to improve learning. 5. Pelgrum (2001): 31% of teachers found the training offered inadequate to prepare them for using technology. 6. Dori et al. (2002) found that training that focused on teachers' prior knowledge and their individual need for support allowed the teachers in their study to

	skills or using ICT in a pedagogically effective manner).	produce more learner-directed ICT tasks, thereby improving the level of their ICT integration. 7. Baylor and Ritchie (2002) found that providing teachers with in-service training specifically designed to meet teachers' ICT needs has a significant positive effect ($p < 0.001$) on teacher morale. 8. Zhao et al*.* (2002) found that the length of training teachers were offered impacted their integration of technology. Single training sessions may provide ideas about how to use new technologies, but are unlikely to lead to sustained use. 9. Zhao and Frank (2003) found that the ICT training offered in one of the four districts in their study was better tailored to meet teachers' needs by offering sequenced training programmes which began with basic skills and progressed to curriculum integration. This programme also offered ongoing evaluation of teachers' needs. 10. The secondary school teachers in the study by Lai and Pratt (2004) expressed a need for more professional development focusing specifically on how to integrate ICT into their teaching, and not on technical skills. 11. McCarney (2004): 47% of teachers rated training focusing on equipping them with pedagogical skills for integrating technology as the most effective type of training. 12. Kanaya et al (2005) found that training focusing on integrating technology into teaching impacted on the computer use of 66% of the 228 teachers in their study. 13. Selwood and Pilkington (2005): Only 34% of teachers in special schools, 9% of primary school teachers and 20% of secondary teachers in this study reported having received training on the use of ICT for instruction. 14. Wood et al*.* (2005) found that the type of ICT training provided impacted on teachers' use of computers for teaching and learning. 15. Sahin and Thompson (2006) reported a need for faculty to have more hands-on experience with using computers. 16. Chigona and Chigona (2010) concluded that the training provided to the teachers in their study was inadequate since teachers were still not sufficiently ICT literate to feel confident using computers for teaching.
Support-related	ICT policy and guidelines: *The extent to which the school has a clear policy for integrating ICT in the teaching and learning practice, including the provision of guidelines.*	1. Zammit (1992): Teachers who do not use computers ranked an increased level of support from the school administration as one of 12 factors that would encourage their use of computers for teaching. 2. Wellington (1999) reported that the presence of a school policy facilitated teachers' use of computers for teaching and learning. 3. Williams et al*.* (2000): Teachers expressed a need for guidelines on how to use technology to support defined teaching and learning goals. 4. Pelgrum (2001): 17% of teachers reported a lack of guidelines from the school board for integrating ICT. 5. Zhao et al*.* (2002) identified the need for a set of institutionalized policies to guide the use of technology as an important factor impacting on technology integration. 6. Russell et al*.* (2003) found that school policies impacted on technology use for instruction. 7. The ICT coordinators in the study by Lai and Pratt (2004) were involved in formulating ICT plans for their schools, often after consulting with teachers. However, many reported a lack of time to plan ICT integration in the school. 8. Tondeur et al*.* (2008): The existence of an ICT policy had a significant positive impact on teachers' use of computers ($p < 0.000$). 9. Ertmer et al*.* (2012, p. 429): One of the 12 teachers mentioned the lack of an "*agenda*" to support technology integration as a discouraging factor. 10. Vanderlinde et al*.* (2012) reported having an ICT policy and providing guidelines for ICT integration as the major factor affecting teachers' use of computers in their study. Two of the three case study schools, ranked first and second with respect to having a school vision and policy for ICT integration out of 62 schools in the initial study, had formal school policies. The third case study school had an informal policy. All three schools displayed moderate to high levels of ICT usage compared to the other schools in the study.

	ICT culture: *The level of ICT usage considered to be the norm in the institution.*	1. Zammit (1992): Teachers who did not use computers cited a positive attitude from their departments as a factor that would encourage their use of computers for teaching. These teachers also indicated that more support from the ICT coordinator would also motivate them to use computers in the classroom. 2. Russell and Bradley (1997): Several junior primary teachers complained about the unequal distribution of computers in the school. They felt that the school administration was overlooking them. 3. Selwyn (1999) reported that the attitude displayed by the head of department impacted on the computer use in a subject area. 4. Wellington (1999) reported that a favourable attitude towards the use of ICT in an institution facilitated teachers' use of computers for teaching and learning. 5. van Braak (2001): Both teachers who use networked computers and those who did not cited the lack of willingness at school to use ICT as the major obstacle to their computer use. Teachers also referred to the negative attitude of the principal towards ICT use in the school as hindering their use of computers for teaching. 6. In their US study, Baylor and Ritchie (2002) found that technology leadership had a significant positive effect ($p < 0.001$) on teachers' technology use. 7. ICT usage among other members of their departments was one of the factors affecting the use of computers for teaching amongst the 125 faculty members in the study by Butler and Sellblom (2002). 8. Dori et al. (2002) reported that teachers who have the support of their principals are more likely to successfully integrate ICT into their teaching. 9. Zhao et al. (2002) reported the support of other teachers to be an important factor affecting technology integration. 10. Shannon and Doube (2003): Faculty members cited support from the university administration as a factor that would encourage them to use computers for instruction. 11. Zhao and Frank (2003) reported that teachers were more likely to use computers when their colleagues were doing so and they felt some pressure to use computers. 12. The ICT coordinators in the study by Lai and Pratt (2004) reported a lack of support, sometimes manifesting as the lack of time to plan the integration of ICT in the school. They also cited a lack of professional development on how to be effective leaders. 13. Wood et al. (2005): Most of the teachers in this study felt that their schools supported the idea of integrating ICT for teacher use (88.9%) and learner use (90.7%). 14. Sahin and Thompson (2006): Participants felt that the administration was not doing enough to support instructional computer use, contributing to a lack of a suitable ICT culture in the school to promote instructional technology use. 15. Drent and Meelissen (2008) reported that the support of the school management influenced teachers' level of innovativeness and hence impacted on their innovative use of ICT for teaching. 16. Hossain and Brooks (2008) found the prevailing ICT culture in an institution to be one of the major factors affecting ICT usage. 17. Tondeur et al. (2008): Fifty percent of the principals interviewed in this study described their impact on ICT integration in their schools as limited, citing a lack of time to manage computer adoption as a reason. 18. Blignaut et al. (2010) rated the principal's vision for the use of ICT as one of the most significant factors affecting teachers' use of ICT. More Chilean principals than South African principals had clear pedagogical objectives for the use of ICT, which could contribute to the higher use of ICT by Chilean science and maths teachers. 19. Chen (2010) found that the prevailing technological culture in the school had a significant effect ($p < 0.001$) on their use of computers for student-centred learning. 20. Vanderlinde et al. (2012) highlighted the importance of leadership and teachers' participation in establishing an ICT culture in schools to be a major factor affecting teachers' use of computers. The three case study schools differed in the degrees to which the school leader was involved in making decisions about ICT strategy in the school and the extent to which teachers were involved in the decision-making process. 21. Ertmer et al. (2012): Three of the 12 teachers regarded the support of their administrators as an enabling factor.

	Technical support: *The level of help available for dealing with the functionality of hardware and software, enabling staff and students to have trouble-free access to, and usage of, the computing facilities.*	1. Chiero (1997): Insufficient technical support was rated the third major obstacle to the use of computers by the teachers in this study. 2. Drenoyianni and Selwood (1998): 83.7% of teachers in this study cited technical problems as a barrier to their computer use. 3. Cox et al. (1999): Some of the 82 teachers in this study stated that their lessons were often negatively affected by hardware and software problems. 4. Ertmer and Hruskocy (1999) reported the provision of technical support to have had a positive effect on teacher's computer use. 5. Quick and Davies (1999): In this qualitative study, teachers expressed an overwhelming need for technical support. 6. Wellington (1999): A lack of technical support was identified as the second major barrier to computer use by most respondents. 7. Williams et al. (2000): Teachers reported the lack of technical support as a factor inhibiting their use of computers for teaching. 8. Cuban et al. (2001): The teachers in this study were discouraged from using computers by the inadequate technical support available to them. 9. Pelgrum (2001) reported the lack of technical support staff (52%) and lack of technical assistance (51%) as obstacles to computer use. 10. van Braak (2001): Teachers cited the lack of computer maintenance as an obstacle to their use of computers. 11. Eleven of the 125 (8.8%) faculty members in the Butler and Sellblom (2002) study cited weak technical support as a problem that discouraged their use of computers for teaching. 12. Zhao et al. (2002) reported that most of the technology projects they reviewed could have benefited from a greater level of technical support. 13. Shannon and Doube (2003): Faculty members cited the availability of technical support as a factor impacting on their decision to use computers for instruction. 14. Zhao and Frank (2003) reported that teachers were discouraged from using computers by technical problems, but these had less of an impact when they could receive help from colleagues. 15. Forty-seven percent of the secondary school teachers in the study by Lai and Pratt (2004) reported the lack of technical support as a factor discouraging their ICT use. 16. The teachers in the study by Bauer and Kenton (2005) did not have technical assistance available and had to rely on "*that person on the staff with the most technical knowledge*" (Bauer and Kenton, 2005, p. 536) to resolve technical hiccups. 17. Wood et al. (2005) found that the level of technical support available impacted on teachers' use of computers. 18. Sahin and Thompson (2006) identified a lack of technical support as the third major barrier to the instructional use of computers. 19. Castro and Alves (2007) reported very low levels of technical support available for teachers at the 11 secondary schools in Rio de Janeiro that had computer laboratories (32% of the total number). Only 1 secondary school had some form of external technical support, which was described as "*usually slow in responding to service requests*" (Castro & Alves, 2007, p.1383). Nine of the 11 (82%) primary schools had computer labs, with technical maintenance available from an external source. Few primary school teachers had problems with the response times. The primary schools also had a technical person on duty to help with equipment hiccups. 20. Al-Fudail and Mellar (2008) reported a lack of technical support for teachers wanting to use ICT as a discouraging factor. 21. Hossain and Brooks (2008) found the level of technical support available to be one of the major factors affecting ICT usage. 22. Tondeur et al. (2008): Teachers' perceptions about the level of technical support available had a significant positive effect ($p < 0.001$) on their ICT use in the classroom. 23. Blignaut et al. (2010) rated the level of technical support available to teachers as one of the most significant factors affecting teachers' use of ICT. They found a higher level of technical support and a higher maths and science teacher use of technology in Chile compared to South Africa. 24. Chen (2010) found that the level of technology support available to teachers had a significant effect ($p < 0.001$) on their use of computers for student-centred learning. 25. The teachers in the study by Chigona and Chigona (2010) were discouraged from using computers by the length of time it took for technical problems to be resolved.

		26. Ward and Parr (2010) found that the level of technical support available to teachers influenced their use of computers for teaching and learning. 27. Ertmer et al. (2012): The level of technology support for teachers was ranked as the most significant external barrier to computer use; and the second most important barrier overall. 28. Vanderlinde et al. (2012) found that the three case study schools, which displayed moderate to high levels of ICT usage compared to the other 59 schools in the initial study, provided excellent levels of coordination and support for teachers' use of ICT in the classroom. The three schools were ranked 1/62, 2/62 and 13/62 with regard to the ICT coordination and support, in the initial study.
	ICT coordinator: *The presence of a person responsible for overseeing the budgeting, planning and strategising with respect to ICT facilities and their use in the institution.*	1. Zhao et al. (2002) reported that most of the teachers attempting to implement technology projects would have benefited from greater assistance with administrative matters like purchasing new equipment and dealing with network issues. 2. Some of the teachers in the study by Lai and Pratt (2004) expressed a need for someone with 'vision' regarding the potential for ICT use in their schools. 3. Wood et al. (2005): Teachers indicated the need for a computer expert to act as a catalyst for ICT integration. 4. Sahin and Thompson (2006): Participants mentioned the lack of a person/people to model instructional use of computers for them, indicating the need for an ICT coordinator. 5. Castro and Alves (2007) believed their results indicated the need for an ICT coordinator (which they called an informatics instructor) to oversee the running of computer labs, including schedules of use, and to help teachers with problems that arise as computers are used for teaching. 6. Drent and Meelissen (2008) reported that the support of the ICT coordinator influenced teachers' level of innovativeness and hence impacted on their innovative use of ICT for teaching. 7. Tondeur et al. (2008): 29.6% of teachers surveyed cited the lack of someone to coordinate the ICT integration as a barrier to their use of computers. 8. Blignaut et al. (2010) found that 88% of Chilean schools had ICT coordinators compared to 41% of South African schools. Chilean maths and science teachers display consistently higher teacher ICT use than South Africa. 9. Vanderlinde et al. (2012) identified the degree to which ICT integration is coordinated as an important factor affecting teachers' use of computers in their study.
	Pedagogical advisor: *Having a person who assists teachers to implement ICT in teaching and learning in ways that enhance learning.*	1. Russell and Bradley (1997): Teachers in this study expressed a need for a person to advise them on how to integrate computers into their subject. 2. Pelgrum (2001): 58% of teachers reported a need for support for with integrating ICT into their subject. 3. Zhao et al. (2002) reported a general need among the teachers implementing technology projects for a translator who could assist them with using technologies according to teachers' particular needs. 4. 58% of the secondary school teachers in the study by Lai and Pratt (2004) reported inadequate curriculum support as a factor discouraging their ICT use. 5. Sahin and Thompson (2006): Participants cited the lack of a person to show them how to use computers for instructional purposes, indicating the need for somebody to advise them on how to include computers in their subject. 6. Tondeur et al. (2008): Some principals indicated the need for a person to assist teachers with pedagogical issues. 7. Blignaut et al. (2010) rated the pedagogical support available to teachers when learners were carrying out activities such as project work as one of the most significant factors affecting teachers' use of ICT. Chile, which displays a higher usage of ICT by maths and science teachers, scored higher than South Africa on a four-point Likert scale for measuring the level of pedagogical support available to teachers. 8. Chen (2010) found that the level of support available had a significant effect ($p < 0.001$) on teachers' use of computers for student-centred learning. 9. Ward and Parr (2010) reported the level of pedagogical support available to teachers influenced their use of computers for teaching and learning. 10. Vanderlinde et al. (2012) identified the degree to which ICT integration is coordinated as an important factor affecting teachers' use of computers in their study. For example, one of the three case study schools employed a person to provide pedagogical support for teachers when using ICT in the classroom.

	Support from other teachers: *The extent to which other teachers at the institution or from other institutions provide assistance to teachers wanting to use ICT in their lessons.*	1. Zammit (1992): Respondents indicated that they relied on other teachers to help them with using computers in lessons. 2. Chiero (1997): 77% of teachers surveyed reported that in the absence of on-site technology support, other teachers were the only source of support available to them. 3. Russell and Bradley (1997): Teachers in this study expressed a need to learn from other, more ICT competent teachers. 4. Wellington (1999) identified the reluctance of other staff members to use ICT as barrier to ICT integration. 5. Williams et al. (2000): Primary teachers reported relying on other teachers for advice about using ICT in the classroom (no figures supplied. 6. Pelgrum (2001): 27% of the respondents in this study cited a lack of support from other teachers as an obstacle to their computer use in the classrrom. 7. van Braak (2001): Teachers who use networked computers were more convinced than teachers who did not use networked computers that a lack of support from other staff members hindered their use of computers ($p < 0.01$). 8. Dori et al. (2002) reported that teachers who receive a high degree of support from colleagues are more likely to use ICT in their teaching. 9. Zhao et al. (2002) found that technology projects that did not require support from other teachers were more successful. 10. Zhao and Frank (2003) reported that teachers were more likely to use computers with their students when they received help from colleagues, especially when IT technicians are not available to help. 11. 70% of the teachers in the study by Lai and Pratt (2004) reported having little to no support when trying to integrate ICT into their teaching. 12. McCarney (2004): The majority of the teachers (68%) rated peer support as only 'satisfactory', as opposed to 11% who rated peer support as highly effective and 21% who rated it not effective. 13. Sahin and Thompson (2006): Participants cited support from colleagues as an important factor influencing their use of computers for teaching. 14. Al-Fudail and Mellar (2008) found a lack of social (taken to mean from other teachers) support for teachers wanting to use ICT, but did not provide data to support the claim. 15. Tondeur et al. (2008): 75% of the schools in this study had benefited from collaborating with other schools, e.g. sharing ICT coordinators. However, only one school included teachers in the collaborations, which allowed teachers to observe other teachers using ICT. 16. Chen (2010) found that the level of support available from other teachers had a significant effect ($p < 0.001$) on teachers' use of computers for student-centred learning. 17. Donnelly et al. (2011): Teachers cited other teachers' willingness to share resources as an enabling factor for their use of computers for teaching and learning. 18. Ertmer et al. (2012). One of the 12 teachers mentioned working with other teachers to achieve specific technological goals.
	Administrative support: *The provision of personnel who implement instructions issued by an ICT coordinator relating to organisational matters around ICT use.*	1. Zhao et al. (2002) reported that most of the teachers attempting to implement technology projects would have benefited from greater assistance with administrative matters like purchasing new equipment and dealing with network issues. 2. Shannon and Doube (2003): Faculty members cited administrative support as an important factor influencing their use of computers for instruction. 3. Wood et al. (2005) found that the level of administrative support available impacted on teachers' use of computers.

	Teaching assistants: *Support staff (e.g. parents or learners) to assist teachers with managing classes when learners are using technology.*	1. Zammit (1992): Respondents indicated that they needed support in class when using computers in lessons. 2. Ertmer and Hruskocy (1999): the teachers in this study made more use of computers in the classroom when classroom support was available. 3. Wellington (1999) identified a need for teaching assistants to help manage learners when using computers in lessons. 4. Williams et al. (2000): Teachers expressed a need for help with managing learners in lessons where learners were using computers (e.g. from parent helpers). 5. Pelgrum (2001): 52% of teachers reported a need for more supervision support in the classroom when integrating ICT. 6. Wood et al. (2005): Teachers in this study indicated a need for help with supervising learners in computer labs. 7. Sahin and Thompson (2006): Participants indicated the need for more support with integrating technology. 8. Chen (2010) found that the level of support available had a significant effect ($p < 0.001$) on teachers' use of computers for student-centred learning. 9. Ward and Parr (2010) found that the provision of practical support available to teachers in managing lessons when learners were using technology influenced their use of computers.
	Support from learners: *The extent to which learners help or hinder teachers using ICT in their lessons.*	1. Zammit (1992): Respondents indicated that they relied on other learners who knew more than they did to help them with using computers in lessons. 2. Ertmer and Hruskocy (1999) reported that the use of student-trainers at their case study school increased over time. Four of the 12 teachers had used students to help them resolve a technical problem or learn how to use a new software programme. 3. Cuban et al. (2001) reported that, in their study at two high schools, there were 5 students at each school (5% of total student body) who provided technical assistance to teachers. These students were simultaneously easing the load of the ICT coordinators while assisting teachers who could not resolve the technical hitches by themselves. 4. Wood et al. (2005) reported that some teachers used learners with good computer skills, sometimes even surpassing the teacher's skill, to teach other learners.
Time available to...	prepare lessons using ICT: *Time provided for teachers to prepare lessons involving ICT (includes redoing previous lessons).*	1. Drenoyianni and Selwood (1998): Many teachers (exact figures not given) mentioned a lack of time to prepare lessons involving computers as a barrier to computer use. 2. Quick and Davies (1999): In this qualitative study, teachers mentioned their workloads as obstacles to preparing lessons using computers. 3. Cuban et al. (2001) reported that teachers they had interviewed (numbers not supplied) identified the lack of time to find and evaluate new software as a barrier to teachers' computer use. 4. Pelgrum (2001): 54% of respondents identified the limited time available to teachers for planning how to use computers as an obstacle to their computer use. 5. Shannon & Doube (2003): 17/67 faculty members cited a lack of time to prepare lessons due to heavy workloads as a barrier to their use of computers for instruction. 6. Zhao and Frank (2003) reported that teachers were more likely to use technologies that required little change to their current teaching practices (e.g. email), and therefore took less time to learn. 7. The secondary school teachers in the study by Lai and Pratt (2004) reported a lack of time to plan lessons integrating ICT. 8. Priest et al. (2004): Many teachers felt that their workloads had increased because of the time required to plan lessons using ICT. 9. Some teachers in the study by Bauer and Kenton (2005) felt it takes much more time to prepare lessons including ICT compared to more traditional lessons. 10. Selwood and Pilkington (2005): 33/592 secondary teachers identified the time needed to convert tasks to digital format as a barrier to their computer use. 11. Ng and Gunstone (2003) reported the lack of time for teachers to plan lessons using computers as an obstacle to ICT integration. 12. Time needed to prepare for technology use and for "*fixing problems*" was reported as a potential cause of stress for teachers (Al-Fudail and Mellar, 2008, p. 1107). 13. Chen (2010) found that the amount of time available to plan lessons using ICT had a significant effect ($p < 0.001$) on teachers' use of computers for student-centred learning.

		14. Ward and Parr (2010) found that the workload involved in using technology influenced teachers' use of computers 15. Donnelly et al. (2011): Some teachers in the Irish study cited a lack of time to prepare lessons using ICT as a barrier to their use of ICT. One teacher mentioned her busy schedule as a reason why she didn't have time to prepare lessons involving ICT.
	use ICT in lessons: *Time available for teachers to use computers during lessons.*	1. Drenoyianni and Selwood (1998): Many teachers (exact figures not given) mentioned a lack of time to carry out computer activities during lessons as a barrier to computer use. 2. Cox et al. (1999): Some of the 82 teachers in this study stated that their lessons were often negatively affected by hardware and software problems, which reduces the time available for teaching during lessons. 3. Selwyn (1999) found that a lack of time to use computers in lessons discouraged teachers from using them. 4. Becker (2000): Secondary academic subject teachers who had longer lessons (90-120 minute lessons) reported more frequent student use of computers (19%) than teachers who had shorter 50 minute lessons (15%). 5. Cuban et al. (2001) reported that teachers they had interviewed (numbers not supplied) identified the lack of time to include computers in their lessons as a barrier to teachers' computer use. 6. van Braak (2001) reported insufficient time during lessons for computer use as the second major institutional-level obstacle. 7. Faculty members in the study by Butler and Sellblom (2002) cited time lost during lessons due to difficulties using the equipment as the fourth most significant factor affecting their adoption of computers for teaching. 8. Some teachers in the study by Bauer and Kenton (2005) mentioned the difficulties encountered with using computers in a computer lab as an obstacle to their use of computers in lessons. 9. Wood et al. (2005): Teachers cited the difficulty of finding time to use technology in lessons. 10. Time needed to prepare for technology use and for "*fixing problems*" was reported as a potential cause of stress for teachers (Al-Fudail and Mellar, 2008, p. 1107). 11. Chen (2010) found that the amount of time available to use computers in lessons had a significant effect ($p < 0.001$) on teachers' use of computers for student-centred learning. 12. Ertmer et al. (2012) found that the combined impact of having to meet state standards and assessment pressures made this one of the most formidable barriers for teachers wanting to use technology in lessons.
	learn to use ICT: *Time provided for teachers to learn how to use computers in their teaching (includes new software).*	1. Zammit (1992): Both teachers who did not use computers (2nd most important out of 7 factors) and teachers who did (3rd most important out of 7 factors) cited the lack of time to properly review software as a factor hindering their use of computers for teaching. Also, teachers who were not using computers felt they would be more encouraged to do so if they had more time to discuss how to use computers in their lessons with other teachers. 2. Chiero (1997): 82.4% of the teachers rated the lack of time to learn how to use new software as the most significant obstacle to their computer use. 3. Russell and Bradley (1997): Teachers in this study expressed a need for time to spend learning how to use computers. 4. Quick and Davies (1999): In this qualitative study, teachers cited a lack of time to learn to use new software as a problem. 5. Wellington (1999) reported that teachers viewed the lack of time to learn to use technology as a barrier to the use of ICT for teaching and learning. 6. Williams et al. (2000): Teachers reported the lack of time to learn how to use computers as an obstacle to their use of a range of computer applications, e.g. 18% of secondary teachers reported insufficient time as an obstacle to learning how to use the Internet. 7. Butler and Sellblom (2002) reported time taken to learn how to use new technology as the second most significant obstacle (18/125) for the faculty members in their study. 8. The secondary school teachers in the study by Lai and Pratt (2004) reported a lack of time to plan lessons integrating ICT, which includes time to learn how

		to use new software. 9. Priest et al. (2004): many teachers felt that their workloads had increased because of the time required to learn to use new software. 10. Wood et al. (2005): teachers mentioned the difficulty of finding time to keep up to date with new technologies. 11. Sahin and Thompson (2006): Participants expressed concern about the amount of time it takes to learn to use new software. 12. Ng and Gunstone (2003) reported the lack of time for teachers to learn to use new software as an obstacle to ICT integration. 13. Ward and Parr (2010) found that the lack of time available to teachers to learn how to use technology influenced their use of computers 14. Ertmer et al. (2012): A lack of time to learn to use technology was identified as 6th most significant barrier overall.

Appendix G:

Teacher-level factors affecting teachers' use of ICT, summarised from 48 studies reviewed

	Factor	Empirical evidence for effect of factor on ICT use in the classroom[7]
Teaching profile	Subject culture*: Differences in content, pedagogy and assessment associated with a teacher's subject area.*	1. Russell and Bradley (1997) reported subject-related differences in the type of ICT training teachers said they preferred. 2. Selwyn (1999) reported that ICT use differed across subjects based on teachers' beliefs about the nature of the subject (subject paradigm), the way the subject content was best taught (subject pedagogy) and how closely ICT use matched the culture associated with that subject . 3. Becker (2000) found that the use of computers among secondary academic subject teachers was highest for English teachers (24%), followed by science, social studies and maths teachers. 4. Williams et al. (2000) reported business and management subject teachers showed higher ICT use than mathematics, science and language teachers. Maths teachers showed the lowest use overall. 5. Cuban et al. (2001) reported that English, science and social studies accounted for 60-70% of the computer use at the schools in their study. Students reported some computer use in English and social studies, but little in maths and science. 6. van Braak (2001) found that teaching a language was the most important predictor of teachers' use of computers for teaching ($p < 0.001$). 7. Zhao and Frank (2003) reported that English teachers were more likely to use computers than other subjects. 8. Priest et al. (2004) reported more ICT use in maths and English in a school with good ICT infrastructure compared to a school with less ICT infrastructure. 9. Wood et al. (2005): Teachers' reported that their use of technology was influenced by how well computers suited the content they were teaching. 10. Sahin and Thompson (2006): Faculty members regarded some subjects as not suitable for instructional ICT use. 11. Chigona and Chigona (2010): Only maths and science teachers were allowed to use the computers available in the schools in this study and had access to ICT support. 12. Ward and Parr (2010) reported lower levels of ICT use in the core academic subjects (English, maths, science and social science) compared to less academic subjects like Drama and Physical Education in one of the four schools in their study. 13. Ertmer et al. (2012) found a subject culture that supports ICT integration to be an enabling factor for teachers' classroom use of ICT.
	Teaching experience*: How long teachers have been teaching for.*	1. Russell et al. (2003) found teaching experience to be an important predictor of whether teachers would use technology use for learner-centred instruction. 2. Sahin and Thompson (2006) reported that older teachers were less willing to use computers for instruction.
Social proficiency	Interpersonal skills: *Teachers' knowledge of school culture and ability to negotiate social aspects of school culture.*	1. Zhao et al. (2002) reported that socially savvy teachers were more likely to know which channels to use to achieve their goals, and were therefore more likely to successfully implement technology projects.
Beliefs about ICT	Teaching philosophy: *Teachers' pedagogical beliefs and how*	1. Drenoyianni and Selwood (1998) found that teachers' use of computers was related to their educational goals. The majority of teachers (89.1%) in this study cited computer awareness as a goal, while other teachers mentioned goals that better exploited the potential benefits of using computers such as self-paced learning (59.4%) and collaborative learning (72.9%). 2. Ertmer and Hruskocy (1999) found that although the teachers in their study used computers more and used a wider variety of applications in their teaching after a collaborative programme (offering professional, technical and instructional support), there was little change in the way teachers' taught,

[7] Figures have been supplied for those studies for which they were available.

	they impact on the use of computers for teaching.	suggesting little change in their underlying teaching philosophies. 3. Quick and Davies (1999): Participants expressed a belief in teacher-centred lessons in which they were in control of all aspects of the lessons. 4. Selwyn (1999) found that some teachers felt their major function was to prepare learners to pass an examination, leaving little time for computer use. 5. Wellington (1999) reported that teacher's use of computers was influenced by their pedagogical beliefs about the best way to teach, e.g. some teachers preferred whole class teaching, using ICT to demonstrate certain points, rather than having learners working on their own. 6. Becker (2000) found that secondary academic subject teachers with constructivist approaches assigned more computer work than teachers with more traditional approaches. 1. Only 4/21 teachers in the study by Cuban et al. (2001) had become more student-centred in their teaching approach, despite teaching in technology-rich schools. 2. Nisan-Nelson (2001) found that the level of ICT integration of one of the three teachers in that study could have been limited by her "*need for personal control in her classroom*" (Nisan-Nelson, 2001, p. 95). 3. Baylor & Ritchie (2002) reported that teachers' teaching philosophy impacted on their use of computers ($p < 0.01$). 4. Zhao et al. (2002) reported that teachers are more likely to use technologies that are compatible with their teaching beliefs and practices. 5. Russell et al. *(*2003) found teacher's philosophy of teaching to be an important predictor of technology use for instruction. 6. Shannon and Doube (2003) reported that faculty members' conception of teaching at university was an important factor impacting their use of computers for instruction (barrier for 36.8%; enabling factor for 31.7%). 7. Zhao and Frank (2003) found that teachers' belief that computers were compatible with their teaching philosophy had a significant impact on their technology use ($p < 0.01$). 8. Kanaya et al (2005) found that teachers' pedagogical approach had a significant effect on teachers' use of a new software programme in their teaching ($p < 0.01$). 9. Wood et al. (2005) reported that teachers' pedagogical beliefs were an important determinant of how they would use computers in their teaching. 10. Ng and Gunstone (2003): Only 41% of the teachers in this study were prepared to change the way they taught and carry out simulations in place of practical work. 11. Drent and Meelissen (2008) found that teachers' teaching philosophy had a direct effect on the innovative use of ICT by teachers. 12. Hermans et al. (2008) found that teachers' constructivist beliefs had a significant positive effect on teachers' classroom use of computers ($p < 0.001$), while traditional beliefs had a negative impact ($p < 0.05$). 13. Blignaut et al. (2010) reported that more teachers in their study used ICT in more traditional ways rather than in more constructivist ways. 14. Chen (2010) found teachers' beliefs about teaching and learning had a significant effect ($p < 0.01$) on their use of computers for student-centred learning. 15. Mueller et al. (2010) reported significant differences between high and low integrators with regard to the extent to which elementary school teachers' held constructivist beliefs ($p < 0.004$). 16. Voogt (2010) found that extensive ICT-using science teachers held more constructivist beliefs than none- extensive ICT-using science teachers ($p < 0.01$). 17. Ward and Parr (2010) found teachers' beliefs about the sorts of activities that should be taking place in a classroom to be a significant factor affecting the use of ICT in the classroom ($p < 0.1$). 18. Donnelly et al. (2011): Some teachers in the Irish study were reluctant to use ICT in their teaching because they considered their current teaching practices sufficient to allow learners to pass exams. One of the five teachers disliked the 'open nature' of the software application while another was not satisfied with the interface (no specific reason supplied). In both cases the researchers felt that these teachers were actually expressing a preference for a more didactic teaching style.

		19. Ertmer et al. (2012) found that teachers' pedagogical beliefs had a strong influence on how they used technology for teaching and learning. Although all 12 teachers felt that using technology was useful in their teaching, they used it in different ways depending on their pedagogical beliefs.
	Perceived relevance of ICT to teaching: *Teachers' perspectives about the value of computers in teaching and learning*.	1. Zammit (1992) reported that teachers who were not using computers were discouraged from learning how to use computers for teaching purposes by not being convinced of the benefits of doing so. On the other hand, teachers who were using computers ranked the belief that learners must learn how to use technology 4th out of 9 factors encouraging their use of computers. 2. Drenoyianni and Selwood (1998) found that teachers views on whether roles of computers in education impacted on their computer use. Some teachers felt that the value of computers in classrooms was to improve computer skills (72.7% of interview responses; 66.7% of questionnaire responses), while others felt that computers could be used to support teaching and learning (63.3% of interview responses; 43.3% of questionnaire responses). 3. Cox et al. (1999): The majority of the 82 experienced ICT and IT teachers in this study perceived the relevance of ICT to teaching and learning to be high. 85% felt that ICT contributed to more interesting lessons, while 90% felt technology use made for more enjoyable lessons. 4. Selwyn (1999) reported that teachers who do not perceive ready benefits for learning are less inclined to use ICT for learning. 5. Wellington (1999) reported that the teachers in his study believed the use of computers added value to teaching and learning in a variety of ways, including allowing for differentiated learning and motivating learners. 6. Becker (2000) found teachers' perspectives objectives for using computers in teaching and learning influenced the way they used computers in their lessons. 7. Williams et al. (2000) reported that teachers who perceived ICT use as benefiting themselves and their learners used technology more often than teachers who perceived the drawbacks as outweighing any potential benefits. Fifty percent of primary school teachers and 69% of secondary school teachers reported that technology use had a positive impact on their teaching while 62% of both primary and secondary teachers reported a positive impact on learning. 8. Cuban et al. (2001): Most of the teachers in this study perceived the benefits of using computers to lie in preparing lessons and providing students with direct access to information. 9. van Braak (2001) found that teachers who used networked computers were significantly ($p < 0.001$) more positive about the relevance of networked computers in education than teachers who did not use networked computers. 10. Butler and Sellblom (2002): Faculty members' perceived value of ICT in improving learning was the 3rd most significant factor affecting the computer use of the 125 faculty members at one United States university. 11. Russell et al. (2003) found teacher perspectives on ICT relevance to be the strongest predictor of technology use for instruction. 12. Shannon and Doube (2003) reported the impact of computer use on teaching and learning as the main factor impacting on faculty members' use of computers for instruction. 13. Zhao and Frank (2003) found that teachers' belief that computers could offer teachers an advantage in their teaching had a significant impact on their technology use ($p < 0.01$). 14. Twenty-five percent of the secondary school teachers in the study by Lai and Pratt (2004) reported a lack of understanding of the value of ICT use to teaching and learning as the largest barrier to ICT integration. 15. Kanaya et al (2005) found that teachers perceptions of the relevance of technology to their teaching and learning to be a significant factor affecting teachers' use of a new software programme in their teaching ($p < 0.01$). 16. Selwood and Pilkington (2005): Many of the teachers in this study felt that ICT use could potentially reduce their workload. Some teachers also felt that ICT could be used to better engage learners during lessons. 17. Ng and Gunstone (2003): 80% of the teachers in the study felt that ICT is relevant in science teaching in the context of present-day society, which influenced their use of computers in their teaching. 18. Wood et al. (2005): Teachers in this study supported the idea of computer integration, but felt they lacked the support to carry it out.

		19. Sahin and Thompson (2006) reported the perceived relevance of using computers as an important attitudinal factor influencing the instructional use of computers. 20. Drent and Meelissen (2008) found that teachers' teaching philosophy had a small indirect effect on their innovative use of ICT for teaching. 21. Tondeur et al. (2008): Only 7.7% of principals instructed their teachers to use ICT because ICT use was not part of the Flemish curriculum at that stage. Teachers' use of computers was found to depend largely on their perceived relevance of computers to teaching and learning. 22. Blignaut et al. (2010) reported that teachers' perceptions of the value of ICT to teaching and learning impacted on computer use in the classroom. They found significant differences between Chilean teachers, who make more use of ICT for teaching and learning, and South African teachers with regard to their beliefs about the positive impact of ICT on education. 23. Chen (2010) found that pre-service teachers' perceived value of using technology in teaching and learning significantly affected ($p < 0.001$) their use of computers for teaching. 24. Mueller et al. (2010) reported significant differences between high and low integrators with regard to the extent to which elementary and secondary teachers' saw the potential for using computers as instructional tools ($p < 0.004$). 25. Ward and Parr (2010) found teachers' beliefs about the advantages of using ICT in teaching and learning to be a significant factor affecting the use of ICT in the classroom ($p < 0.1$). 26. Donnelly et al. (2011): The teachers in this Irish study cited a number of reasons why they would use ICT. One of the 5 teachers felt that the value of ICT was that it allowed information to be presented in different ways. Other teachers felt that the value was that learners could work at their own pace and at any time. Another teacher felt that using computers saves a lot of paperwork while yet another felt that technology use was more modern and therefore relevant to learners. Specific to the Virtual Chemistry Lab software used in the study, one teacher felt that it would allow practical work to be carried out even when the equipment was not available, while another said it would be useful to use the software when she couldn't use the physical lab due to timetabling clashes with other teachers. 27. Ertmer et al. (2012): All 12 teachers in this study saw value in using technology in their teaching, although they used it in different ways depending on their pedagogical beliefs. 28. Vanderlinde et al. (2012) identified teachers' perceptions of whether the Flemish ICT curriculum would improve teaching and learning as an important factor affecting teachers' use of computers. The three schools with the highest perceptions of relevance of the ICT curriculum showed high to moderate levels of ICT usage out of the 62 schools surveyed. At the high end of ICT usage one school was ranked 3/62 for use of ICT as a learning tool while another school was ranked 25/62 for use of ICT as an information tool (moderate usage).
Attitudes towards ICT	Fears about managing learners in lessons*: Teachers' inability to maintain discipline when using computers in lessons.*	1. Drenoyianni and Selwood (1998): 54% of the teachers in this study cited problems with managing lessons involving ICT as a discouraging factor. 2. Cox et al. (1999): Less than 10% of the 82 experienced ICT and IT teachers in this study were afraid of using ICT in lessons because they were afraid of not being able to manage their classes. 3. Selwyn (1999) reported that some teachers were discouraged from using computers because they might not be in control of what learners are doing when using computers. 4. Williams et al. (2000): Teachers reported problems with class management due to limited resources. 5. Nisan-Nelson (2001) found that one of the three teachers in that study was discouraged from using computers by problems managing her classes in the computer lab. 6. Wood et al. (2005): Teachers cited three types of problems managing classes when learners were going to be using computers: the difficulties associated with moving a class of young children to a computer lab; the difficulties managing groups of learners with different skill levels, and thirdly, their fears about possible sabotage of computers and hacking or vandalism. 7. Ng and Gunstone (2003) believe that issues related to classroom management when using computers for teaching, for example, avoiding vandalism of computers and managing technology-based activities for which there is insufficient equipment, discourage teachers from using computers in their lessons .

	Enthusiasm for using ICT: *The extent to which the teacher displays a positive attitude towards using computers.*	1. Zammit (1992): Teachers who used computers for teaching ranked their motivation to keep up-to-date with changes as the 3rd of 9 factors which encouraged their use of computers. 2. Cox et al. (1999): The majority of the 82 experienced ICT and IT teachers in this study displayed positive attitudes towards using computers in their teaching. About 70% planned to increase their range of usage in the future. 3. Selwyn (1999) reported that teachers who were enthusiastic about using computers often transferred their enthusiasm to other teachers in their department. 4. Williams et al. (2000) reported low attitude scores for maths, science and language teachers, who showed less frequent use of ICT for teaching and learning than teachers who displayed more positive attitudes (business and management studies teachers). 5. Pelgrum (2001): 27% of teachers reported a lack of interest for integrating ICT. 6. Shannon and Doube (2003): 42% of respondents indicated a lack of personal motivation to use computers for instructional purposes. 7. Zhao et al. (2002) found that teacher's attitude towards computers affected the success of their computer use with learners. 8. Lai and Pratt (2004) reported that the ICT coordinators in their study had higher expectations for their students to use ICT compared to other teachers and showed higher levels of technology integration. 9. Sahin and Thompson (2006) reported that a positive attitude towards computers significantly correlated with the use of computers for instruction ($p < 0.05$). 10. Ng and Gunstone (2003): 95% of the teachers displayed positive attitudes towards using computers, but only 43% used computers in their teaching. 11. Drent and Meelissen (2008) found that teachers' attitude towards ICT had a direct effect on the innovative use of ICT by teachers. 12. Hermans et al. (2008) found that teachers' attitude towards using computers significantly affected their level of technology integration ($p < 0.001$). 13. A positive attitude towards computers in education was found to have a significant positive effect ($p < 0.01$) on ICT use in classrooms (Tondeur et al., 2008). 14. Mueller et al. (2010) reported significant differences between high and low integrators with regard to the extent to which elementary and secondary teachers' were motivated to use computers as instructional tools ($p < 0.004$). 15. Donnelly et al. (2011) found that teachers' level of enthusiasm for using computers impacted on their classroom technology use. 16. Ertmer et al. (2012): All 12 teachers who had won awards for their technology practices displayed positive attitudes towards using computers for teaching and learning.
	Teachers' preferred learning style: *The method of perceiving and processing information preferred by the teacher.*	1. Drenoyianni and Selwood (1998): Some of the teachers in this study displayed a research-oriented attitude by requesting training about the "*educational aspects*" of integrating ICT (Drenoyianni & Selwood, 1998, p. 96). 2. Cox et al. (1999): More than 60% of the 82 experienced ICT and IT teachers in this study used the Internet for collaborating with others about ways to use ICT in their teaching. 3. Nisan-Nelson (2001): Findings suggest that the type of instructional activities teachers use computers for reflects their preferred learning style.
	Locus of control: *The extent to which a teacher perceives they are in control of events relating to their ICT use in*	1. Marcinkiewicz (1993) found teachers' locus of control to be an important predictor of whether teachers would use computers in their lessons ($p < 0.001$). 2. Cox et al. (1999): Most of the 82 experienced ICT and IT teachers in this study were confident about their ability to use computers effectively and to manage lessons using computers, which might have contributed to their extensive ICT use in their teaching. 3. Nissan-Nelson (2001): Findings suggest that teachers' level of perceived control influences whether they will use computers in innovative ways. 4. Zhao et al. (2002) reported that teachers who were less willing to confront possible barriers to their computer use in lessons were less likely to use computers successfully for teaching and learning.

	the classroom.	5. Chen (2010) found that preservice teachers perceived confidence in their ability to use computers effectively in the classroom and to manage tasks involving computers impacted on their use of computers for teaching ($p < 0.001$).
	Fear of embarrassment: *Teachers' self-consciousness that their lack of ICT skills might show them up in front of learners.*	1. Russell and Bradley (1997) reported teachers' fear of embarrassment as a discouraging factor for the use of computers for teaching purposes. 2. Selwyn (1999) reported that some teachers were afraid that their learners might know more than they do. 3. Al-Fudail and Mellar (2008): Teachers reported feeling frightened about not being able to meet students' expectations, or when teachers were not able to use software effectively.
	Fear of loss of status: *Teachers' viewpoint that computers might usurp their role.*	1. Selwyn (1999) reported that some teachers were felt that computers posed a threat to their teaching. 2. Ward and Parr (2010) found teachers' concerns about the use ICT in education (e.g. the possibility of relinquishing instructional responsibility to computers) as a significant factor affecting the use of ICT in the classroom ($p < 0.1$).
	Level of confidence*: The extent to which the teacher feels at ease using computers.*	1. Zammit (1992) ranked self-confidence as 1st out of 7 factors preventing computer use by teachers who do not use computers and 5th by teachers who do, with significant differences ($p < 0.0001$) in the confidence levels between the two groups . 2. Russell and Bradley (1997) reported that some teachers' lack of confidence in their ability to use computers impacted negatively on their use of computers for teaching. 3. Cox et al*.* (1999) reported that the 82 experienced ICT-using teachers in this study displayed high levels of confidence, which encouraged them to increase their use of ICT in the future 4. Ertmer and Hruskocy (1999) found that the ICT confidence levels of 12 of the 13 teachers in their study increased with instructional, technical support and professional support. 5. Wellington (1999) identified teachers' lack of confidence in using computers as a barrier to computer use. 6. Williams et al*.* (2000): Teachers felt they needed to build up their confidence through improving their basic skills before they would feel sufficiently confident to use ICT for teaching and learning. 7. Nisan-Nelson (2001): Findings suggest that teachers' level of ICT confidence influences whether they will use computers in innovative ways. 8. Bauer and Kenton (2005) reported that teachers' level of confidence impacted on their use of computers for teaching. 9. Russell et al*. (*2003) found teachers' confidence influenced their level of technology use for instruction. 10. Selwood and Pilkington (2005): Teachers' level of confidence was identified as a factor influencing their use of computers for instruction. After participating in an initiative to promote ICT use in the classsroom, 38% of special school teachers, 52% of primary and 31% of the secondary teachers felt more confident about using technology to support teaching and learning. 11. Wood et al*.* (2005) found teachers' level of confidence to be a significant predictor of teacher use of computers ($p < 0.001$). 12. Al-Fudail and Mellar (2008): Teachers reported feeling uncomfortable when using ICT for teaching. 13. Blignaut et al*.* (2010) reported that teachers' level of confidence impacts their use of computers for teaching. 14. Chen (2010) found teachers' perceived level of self-efficacy to the most important factor impacting on their use of computers for teaching and learning. 15. Many of the teachers in the study by Chigona and Chigona (2010) were not confident about using computers for teaching. 16. Mueller et al*.* (2010) reported significant differences between high and low integrators with regard to the levels of confidence of elementary and secondary teachers ($p < 0.004$). 17. Voogt (2010) found that extensive ICT-using science teachers were more confident about using technology for teaching than non-extensive ICT-using

		science teachers ($p < 0.01$). 18. Ward and Parr (2010) found teachers' level of confidence about using ICT for teaching and learning to be the most significant factor affecting their ICT use in the classroom ($p < 0.1$). 19. Ertmer et al. (2012): The 12 technology award-winning teachers rated their own attitudes and beliefs about technology as the biggest enabling factor, but 2/12 teachers mentioned other teachers' lack of confidence as a barrier to integrating technology.
	Level of innovativeness: *Teachers' willingness to introduce computers in the classroom, or their resistance to change.*	1. Zammit (1992) reported that teachers who were self-motivated to learn how to use computers were more likely to use computers for teaching. 2. Marcinkiewicz (1993-1994) found teacher innovativeness to be a significant predictor of whether teachers would use computers in their lessons ($p < 0.001$). 3. Selwyn (1999) reported that teachers who were resistant to change were less likely to use ICT for teaching and learning. 4. Nisan-Nelson (2001): Findings suggested that teachers' level of innovativeness influences whether they will use computers in learner-centred ways. 5. Pelgrum (2001): 8% of respondents reported the difficulty they experienced integrating ICT into their teaching as a discouraging factor. 6. van Braak (2001) reported that teachers who used networked computers displayed a significantly higher degree of technological innovativeness ($p < 0.001$) compared to teachers who did not use networked computers. 7. Baylor and Ritchie (2002) found teachers' openness to change to be a significant factor affecting their use of computers ($p < 0.01$). 8. Dori et al. (2002) found that teachers who display a positive attitude to change are more likely to use web-based teaching methods. 9. Bauer and Kenton (2005) reported that teachers' level of innovativeness impacted on their use of computers for teaching. 10. Zhao and Frank (2003) found that teachers' willingness to explore new technologies on their own to be a highly significant factor affecting technology use ($p < 0.001$). 11. Lai and Pratt (2004) reported that the ICT coordinators in their study took more responsibility for their own professional development and were more willing to spend time and money upgrading their ICT skills than other teachers. The ICT coordinators were more likely to have better ICT skills compared to other teachers and to use computers more. 12. Vannatta and Fordham (2004) reported teachers' willingness to change as an important predictor of their computer use in the classroom ($p < 0.01$). 13. Sahin and Thompson (2006) found that teachers' instructional use of computers was related to their level of innovativeness. 14. Drent and Meelissen (2008) found teachers' level of innovativeness to be the key factor influencing their innovative use of computers for teaching and learning. Three of the 4 teachers interviewed in this study were regarded as highly innovative because they were strongly motivated to use ICT in innovative ways to enhance learning. 15. Technological innovativeness was found to have a significant positive effect ($p = 0.03$) on ICT use for teaching (Tondeur et al., 2008). 16. Donnelly et al. (2011): Teachers' lack of willingness to change was mentioned as a factor discouraging their use of ICT for teaching and learning. 17. Vanderlinde et al. (2012) reported that one of the 3 schools they surveyed, which displayed a high level ICT use, had won awards for teachers' innovative use of ICT. 18. Ertmer et al. (2012): The 12 technology award-winning teachers displayed high levels of innovativeness, e.g. all 12 had found ways to overcome any external barriers to their computer use. Also, four of the twelve teachers used professional learning networks (e.g. Twitter), which they described as having had the biggest influence on their technology integration.
ICT profile	Length of ICT experience*: The length of time for which teachers have been using computers*	1. Russell and Bradley (1997): Teachers who reported using computers for a longer period of time were more likely to feel competent doing so. 2. Lai and Pratt (2004) reported that the ICT coordinators in their study, who had more ICT experience, than other teachers, were more likely to integrate computers into their teaching. 3. Kanaya et al. (2005) found the length of teachers' prior technology use to be a significant predictor of their use of technology in lessons ($p < 0.01$). 4. Wood et al. (2005): Teachers' individual experience with using ICT impacted on their use of technology for teaching, with this factor being more important for elementary teachers than secondary teachers.

		5. Hermans et al. (2008) found teachers' length of use of ICT to have a significant effect ($p < 0.001$) on their use of computers in the classroom. 6. Tondeur et al. (2008) found that the length of teachers' computer experience impacted on their use of computers. 7. Drent and Meelissen (2008) found that teachers' computer experience had a direct effect on their innovative use of ICT. 8. Donnelly et al. (2011): Teachers who had not grown up with computers were regarded as less likely to use computers in their teaching.
	ICT use outside of teaching: *The extent of use of ICT by teachers outside of the classroom, both for work (e.g. for preparing lessons) and for personal use.*	1. Zammit (1992) reported that teachers' use of computers at home could positively impact on their use for teaching. 2. Russell and Bradley (1997) reported that only a minority of teachers had access to computers at home, which they said made them feel competent about using computers in lessons. 3. Cox et al. (1999) reported that teachers who make regular use of ICT outside of school have higher perceptions of its value for enhancing teaching and learning. 4. Selwyn (1999) reported that teachers' level of ICT use outside of the classroom impacted on their classroom use. 5. Becker (2000) found that teachers who used computers outside of school, for their own purposes, used computers more with their learners. 6. Williams et al. (2000) reported that teachers who used computers at home used ICT more for teaching and learning. 7. Cuban et al. (2001): More than 80% of the teachers at both high schools had access to computers at home, with similar numbers making frequent use of computers for personal use and school prep. 8. Baylor and Ritchie (2002) found that where teachers did not use computers outside of school, this had a negative impact on their computer use in the classroom ($p < 0.05$). 9. Lai and Pratt (2004) reported that the ICT coordinators in their study, who used computers more outside of school, e.g. for professional development, were more likely to integrate computers into their teaching than teachers with less experience. 10. Vannatta and Fordham (2004) found time teachers spent using computers outside of lessons to be an important predictor of their classroom computer use ($p < 0.01$). 11. Kanaya et al (2005) found the extent of teachers' technology use outside of school was a significant predictor of their use of technology in lessons ($p < 0.01$). 12. Selwood and Pilkington (2005): Teachers in this study reported that technology access at home influenced their use of ICT for instruction. 13. Drent and Meelissen (2008) found that highly motivated teachers experimented with technology outside of school hours to improve their ICT skills. 14. Hermans et al. (2008) found that the extent of teachers' use of computers outside the classroom impacted on their computer use in the classroom (non-significant difference). 15. Hossain and Brooks (2008): Teachers' technology usage outside of the school had a huge effect on their ICT competence. 16. Tondeur et al. (2008) reported that teachers' intensity of ICT use had a significant positive effect on their computer use ($p < 0.000$). 17. Mueller et al. (2010) reported significant differences between high and low integrators with regard to the extent of elementary and secondary teachers' computer experience ($p < 0.004$). 18. Ertmer et al. (2012): The 12 technology award-winning teachers all used computers outside the classroom, e.g. all 12 had their own website and four of the twelve teachers used Twitter and blogs for their own professional development.
	ICT training: *The nature and extent of the opportunities teachers have had to develop their ICT skills.*	1. Zammit (1992) reported highly significant differences ($p < 0.0001$) in the amount of training between teachers who used computers in the classroom and teachers who didn't. 2. Russell and Bradley (1997) reported that teachers who had prior ICT training used computers more. 3. Ertmer and Hruskocy (1999): 9 of the 12 teachers reported the ICT training they had received as having had a positive effect on their use of computers. 4. Baylor and Ritchie (2002) reported that teachers' level of ICT training impacted on their use of computers ($p < 0.001$). 5. Zhao et al. (2002) concluded that teachers who were proficient in using computers were more likely to use computers successfully for teaching and

		learning. 6. Bauer and Kenton (2005): some teachers in this study attributed their lack of ICT skill to a lack of ICT training. 7. Shannon and Doube (2003): Faculty members indicated a lack of ICT training impacted on their use of computers for instruction. 8. Lai and Pratt (2004) reported that the ICT coordinators in their study, who had more ICT training than other teachers, were more likely to integrate computers into their teaching than teachers with less experience. 9. Vannatta and Fordham (2004) found that teachers' number of hours of technology training was an important predictor of their classroom use of computers ($p < 0.01$). 10. Kanaya et al. (2005) found the extent of teachers' ICT training to be a significant predictor of their use of technology in lessons ($p < 0.05$). 11. Hossain and Brooks (2008) found teachers' ICT training to be one of the major factors affecting their ICT usage. 12. Tondeur et al. (2008) reported that teachers' level of ICT training had a significant impact on their use of computers for teaching ($p < 0.01$). 13. Chen (2010): found teachers' level of ICT training had a significant effect ($p < 0.01$) on their use of computers for student-centred learning. 14. The teachers in the study by Chigona and Chigona (2010) had not had sufficient training to feel confident about using computers in lessons. 15. Mueller et al. (2010) reported significant differences between high and low integrators with regard to the extent of elementary teachers' computer training ($p < 0.001$). 16. Voogt (2010) found that extensive ICT-using science teachers had more technology training for teaching than non-extensive ICT-using science teachers ($p < 0.01$). 17. Ward and Parr (2010) found teachers' level of ICT training to be a significant factor affecting their ICT use ($p < 0.1$). 18. Donnelly et al. (2011) reported that teachers' level of ICT training impacted on their ability to use computers for teaching and learning. 19. Vanderlinde et al. (2012) identified the extent of teachers' computer training as a factor impacting their use of computers for teaching.
	ICT competence*: Teachers' ICT skills and technological pedagogical knowledge (TPACK).*	1. Zammit (1992) reported significant differences ($p < 0.0001$) in the ICT competence levels between teachers who use computers and those who don't. 2. Marcinkiewicz (1993-1994) found teacher self-competence to be an important predictor of whether teachers would use computers in their lessons ($p < 0.001$). 3. Chiero (1997): A lack of training was mentioned as the second most significant obstacle to teacher computer use. 4. Russell and Bradley (1997): Teachers who felt they were not competent using computers (43% of sample) were less likely to use computers than those who felt competent (22% of sample). 5. Drenoyianni and Selwood (1998): 54% of the teachers cited their lack of ICT competence as an obstacle to their use of computers. 6. Cox et al. (1999): The majority of the 82 experienced ICT and IT teachers in this study felt competent about using computer hardware and software. More than 75% of these teachers were able to perform various ICT tasks such as loading software and connecting to external devices. 7. Ertmer and Hruskocy (1999) found that the teachers in their study used computers more as their computer skills improved. 8. Quick and Davies (1999): Participants did not have the skill to use the type of software they wanted to use in their teaching. 9. Wellington (1999) identified a lack of competence in using computers as a barrier to computer use by teachers. 10. Becker (2000) found that teachers who reported a high level of expertise in using computers used three times the number of software programmes with their learners than teachers with low levels of computer skills. 11. Williams et al. (2000): More than 10% of primary school teachers reported not knowing how to use 11 out of 15 computer applications (e.g. using email and the Internet). 12. Pelgrum (2001) found a lack of ICT competence to be the 2nd major obstacle out of 38 possible obstacles to computer use for 66% of the respondents. 13. Baylor and Ritchie (2002) reported that teachers' level of ICT skills impacted on their use of computers for teaching and learning. 14. Butler and Sellblom (2002): Knowledge of how to use a technology was the second most important factor affecting adoption of computers among the

		125 faculty members at one US university. 15. Zhao et al. (2002) found that teachers' technology proficiency plays a major role in determining how they use computers in the classroom. Where teachers better understand the enabling conditions for a particular technology, they are more likely to use it successfully. 16. Bauer and Kenton (2005): 5/30 teachers (17%) reported their lack of ICT skills hindered their use of computers for teaching. 17. Shannon and Doube (2003): Faculty members were discouraged from using computers for instruction by their lack of ICT skills. 18. Lai and Pratt (2004) reported that teachers with better ICT skills were more likely to integrate computers into their teaching than teachers who were less ICT competent. 19. Kanaya et al (2005) found the extent of teachers' ICT competence to be a significant predictor of their use of technology in lessons ($p < 0.05$). 20. Selwood and Pilkington (2005): Teachers in this study identified their lack of ICT skill as a factor influencing their use of computers for instruction. 21. Wood et al. (2005): A lack of ICT skill was an important barrier for the teachers in this study. 22. Sahin and Thompson (2006) identified computer expertise as the most important factor affecting faculty members' use of computers. 23. Ng and Gunstone (2003) reported considerable variation in the level of ICT skills for the teachers they interviewed, which they said could account for the low numbers of teachers (42.9% of the sample) using technology in the classroom. 24. Al-Fudail and Mellar (2008): Teachers reported that a lack of technological skills hindered their use of computers for teaching. 25. Drent and Meelissen (2008) found that teachers' level of ICT competence had a small, indirect effect on their innovative use of ICT. 26. Hossain and Brooks (2008) found teachers' level of ICT skill to have a moderate effect on their ICT usage. 27. Blignaut et al. (2010) reported that the level of ICT skills of South African and Chilean teachers impacted on their computer use. 28. Chen (2010) found teachers' level of ICT skill had a significant effect ($p < 0.01$) on their use of computers for student-centred learning. 29. Chigona and Chigona (2010) reported that the low levels of technology literacy amongst the teachers in their study hampered their use of computers for teaching. 30. Voogt (2010) found that extensive ICT-using science teachers felt more competent about using technology for teaching than non-extensive ICT-using science teachers ($p < 0.01$). 31. Ward and Parr (2010) found teachers' level of ICT skill to be a significant factor affecting their ICT use for administrative tasks and lesson preparation ($p < 0.1$). 32. Donnelly et al. (2011): Teachers' lack of ICT skills was mentioned as a barrier to their integration of ICT. 33. Vanderlinde et al. (2012): Teachers at two of the schools in the initial study were ranked 4/62 and 5/62 for their ICT competencies. Both schools displayed high levels of ICT usage (3/62 and 7/62, respectively, for using ICT as a learning tool). 34. Ertmer et al. (2012) reported teachers' level of ICT competence as a huge enabling factor for the 12 award-winning teachers in their study. However, 2 of the12 teachers mentioned a lack of skill as a barrier for other teachers' technology integration.
	Difficulty integrating ICT into instruction: *The extent to which teachers have had success with using computers in teaching.*	1. Al-Fudail and Mellar (2008): Teachers reported using computers as stressful because of their lack of ICT skills. 2. Pelgrum (2001): Difficulty with using computers was ranked 3rd highest obstacle after lack of knowledge and skills.

	Positive experiences using ICT: *The extent to which previous successful ICT encounters motivates teachers to use computers for teaching.*	1. Ertmer and Hruskocy (1999) found that the teachers in their study became more positive about using computers when they saw an increase in learners' level of motivation and skills. 2. Mueller et al. (2010) reported significant differences between high and low integrators in the number of positive experiences elementary and secondary teachers had using computers ($p < 0.004$).

Appendix H:

Learner-related factors affecting teachers' use of ICT, summarised from 48 studies reviewed

	Factor	Empirical evidence for effect of factor on ICT use in the classroom
Access to ICT resources	Access to computer hardware: *The extent to which learners have technological resources (e.g. machines, printers, speakers) to use at home.*	1. Wellington (1999) reported that ICT integration into teaching and learning was enhanced by learner access to computers at home. 2. Cuban et al. (2001): More than 80% of the students in this study had access to computers at home. 3. Wood et al. (2005) reported that learners' access to computers at home influenced how much computer work teachers could set.
Attitudes to use of ICT	Level of learner interest: *Learners' motivation to use ICT, at school and at home*	1. Ertmer and Hruskocy (1999) found that learners' attitudes to the use of ICT in lessons improved as they became more skilled and more confident about using ICT. 2. Wellington (1999) reported that learner's level of interest impacted on the use of ICT for teaching and learning. 3. Selwyn (1999) reported that learners were not interested in using computers in lessons, because they would rather focus on work that was going to be examined. 4. Williams et al. (2000): Learner interest in using computers for teaching and learning encouraged teachers to use computers more. 5. Ng and Gunstone (2003): Nearly 80% of the teachers reported that their students responded positively to using computers in lessons. 6. Donnelly et al. (2011): Some of the teachers in the Irish study found that it was difficult to motivate learners to use computers because learners were not interested in work that was not going to be examined. Other teachers were encouraged to use computers in lessons because they were encouraged by how much learners' enjoyed lessons involving technology. 7. van Braak (2001) reported that the lack of learner interest in the use of ICT in class impacted on teachers' use of computers. However, teachers who used networked computers were more convinced of learners' interest than those who did not ($p < 0.05$). 8. Wood et al. (2005) reported that learners' motivation to computers influenced how much teachers used computers for teaching and learning. 9. Ward and Parr (2010) found that the level of interest in ICT use displayed by learners encourages teachers to use technology. 10. Ertmer et al. (2012): Two of the 12 teachers were encouraged to use technology by students' level of interest.
Learner ICT profile	ICT competence: *Level of learners' technology skills.*	1. Zammit (1992): Some teachers felt comfortable relying on learners to help them with using computers in lessons, while other teachers felt uncomfortable when learners knew more than they did (no figures supplied for this factor). 2. Selwyn (1999) reported that teachers were more likely to use computers with students who are more competent at using them without needing assistance. 3. Wellington (1999) reported that learner's ICT skill impacted the use of ICT for teaching and learning. 4. Bauer and Kenton (2005): 7/30 teachers (23%) reported having students with different levels of ICT competency in their classes as a barrier to their use of computers. 5. Ertmer and Hruskocy (1999) found that teachers could use ICT-competent learners to help other less-skilled learners, which impacted positively on computer use. On the other hand, some teachers were reluctant to use trained students to help them resolve technical issues. 6. Pelgrum (2001): 29% of the learners had better ICT skills than teachers. 7. Wood et al. (2005) reported that differences in learners' level of ICT skill impacted on teachers' use of computers for teaching and learning. 8. Al-Fudail and Mellar (2008): Teachers reported learners' lack of ICT skills as an obstacle to their use of computers, but also found it stressful when learners potentially knew more than the teachers did. No figures supplied. 9. Ertmer et al. (2012) found learners' level of ICT competence to be an enabling factor for teachers' technology integration. 10. Vanderlinde et al. (2012): One of 3 case study schools, ranked 7/62 in initial survey on the use of ICT for learning, had an ICT curriculum policy focused specifically on developing learner's ICT competencies.

Appendix I:

Teacher interview schedule for first phase of study

reason(s) why information is required	Justification for information required	Main questions	Follow-up situations or probe questions
Subject and classes taught			
To obtain background information on the teachers being interviewed.	Teacher background is necessary in order to be able to describe the group of teachers being interviewed.	*I would like you to tell me a little bit about what you teach.*	
		1. What subject(s) do you teach?	
		2. How long have you been teaching this subject at this school?	
		3. What grades are you currently teaching?	
Knowledge about computers and computer literacy			
To obtain background information on how comfortable the teacher is about using computers.	Will provide insight into teacher's level of computer literacy. May provide insight into their current usage of computers, and their views about how computers should be used.	*I'd like to ask you some questions about your personal computer use.*	
		4. Do you use computers at all?	*If respondent answers "yes" probe further* • What do you use computers for? *if they seem unsure, ask* • What programmes do you use? *Probe for use of word-processing, spreadsheets, PowerPoint, e-mail, Internet, Internet banking* • What do you use computers for at school?
		5. How competent would you say you are at using a computer?	*Give respondent time to think about level of competency, then ask probe questions:* • Would you describe yourself as not very competent, fairly competent or highly competent?
		6. Have you ever had any formal computer training?	*If respondent answers "yes" probe further* • What sort of computer training have you had? Have you had in-service training or have you attended any training courses?
		7. Have you ever loaded a computer programme?	• Would you know how to load one? Would you require a technician to help you?
		8. How do you feel about using computers?	*If they seem unsure about what is being asked, rephrase as follows:* • How comfortable or uncomfortable are you about using computers?
Teacher's views on the use of computers in the school			
To establish what the teacher means when they say	To understand the reasons teachers think computers are being	*At a recent strategic planning meeting for staff, you suggested that computer use in the school could be improved.*	
		9. What do you think about the way computers are being used in the school?	*Give respondent time to think about the way computers are being used, then ask probe questions:* • What is access to the computers like? How well does the booking system for

computer use in the school can be improved and to explore why they think computers are being underutilised.	underutilised.		the computer room work? Are there sufficient computers for staff? Are there sufficient computers in the computer room? • Have you ever needed any technical support when using the computers, either in the staffroom or the computer lab? What for? How good was the support? • Are there any other factors that you think affect the way computers are being used in the school?
		10. What exactly did you mean when you suggested that computer use in the school could be improved?	In what ways could it be improved?
Teacher's views on the use of computers in their subject			
To establish how much the teacher is currently using computers in their subject.	To be able to compare actual and desired practice	*Let's focus on how you currently use computers in your lessons.*	
		11. Do you currently make use of computers in your lessons?	*If they answer "yes"* • Approximately how frequently would you say you use computers during lessons? *If there is no response, respondent can be prompted with the following questions:* • About once a week? Once a month? Only when needed? When would that be? *Go to question 12.* *If they answer "no"* • Would you like to make use of computers in your lessons? *If they answer "yes" go to question 13.*
		12. How do you **currently** make use of computers in your lessons?	
		13. How **would you like to** use computers **in your subject?**	Standby question: In other words, what are the specific reasons you would use or want to use computers **for in your subject**?
		14. Have you ever considered using computers **to actually teach a new section of work**?	
		15. Do you know of any software available in the school that you could use as part of your lessons?	*If respondent answers in the affirmative, then ask question 16. If respondent answers in the negative, then ask question 17.*
		16. Have you ever made use of it?	*If they answer "yes"* • Have you found it to be useful from a teaching point of view or not? • How would you rate the quality of the software? *If they answer "no"* • How would you make use of it?

		17. If such software was available would you make use of it?	• How would you make use of it?
Factors preventing teachers from using computers in their subject			
To identify any factors which are specific to a particular subject that may affect teachers using computers in their lessons.	To establish what factors teachers feel affect their use of computers in their particular subject.	18. What would you say are the major factors affecting your use of computers in your subject?	*If respondent has difficulty formulating an answer, the following prompt questions may be asked:* • What factors encourage you to use or to attempt to use computers in your lessons? • What factors discourage you from using or attempting to use computers in your lessons? *If necessary, probe:* – computer access, – teacher's confidence with using computers, – lack of knowledge about what is available and how it can be used – time available – amount of technical support, – suitability / quality of the software
Teachers use of the Smart board			
To establish the frequency with which teachers are using the Smart board and how they are using it.	To establish compare frequency of use and nature of use of Smart board by different teachers.	*At the strategic planning meeting there was some discussion around the use of the Smart board.* 19. Have you ever used the Smart board?	*If they answer "yes"* • Approximately how many times have you used it? *If there is no response, respondent can be prompted with the following questions:* • Have you used it once or twice? More than five times? When was the last time you used it? • How have you used it? • How did you find the experience? *If they answer "no" ,* • What are the reasons you have not used the Smart board? • Would you ever consider using it? • How would you use it?

Appendix J:

Ethics clearance form for first phase of study

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 George

CLEARANCE CERTIFICATE	H0**PROTOCOL NUMBER 61107**
PROJECT Support Material	Factors Affecting the Use of Instructional oftware as
INVESTIGATORS	Mrs A George
DEPARTMENT	APES/APES
DATE CONSIDERED	06.11.22
DECISION OF THE COMMITTEE*	APPROVED UNCONDITIONALLY

This ethical clearance is valid for 2 years and may be renewed upon application

DATE 07.01.11 **CHAIRPERSON** .....
(Professor M Vorster)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Prof Sanders
APES

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10005, 10th Floor, Senate House, University.

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

This ethical clearance will expire on 1 February 2008

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix K:

Ethics clearance form for second phase of study

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (NON MEDICAL)
R14/49 George

CLEARANCE CERTIFICATE **PROTOCOL NUMBER H100 908**

PROJECT Factors affecting teachers use of computer technology with particular reference to teaching biodiversity

INVESTIGATORS Ms A George

DEPARTMENT APES

DATE CONSIDERED 17.09.2010

DECISION OF THE COMMITTEE* Approved Unconditionally

NOTE:

Unless otherwise specified this ethical clearance is valid for 2 years and may be renewed upon application

DATE 11.10.2010 **CHAIRPERSON** .....
(Professor R Thornton)

cc: Supervisor : Prof M Sanders

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10005, 10th Floor, Senate House, Univers

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

Signature

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix L:

Permission from the school authorities to carry out the study

[redacted]

2 August 2010

Dear Ann

Following our discussion relating to your research, you have been granted permission to expand your research study investigating the factors affecting the use of computer technology by teachers at the school.

Yours faithfully

[redacted]
College Head

Appendix M:

Talk inviting teachers to participate in the second phase of the study

Some of you are aware that I conducted some research on the use of computers at the school when I was teaching here. I'm using this visit as an opportunity to introduce myself to the many new people who have joined the College staff, and to reacquaint myself with some of the others. I'm also here to explain to you, very briefly, about that original research and some new research I will be doing.

The original research revealed some of the obstacles facing teachers wanting to use computers in their teaching. One of the benefits of research is that it can lead to better practice. I have talked to the headmaster and offered to present the findings to the school.The introduction of DigiDays provides an opportunity to expand the research to investigate the effect of DigiDays on teachers' use of computers.

The aim of the study is to develop a better understanding of factors which affect the use of computers in teaching. I hope this will allow me to suggest ways of helping teachers use computers more effectively, so that the many advantages of computers in education can be met.

Thanks for your time. I will be available for questions after the staff meeting.

Appendix N:

Participant information sheet and consent form (Phase 1)

PARTICIPANT INFORMATION SHEET

I am currently conducting a research study of the factors affecting the use of instructional software at_____. Over the course of the last eight months I have identified you as a teacher who is attempting to make use of computer technology in your lessons. This identification was based on your use of the school's computer lab during this period and disclosures made by you at our Strategic Planning Meeting on 7 October 2005.

Owing to the nature of my research, I am extremely interested in interviewing you to explore how you currently use computers in your teaching and how you would like to use computers in your teaching. I would further like to explore your perspectives on any factors which you feel are currently encouraging or discouraging your use of computers in your lessons.

Your participation in this study would involve being interviewed by me, with the interview being tape-recorded and transcribed for later analysis. The analysis would involve the transcripts being coded to look for emerging patterns and trends of computer use among the teachers interviewed and for common factors affecting computer use in the school. On completion of the study, the tapes will be destroyed and the transcripts shredded.

Your participation in this study would be entirely voluntary and complete confidentiality will be ensured. Teachers will not be identified by name in the write-up of this research study, but rather by labels, e.g. Teacher 1. As a participant, you would be entitled to feedback on the results of the study should you so desire.

I would like to invite you to participate in this study. Should you agree to be a participant, please complete the attached consent form. Please contact me on _____should you have any questions about the study.

CONSENT FORM

I, _____, hereby agree to participate in the study being conducted by _____ investigating the factors affecting teachers' use of computers in the school. I give permission to be interviewed and to have the interview tape-recorded. I understand that the interview will be transcribed and analysed and the data used to identify trends and patterns in the use of computers by teachers in the school.

I understand that my participation is entirely voluntary and that I can withdraw from the study at any time without suffering any penalty. I further understand that the interview, transcript and any other information arising from the interview and transcript will be treated with the greatest confidentiality.

I further understand that I am at liberty to approach the researcher with any queries or concerns I may have at any stage of the study.

Signed: _____ at _____ on _____

Appendix O:

Participant information sheet and consent form (Phase 2)

PARTICIPANT INFORMATION SHEET

Following the talk I gave at the school during which I introduced myself and outlined my research, here is an information sheet to remind you of what the study is about and to give you some more information about what it means to participate in the study.

What the study is about

Some of you are aware that I conducted research on the use of computers at the school when I was teaching here. The original research revealed some of the obstacles facing teachers wanting to use computers in their teaching. The introduction of digidays provides an opportunity to expand the research to investigate the effect of digidays on teachers' use of computers.

The aim of the study is to develop a better understanding of factors which affect the use of computers in teaching. I hope this will allow me to suggest ways of helping teachers use computers more effectively, so that the many advantages of computers in education can be met.

Why you are being invited to participate in the study

As a teacher at a school which is promoting the use of computers in teaching, your participation in this study may provide information which could lead to a better understanding of how teachers are using computers and what factors influence teachers' use of computers.

What it will mean if you participate in the study

Should you choose to participate in the study,

- I would invite you to complete a series of short online questionnaires over the course of the next few months.
- I may also ask to interview you to further explore how you feel about using computers for teaching. Should I ask to interview you, I would need to tape-record the interview.

What I am promising you

- Your participation in the study is voluntary, and you will not be penalized if choose not to participate.
- You are free to withdraw from the study at any stage and you will not be penalized for this.

- Your name and other details will be kept confidential at all times. Teachers will not be identified by name in the write-up of this research study, but rather by labels, e.g. Teacher 1.

- You are entitled to feedback on the results of the study, should you so desire.

If you have any questions about the study, please contact me or the other person involved in the study (see details given below).

Ann George
email: robinann@telkomsa.net
Tel: 082 870 9199

Martie Sanders
email: Martie.Sanders@wits.ac.za
Tel: (011) 716-6489

PARTICIPATION CONSENT FORM

I, _____, hereby agree to participate in the study being conducted investigating teachers' use of computers in the school.

- I understand that my participation is entirely voluntary and that I can withdraw from the study at any time without suffering any penalty.
- I understand that any information I disclose will be treated confidentially.
- I understand that I can approach the researchers with any queries or concerns I may have at any stage of the study.
- I agree to complete the online questionnaires.
- I agree to be interviewed, and agree that the interviews can be tape-recorded.

Signed: _____ at _____ on _____

Appendix P:

Guidelines for evaluating interface design

Category		Guideline	Reason	Reference
Text design	Font and style	Select a simple, clean typeface, preferably *sans serif* such as Arial or Verdana.	A simple font is easier to read and may improve the legibility and readability of the text display. Sheedy, Subbaram, Zimmerman, and Hayes (2005), in their study investigating the effect of font type on text legibility, found Verdana and Arial to be the easiest fonts to read and Times New Roman (serif) one of the least legible fonts.	Hooper and Hannafin (1986), Marcus (1992), Nielsen and Norman (2012), Oliver and Herrington (1995), Reynolds (1979), Sheedy et al. (2005), Stemler (1997)
		Use mixed type sizes and styles (italic, boldface, etc.) where appropriate, but do not use more than a few styles in any one screen or application.	Mixed type sizes and styles are useful for emphasizing certain materials and to provide variety, but the use of too many styles adds to the complexity of the screen design, increasing cognitive load and slowing down reading.	Marcus (1992), Nielsen and Norman (2001), Reeves (1994), Stemler (1997)
		Avoid using all upper case letters.	Text completely in uppercase letters reduces readability. Reynolds (1979) reports on one study in which reading speed was reduced by 13.9% when upper case letters were used.	Hartley (1987), Isaacs (1987), Marcus (1992), Nielsen and Norman (2001), Reeves (1994), Reynolds (1979), Sanders and Ayayee (1997), van Nes (1986)
	Text layout	Left-justify text rather than full-justify it.	Full-justification of text slows down reading because the resulting irregular spaces interfere with eye movement and reduce readability.	Hartley (1987), Hooper and Hannafin (1986), Isaacs (1987), Marcus (1992), Reeves (1994), Williams (20000
		Use kerning to improve the appearance of text. Some fonts allow auto kerning, but kerning can also be done manually.	Some combinations of characters like 'AW', 'VA' and 'TA' create awkward spaces in a line of text. Kerning refers to the reduction of the spaces between certain adjacent pairs of letters to improve the readability of the text. Headings and text in all upper case letters look better once they've been kerned.	Bear (n.d.)
		Use appropriate leading (the vertical spacing between lines measured from baseline to baseline) to make text easier to read. The default leading of 120% of the font height should be increased for long lines of text (more than about 12 words).	Text without leading appears cramped, with ascenders in one line touching descenders from the previous line. Increasing the vertical spacing between lines makes it easier for the eye to track from line to line, thereby improving readability.	Bear (n.d.-b), Reeves (1994), Reynolds (1979)
	Text density	Try to limit text to between 40 and 60 characters per line, or about 8 to 10 words per line.	Text lines longer than 60 characters per line are difficult to read, because the eye has to shift too wide a distance from line to line. This makes it easier to lose your place.	Hooper and Hannafin (1986), Isaacs (1987), Marcus (1992), Reeves (1994), Reynolds (1979), van Nes (1986
		Try not to cover more than 25% - 40% of the screen with text ('low density text').	The use of white space makes text easier to read. Marcus (1992, p. 11) refers to "*breathing space*" that text areas need around them which helps to make screens less cramped.	Marcus (1992), Olsen and Wilson (1985), Reeves (1994), van Nes (1986)
	Highlighting text	Highlight text using colour or boldface to draw attention to main points. Use highlighting techniques like blinking and underlining purposefully and conservatively. If blinking is used to gain attention, limit the length of time for which it runs.	Highlighting and blinking can be distracting. Underlining and blinking should be used only if they serve a particular purpose and if they do not interfere with the legibility of the text.	Hannafin and Hooper (1989), Isaacs (1987), Oliver and Herrington (1995), Oud (2009), Reeves (1994), Stemler (1997), Williams (2000)
	Text movement	Avoid text movement (left to right).	Moving text can be distracting.	Austin (2009)

Category	Guideline	Reason	Reference
Layout	Use white space in the structure of a display, e.g. to separate different groups of data.	The use of white space makes a display easier to read and can be used to divide text into chunks of content.	Marcus (1992), Reeves (1994), van Nes (1986)
	Use balance and symmetry in the display.	Balancing a menu or portion of text with graphics helps to focus the learner's attention, and looks more attractive.	Reeves (1994)
	Be consistent in the appearance, location and function of screen elements (e.g. textual signals, cues, control options).	Consistency of features makes multimedia programmes easier to learn and easier to use because the same features can be located in the same position on any screen.	Oliver and Herrington (1995), Ozok and Salvendy (2004), Reeves (1994), Stemler (1997)
	Avoid clutter.	Closely packed data are more difficult to read and contributes to cognitive overload.	Alessi and Trollop (1991), Feifer and Tazbaz (1997), Marcus (1992), Stemler (1997)
	Group related objects together.	Users may overlook features, e.g. checkboxes or control buttons, that are placed "*too far away from the objects they act on"* (Nielsen & Norman, 2010, p. 1).	Nielsen and Norman (2010)
Graphics and images	Use simple, clear images.	Simple images are more effective for instructional purposes than complex images. Detailed images are not effective when shown on a small scale.	Hartley (1987), Oud (2009).
	Images must be used for a clear purpose based on the type of software and not just for aesthetic purposes.	Images that are used just for the sake of including them on screen have no instructional or motivational benefit to the user and can be distracting.	Nielsen and Norman (2001), Oliver and Herrington (1995), Oud (2009), Williams (2000)
	Label all the key components of an image used to explain something.	Images without the key components labelled may have limited instructional benefits for the learner.	Nielsen and Norman (2001), Williams (2000)
	Avoid watermark graphics.	Putting text on top of background images makes it difficult to read and could make the screen appear too cluttered.	Nielsen and Norman (2001)
Colour	Aim for high contrast between the text and the background. Certain colours of text are easier to read against dark backgrounds, but dark text contrasts well against a light background.	High contrast between the letters and the background improves legibility and hence readability.	Hooper and Hannafin (1986), Marcus (1992), Nielsen and Norman (2001), Oliver and Herrington (1995), Sanders and Ayayee (1997), Stemler (1997), van Nes (1986)
	Use colours selectively to manipulate attention.	A bright colour can be used to highlight text or graphics to make them stand out, but the injudicious use of colour may prove distracting and may hamper the interpretation of colour coding used in certain displays. The use of multiple colours may add to the complexity of the screen design.	Reynolds (1979), Pastoor (1990), Marcus (1992), Oliver and Herrington (1995), Stemler (1997)
	Keep colour coding consistent.	A consistent coding scheme makes it easier for the learner to identify visual devices like menus and titles.	Marcus (1992), Stemler (1997), van Nes (1986)
	Avoid red-green and blue-yellow colour combinations because of colour-blindness.	The most frequent forms of human colour blindness involve difficulties in discriminating reds, yellows, and greens from one another (red-green colour blindness). Other forms of colour blindness are much rarer. They include problems in discriminating blues from yellows. Since 1 in 12 men have some degree of colour blindness, these colour combinations should be avoided.	"Color blindness (" n.d.), Olsen and Wilson (1985), Stemler (1997)

Category	Guideline	Reason	Reference
Anim-ation	Use animation that is relevant to the learning task and serves a particular purpose e.g. to teach about a process happening over time.	The use of animation may require different cognitive processing that can make the information more difficult for the learner to process.	Alessi and Trollop (1991), Hartley (1987), Lowe (2003), Nielsen and Norman (2001), Stemler (1997), Williams (2000)
Navigation	Use a simple navigation system that is consistent in its design.	The user needs to be able to move around in the package in an intentional manner with the minimum of difficulty. A consistent screen design with navigation buttons in the same place on different screens will reduce difficulties with navigation.	Oliver and Herrington (1995), Ozok and Salvendy (2004), Reeves and Harmon (1994)
	Include a detailed mapping system or "*path trail*" (Oliver & Herrington, 1995, p. 7) in the package so that the user has a means of orientating themselves in the package.	The user needs to know where they are in the package, how to get there and where they have been. 'Mapping' refers to the package's "*ability to track and graphically represent to the user his or her path through the program*" (Reeves & Harmon, 1994, p. 490). A detailed mapping system allows the user to determine which parts of the package they have used and which not.	Oliver and Herrington (1995), Reeves and Harmon (1994)
	Use control buttons with explanatory texts rather than picture icons to avoid ambiguity.	The meanings of icons are not always intuitively understood. Using explanatory text improves the chances of people understanding the function of the control button. Feifer and Tazbaz (1997, p. 59) suggest that "*icons should ideally be non-ambiguous* without *text*" (authors' emphasis) and that text should only serve to "*confirm what the user already thinks the icon will do*". These authors further suggest that text is preferable to an icon that could be ambiguous (Feifer & Tazbaz, 1997, p. 59).	Amory and Mars (1994), Feifer and Tazbaz, (1997), Nielsen and Norman (2001), Sanders and Ayayee (1997)

Appendix Q:

Theoretical framework of pedagogical principles of good teaching practice

Learning principle	Reason why this constitutes good practice	Underlying learning theory	Examples of researchers who espouse the principle		
			Sorcinelli's research findings on the Seven Principles (1991)	**Ramsden's five criteria for effective teaching and learning (1992)**	**Angelo's "*teacher's dozen*" (1993)**
1. Teaching should explicate clear and appropriate goals for each level of learning.	A clear understanding of the goals being aimed towards will contribute to a realisation of the purpose of the learning activities and contribute to a higher level of motivation on the part of the learner to achieve those goals.	Keller's ARCS Model (Keller & Suzuki, 1988): learning objectives must be made known to learners. Second of Gagne's nine steps of instruction (Gagne & Briggs, 1974): learners must be informed of learning objectives.		Clear learning goals should be stated.	Learning is more effective and efficient when learners' have explicit, reasonable, positive goals, when they understand the purpose of the learning task and when their goals fit well with the teacher's goals.
2. Learning involves the construction of knowledge.	For learning to occur, new material must be incorporated into the learner's existing cognitive structure by relating it to existing knowledge/ concepts. Learning should involve activities which have the potential to allow the construction of knowledge through the learner thinking and reflecting on what they are doing and developing their own explanations for what they observe.	Piaget's theory of cognitive development (Piaget, 1970); Ausubel's subsumption theory (Ausubel et al., 1968).			To be remembered, new information must first be meaningfully connected to prior knowledge, and it must be remembered in order to be learned.
3. Learning should be an active process.	Learners are more likely to understand knowledge which they have constructed for themselves through active learning.	Theory of cognitive development (Piaget, 1970); Vygotsky's social development theory (Vygotsky, 1978); Bruner's model of discovery learning (Bruner, 1966); cognitive flexibility theory of Spiro, Feltovich, and Coulson (1992).	Good practice encourages active learning.	An emphasis on independence involves implementing teaching techniques that require students to learn actively.	Active learning is more effective than passive learning.

Learning principle	Reason why this constitutes good practice	Underlying learning theory	Examples of researchers who espouse the principle		
			Sorcinelli's research findings on the seven principles (1991)	**Ramsden's five criteria for effective teaching and learning (1992)**	**Angelo's "*teacher's dozen*" (1993)**
4. Learning requires focused attention on the part of the learner and efforts on the part of the teacher to focus the learner's attention.	Fundamentally, the learner must want to learn. There are many ways, however, that the teacher can gain the learner's attention.	Hull's drive reduction theory (Hull, 1952). Ausubel's subsumption theory (Ausubel et al., 1968). First of Gagne's nine steps of instruction (Gagne & Briggs, 1974): gaining learners' attention. Keller's ARCS model (Keller & Suzuki, 1988): learner's 'attention' must be gained.			Learning requires focused attention, an awareness of the purpose of the learning task and an awareness of the importance of what is to be learned.
5. Information to be learnt should be presented in small chunks.	Working memory can only contain a limited number of elements (7 +/-2) at the same time. To reduce working memory load and facilitate incorporation of information into schema, information should be organised into groups of similar information or 'chunks'.	Miller's magic number 7 (Miller, 1956). Sweller's cognitive load theory (Sweller, 1988)			
6. Information to be learnt should be organized into increasing levels of difficulty.	Learning should progress from the lower order activities like recall to higher order activities like critical thinking.	Fourth of Gagne's nine steps of instruction (Gagne & Briggs, 1974) which deals with presenting information in a specific sequence according to hierarchies of learning; Bloom's taxonomy (Bloom et al., 1956) provides levels of difficulty according to which information can be presented.			
7. Learning should be contextual.	Learning is more likely to occur within the context of experiences and contexts that are relevant to the learner.	Bruner's model of discovery learning (Bruner, 1966). Vygotsky's social development theory (Vygotsky, 1978). Theory of situated learning (Lave & Wenger, 1991)			Information organized in personally meaningful ways is more likely to be understood, retained and used.

Learning principle	Reason why this constitutes good practice	Underlying learning theory	Examples of researchers who espouse the principle		
			Sorcinelli's research findings on the Seven Principles (1991)	**Ramsden's five criteria for effective teaching and learning (1992)**	**Angelo's "*teacher's dozen*" (1993)**
8. Instructional activities should cater for different forms of intelligence.	Teaching and learning should make allowances for the fact that different individuals possess different forms of intelligences in varying degrees.	Gardner's Theory of Multiple Intelligences (Gardner, 1983)	Good practice respects diverse talents and ways of learning.		Teachers need to balance levels of intellectual challenge and instructional support.
9. Learning should be collaborative (where appropriate).	Learning requires social interaction and collaboration since it is through social interactions that learners attach meaning to knowledge and skills making it more likely they will develop an understanding of what they have learned.	Vygotsky's social development theory (Vygotsky, 1978).	Good practice encourages cooperation among students.		Interaction between teachers and learners is one of the most powerful factors in promoting learning; interaction among learners is another.
10. Assessment should be interwoven with teaching so that regular feedback can be given to learners.	Regular assessments allow teachers and learners to analyse how much has been learned and to give learners regular feedback on their progress. Regular feedback on their performance allows learners to know what they can do and what they still need to improve on.	Seventh and eighth of Gagne's Nine Steps of Instruction (Gagne & Briggs, 1974) which deal with assessing performance and providing feedback. Keller's instructional design model for motivation (Keller & Suzuki, 1988).	Good practice gives prompt feedback.	Appropriate assessment methods should be applied, the purpose of which is clearly understood. Appropriate assessment requires giving feedback of the highest quality.	Learners need feedback on their learning, early and often, to learn well. The ways in which learners are assessed and evaluated powerfully affects the ways they study and learn.
11. Learning should allow for the practicing of new knowledge and skills.	The application of knowledge and skills in new contexts promotes the transfer of the use of such knowledge and skills (Angelo, 1993).	Sixth of Gagne's nine steps of instruction (Gagne & Briggs, 1974): learners must be afforded the opportunity to practice new skills or knowledge.			Learning to transfer, to apply previous knowledge and skills to new contexts, requires a great deal of practice.

Appendix R:

Basic principles of multimedia learning

Design principle	Explanation of principle	Original author
Multimedia principle: Augmenting words (text or narration) with pictures can lead to better learning than with words alone (Fletcher & Tobias, 2005).	According to dual coding theory, words and pictures use different channels for cognitive processing that work independently, but additively (Paivio, 1986). Using both pictures and words uses both channels, overcoming the limited capacity of each channel, and aids the retention and transfer of knowledge (Fletcher & Tobias, 2005).	Mayer (1997)
Split-attention principle: Integrate words and pictures temporally and spatially to avoid learners having to split their attention between the two (Ayres & Sweller, 2005).	Integration of information by the designer reduces the need for mental integration by the user of the multiple sources of information needed for understanding to occur, thereby reducing extraneous cognitive load and freeing up working memory resources for learning (Ayres & Sweller, 2005).	Tamizi and Sweller (1988)
Modality principle: Combine graphics with oral narration rather than just with printed text (Low & Sweller, 2005).	Combining graphics and narration uses both the verbal (auditory) and non-verbal (visual) working memory systems as opposed to graphics and printed text, which use the same (visual) system (Low & Sweller, 2005). Since the visual and auditory systems are capable of processing information independently of each other, the use of the dual modalities of auditory and visual information allows more efficient processing than the single mode of visual information (Low & Sweller, 2005).	Allport et al. (1972, as cited in Low & Sweller, 2005).
Redundancy principle: Present information in a single format as opposed to multiple forms of the same information, e.g. present **self-contained** diagrams on their own instead of with explanatory text (Sweller, 1994). Present animations with narration only rather than with narration and accompanying text which repeats the auditory message (Mayer, 2005[b]).	The theory behind this principle is based on reducing the cognitive load associated with processing two forms of the same information. Co-ordinating different forms of the same information where one form is sufficient to provide understanding takes up working memory resources. For example, in the case of a self-contained diagram presented with explanatory text, integrating the diagram and text could require extra processing by the learner (Sweller, 1994). Having the diagram on its own could reduce the extraneous cognitive load and enhance learning. Mayer (2005[b]) uses the example of combining pictorial information only with narration as opposed to narration and text with the same messages. In this way the cognitive load will be reduced because the visual channel will only be occupied with the pictorial information and not the pictorial information and the redundant text.	Chandler and Sweller (1991)
Segmenting principle: Present narrations of material of high complexity in "*learner-paced segments rather than as a continuous unit*" (Mayer, 2005[a], p. 169).	Complex material possesses a high intrinsic cognitive load. Having to process such material continuously is likely to overload both cognitive channels (visual and audio) and impede learning (Mayer, 2005[b]). By segmenting or breaking up the material into smaller sections and allowing the learner to control the pace at which the material is presented, the intrinsic cognitive load is reduced.	Mayer and Chandler (2001).

Design principle	Explanation of principle	Original author
Pre-training principle: Provide pre-training in the names and characteristics of the main components in a narrated animation (Mayer, 2005[a]).	Pre-training in the form of learning names and characteristics related to a narrated animation provides the learner with prior knowledge, which reduces the overall amount of processing required to understand the animation.	Pollock et al. (2002, as cited in Mayer, 2005[a]).
Coherence principle: Omit extraneous material or keep the amount of extraneous material to a minimum (Mayer, 2005[b]).	Extraneous material, i.e. material that will not directly contribute towards understanding, increases the extrinsic cognitive load and impedes learning (Mayer, 2005[b]). An example of extraneous material is graphics that are interesting but irrelevant, and so contribute little or nothing towards conceptual understanding (Mayer, 2005[b]).	Chandler and Sweller (1991)
Signalling principle: Use cues to highlight information that is essential for learning (Mayer, 2005[b]).	Highlighting essential information helps learners decide what information is important and reduces the need for learners to process non-essential material (Mayer, 2005[b]). An example of signalling is using a bold font to emphasise key words.	
Personalisation principle: Use a conversational style for delivering words rather than a formal style (Mayer, 2005[c]).	These principles are based on increasing learners' "*motivation to engage in active cognitive processing*" (Mayer, 2005[c], p. 202). The 'nature of voice' and writing style used in message delivery act as social cues. According to social agency theory (Mayer, 2005[c]), social cues activate a social response in the learner which increases active cognitive processing and contributes to enhanced learning (Mayer, 2005[c]). Although the use of an on-screen image to deliver information does not appear to act as a social cue, on-screen agents may be useful by directing learners' attention to important information (Mayer, 2005[c]).	Moreno and Mayer (2000).
Voice principle: Use a human voice with a "*standard-accent*" as opposed to a machine-synthesised voice or a voice with a foreign accent (Mayer, 2005[c], p. 207).		Mayer et al. (2003).
Image principle: Using an on-screen character (like an animated pedagogical agent) to deliver the script does not enhance learning (Mayer, 2005[c]).		Moreno et al. (2001, as cited in Mayer, 2005[c]).

Appendix S:

Advanced principles of multimedia learning[9]

[9] Not all of these principles would be applicable to every multimedia resource.

Design principle	Explanation of principle	Original author
Guided discovery principle: Incorporate guidance for learners into discovery-based multimedia environments (de Jong, 2005)	Discovery learning is a self-directed way of learning in which learners discover principles for themselves rather than being instructed in principles (de Jong, 2005). Learners benefit from guidance in the discovery process, e.g. hints to learners to advise them to perform certain actions which would promote the discovery of the required principles (de Jong, 2005). Research is on-going.	de Jong, 2005
Worked-out examples principle: Provide more than one worked-out example for the teaching of new skills (Renkl, 2005.	When learning a new skill, learners may lack the domain-specific procedures necessary to solve problems, causing them to rely on general problem-solving procedures (Renkl, 2005). Using general problem-solving technique does not help to develop the domain-specific procedures and carries a high extrinsic cognitive load which hinders learning (Renkl, 2005). Also, learners may not have the schemas within which the new knowledge can be incorporated, leading to a high intrinsic load if the new skill has a high number of interactive elements (Renkl, 2005). Because learners are not required to solve the problem in worked-out examples, learners can focus on gaining an understanding of the procedures needed to solve that type of problem (Renkl, 2005).	Sweller & Cooper (1985, as cited in Renkl, 2005).
Collaboration principle: Use collaborative learning when using computer systems so learners can communicate and access information interactively, and engage in collaborative problem-solving activities (Jonassen, Lee, Yang, & Laffey, 2005)	Collaborative learning involves a group of learners participating in a joint activity to achieve a common goal (Jonassen et al., 2005). According to the socio-cultural theory of learning (Vygotsky, 1978) the benefits of collaborative learning are believed to arise from the idea that "*individual cognition results from interpersonal interaction within our social environment*" (Jonassen et al., 2005, p. 248). There are seven different issues related to collaborative learning with computer systems. These areas include composition of group (e.g. size of group) and the type of task. Each issue is an area of on-going research.	
Self-explanation principle: Facilitate the generation of self-explanations by learners during multimedia learning (Roy & Chi, 2005).	Self-explanation involves learners attempting to explain things to themselves and monitoring their understanding of the material (Roy & Chi, 2005). Such activities on the part of learners promote learning through learners playing an active role in constructing their knowledge.	Chi et al. (1989, as cited in Roy & Chi, 2005)

Design principle	Explanation of principle	Original author
Animation and interactivity principle[10]: Combine animations with interactivity to enhance the potential of animations to improve learning (Tversky et al., 2002).	The literature suggests that animations are not necessarily better than static diagrams (Lowe, 2003; Tversky et al., 2002), but are more likely to contribute to effective learning when well-designed animations are combined with learner interactivity (Tversky et al*.,* 2002*)*. According to Tversky et al*.* (2002) animations should meet the following principles to qualify as well-designed. Firstly, the structure and content of the animation should correspond to the desired cognitive or internal representation (known as the congruence principle). Secondly, the animated material should be readily and accurately perceived and understood by learners (known as the apprehension principle). Including interactivity in an animation allows learners to control the pace of the animation and to revise parts of the animation according to their individual needs.	Tversky et al. (2002).
Navigation principle: Use appropriate navigational aids like site maps to improve learners' comprehension (Rouet & Potelle, 2005).	Navigational aids include a wide range of signalling devices designed to assist learners to "*make their way through complex information*" (Rouet & Potelle, 2005, p. 297). Where the signalling devices used on the user interface are not effective, learners may become disorientated, increasing cognitive load as users try to navigate through material (Rouet & Potelle, 2005). Site maps can help orient learners and reduce cognitive load.	Wright (1991, as cited in Rouet & Potelle, 2005).
Prior knowledge principle: Instructional design principles that enhance learning for novices may hinder learning for more expert learners.	Learners with high prior knowledge may experience cognitive conflict when trying to integrate models in instructional materials with schemas they have already constructed (prior knowledge) (Kalyuga, 2005). The effort of integrating the new construct with their prior knowledge may cause cognitive overload, leading to the expertise reversal effect (Kalyuga et al*.*, 2003). To avoid the expertise reversal effect, multimedia presentations must be designed to gradually replace high-structured formats with low-structured instructions to accommodate learners' increasing knowledge levels (Kalyuga, 2005).	(Mayer, 2005b)Mayer (1999, as cited in Kalyuga, 2005).
Cognitive aging principle: Design instruction according to principles that reduce cognitive load and expand working memory capacity to compensate for age-related declines in cognitive ability (Paas, van Gerven, & Tabbers, 2005).	The efficiency of working memory decreases with age in adults because of reduced capacity, decreased processing speed, difficulties with inhibiting irrelevant information and deficiencies in integrating information in working memory (Paas et al., 2005). Cognitive load can be reduced by applying the basic principles of multimedia design (modality, coherence, redundancy, signalling, and split-attention principles) so as to compensate for age-related declines.	Van Gerven et al. [2000, as cited in Paas et al. (2005)].

[10] Animation and navigation were included in Appendix Y as interface design elements. However, these features have also been included in this table because specific research-based principles have been formulated for their effect on learning with multimedia.

Appendix T:

The first section of the *Curriculum Requirements Checklist* developed for this study

Question 1.1 To what extent have the outcomes required by the new curriculum been explicitly stated as either critical outcomes, developmental outcomes or learning outcomes so that it is **clearly** stated what goals learners are supposed to have achieved after completing the topic?	
Evaluator's comments	
Question 1.2 To what extent has the topic been designed to incorporate or teach the *Life Sciences* learning outcomes?	
	Evaluator's comments
Learning outcome 1 – *the learner is able to confidently explore and investigate phenomena relevant to Life Sciences by using inquiry, problem solving, critical thinking and other skills.*	
Learning outcome 2 – *the learner is able to access, interpret, construct and use Life Sciences concepts to explain phenomena relevant to Life Sciences.*	
Learning outcome 3 – *the learner is able to demonstrate an understanding of the nature of science, the influence of ethics and biases in the Life Sciences and the interrelationship of Science, Technology, indigenous knowledge, the environment and society.*	

Appendix U:

The outcomes of the new curriculum

Critical Outcomes for the new curriculum ("Revised National Curriculum Statement Grades R-9," 2002)

1. Identify and solve problems and make decisions using critical and creative thinking.
2. Work effectively with others as members of a team, group, organization and community.
3. Organise and manage themselves and their activities responsibly and defectively.
4. Collect, analyse, organise and critically evaluate information.
5. Communicate effectively using visual, symbolic and/or language skills in various modes
6. Use science and technology effectively and critically, showing responsibility towards the environment and the health of others.
7. Demonstrate an understanding of the world as a set of related systems by recognizing that problem solving contexts do not exist in isolation.

Developmental Outcomes for the new curriculum ("Revised National Curriculum Statement Grades R-9," 2002)

1. Reflect on and explore a variety of strategies to learn more effectively.
2. Participate as responsible citizens in the life of local, national and global communities.
3. Be culturally and aesthetically sensitive across a range of social contexts.
4. Explore education and career opportunities.
5. Develop entrepreneurial opportunities.

The Specific Outcomes for Natural Science for the new curriculum**, General Education and Training Band** (Accessed at http://www.thutong.doe.gov.za/ResourceFiles/edn/science01/content/documents/specific_outcomes_ns.htm

SO1	Use process skills to investigate phenomena related to the Natural Sciences.
SO2	Demonstrate the acquisition of knowledge and an understanding of concepts and principles in the Natural Sciences.
SO3	Apply scientific knowledge and skills to problems in innovative ways.
SO4	Demonstrate an understanding of how scientific knowledge and skills contribute to the management, develop and utilisation of natural and other resources.
SO5	Use scientific knowledge and skills to support responsible decision making.
SO6	Demonstrate knowledge and understanding of the relationship between science and culture.
SO7	Demonstrate an understanding of the changing and contested nature of the Natural Sciences.
SO8	Demonstrate knowledge and understanding of ethical issues, bias and inequities related to the Natural Sciences.
SO9	Demonstrate an understanding of the interaction between the Natural Sciences, technology and socio-economic development.

Learning Outcomes and Assessment Standards ("National Curriculum Statement Grades 10-12 (general): Learning programme guidelines," 2008)

Learning Outcome 1 – the *learner is able to confidently explore and investigate phenomena relevant to Life Sciences by using inquiry, problem solving, critical thinking and other skills.*	Assessment Standard 1	The learner identifies and questions phenomena and plans an investigation.
	Assessment Standard 2	The learner conducts an investigation by collecting and manipulating data.
	Assessment Standard 3	The learner analyses, synthesises, evaluates data and communicates findings.
Learning Outcome 2 – *the learner is able to access, interpret, construct and use Life Sciences concepts to explain phenomena relevant to Life Sciences.*	Assessment Standard 1	The learner accesses knowledge.
	Assessment Standard 2	The learner interprets and makes meaning of knowledge in Life Sciences.
	Assessment Standard 3	The learner shows understanding of how life sciences knowledge is applied in everyday life.
Learning Outcome 3 – *the learner is able to demonstrate an understanding of the nature of science, the influence of ethics and biases in the Life Sciences and the interrelationship of science, technology, indigenous knowledge, the environment and society.*	Assessment Standard 1	The learner explores and evaluates the scientific ideas of past and present cultures.
	Assessment Standard 2	The learner compares and evaluates the uses and development of resources and products and their impact on the environment and society.
	Assessment Standard 3	The learner compares the influence of different beliefs, attitudes and values on scientific knowledge.

Learning Outcomes and Assessment Standards ("National Curriculum Statement Grades 10-12 (general): Learning programme guidelines," 2008)

Learning Outcome 1 – the *learner is able to confidently explore and investigate phenomena relevant to Life Sciences by using inquiry, problem solving, critical thinking and other skills.*	Assessment Standard 1	The learner identifies and questions phenomena and plans an investigation.
	Assessment Standard 2	The learner conducts an investigation by collecting and manipulating data.
	Assessment Standard 3	The learner analyses, synthesises, evaluates data and communicates findings.
Learning Outcome 2 – *the learner is able to access, interpret, construct and use Life Sciences concepts to explain phenomena relevant to Life Sciences.*	Assessment Standard 1	The learner accesses knowledge.
	Assessment Standard 2	The learner interprets and makes meaning of knowledge in Life Sciences.
	Assessment Standard 3	The learner shows understanding of how life sciences knowledge is applied in everyday life.
Learning Outcome 3 – *the learner is able to demonstrate an understanding of the nature of science, the influence of ethics and biases in the Life Sciences and the interrelationship of science, technology, indigenous knowledge, the environment and society.*	Assessment Standard 1	The learner explores and evaluates the scientific ideas of past and present cultures.
	Assessment Standard 2	The learner compares and evaluates the uses and development of resources and products and their impact on the environment and society.
	Assessment Standard 3	The learner compares the influence of different beliefs, attitudes and values on scientific knowledge.

Appendix V:

Typology of activities that can be carried out on computer (adapted from Mashalaba & Sanders, 2003)

Categories	Sub-categories	Types	Sub-types
Communication activities	Oral	Presentations, talks	
		Reading into a microphone when using a computer	
		Debates	
		Group discussions	
	Reading tasks	Reading to oneself	
		Reading to someone else	
	Writing tasks	Writing essays	
		Writing science reports	
		Write a letter	
		Drawing	
	Plays/ dramas		
	Role plays		
Text-based activities	Review tasks	Assessment tasks	
		Answering review questions	
	Translation activities	Involving tabulated data	
		Involving text	
		Involving graphs	
		Involving diagrams	
	Completion tasks	Fill-in-the-blank (text)	
		Supply the term for the definition provided	
		Complete the table	
		Label the diagram	
		Crossword puzzles	
	Analysis tasks	Simple close-ended tasks	Matching words from columns
			Identifying the odd one out
			Multiple choice
		Problem-solving	Solving mathematical problems
			Practical problem-solving
		Data-response activities	Observation tasks
			Classification tasks
			Summarising
			Re-sequencing disordered text
			Comprehension exercises
			Brain teasers/puzzles
			Critique
			Comparison tasks
			Concept maps
	Mind experiments	Identify a problem	
		Suggest an hypothesis	
		Design an experiment	

Appendix W:

The *Content Coverage Checklist*

Criterion 1: Suitability of content					
Content	**Question**	**Good**	**Fair**	**Poor**	**Reviewer's comment**
Biodiversity of plants and animals	To what extent does the software offer a suitable definition of the term 'biodiversity'?				
	To what extent does the software cover the different levels of biodiversity: genetic diversity, species diversity and ecosystem diversity?				
	To what extent does the software cover the five kingdom classification system? (The National Curriculum Statement does not require details of classification system.)				
Significance and value of biodiversity to ecosystem function and human survival; conservation	To what extent does the software cover the value of diversity?				
	To what extent does the software offer a suitable definition of the term 'conservation'?				
	To what extent does the software comprehensively explain the need for conservation?				
Threats to biodiversity	To what extent does the software cover what is meant by 'loss of biodiversity'?				
	To what extent does the software address the various threats to biodiversity?				
Criterion 2: Language and terminology usage					
Question		**Good**	**Fair**	**Poor**	**Reviewer's comment**
To what extent does the software use language that is appropriate for both English first and second language users?					
To what extent does the software use subject-related terminology at an appropriate level for Grade 10 learners?					
To what extent does the software avoid grammatical and spelling errors*?					

***** Grammar and spelling have been judged using U.K. English, which is the standard in South Africa

Appendix X:

Terms and concepts which should be covered in the section *Diversity, change and continuity* at Grade 10 level

Term/ concept	Definition/ content which must be included to cover concepts appropriately
biodiversity	Definition must make reference to *the variety of living organisms on earth* (Bezuidenhout et al., 2005; Boyle & Senior, 2002).
ecosystem diversity	Ecosystem diversity refers to the variety of types of different ecosystems. This variety is due to the different locations of ecosystems on the earth's surface. The location of an ecosystem determines factors, such as climate patterns, soil profiles and altitude, which, in turn influence the "*characteristic clusters of organisms*" found in ecosystems (Galbraith, 1993). The major clusters are known as biomes, for example, grasslands, rainforests, deserts (Galbraith, 1993).
species diversity	Species diversity refers to the range of different species found on Earth. A species is a group of organisms that have similar features and that can interbreed to produce fertile offspring. Species diversity is caused by each species having a different set of genes which form the gene pool for that particular species (Bezuidenhout et al., 2005; Boyle & Senior, 2002).
genetic diversity	Genetic diversity refers to differences between individuals of the same species as caused by different combinations of genes from the gene pool of that species (Bezuidenhout et al., 2005; Boyle & Senior, 2002).
'five kingdom classification system'	Should include the names of the 5 kingdoms and the distinguishing characteristics of organisms found in each kingdom. It should also include an explanation of the binomial naming system and a review of the various taxonomic groups from kingdom down to species: kingdom, phylum, class, order, family, genus, species (Bezuidenhout et al., 2005).
value of diversity	'*Value of diversity*' should explain some of the ways humans benefit from diversity, e.g. the provision of food, fuel, shelter using various building materials, and medicines (Bezuidenhout et al., 2005). Another important value of diversity is that a high level of biodiversity makes for efficient recycling of nutrients and gases (Bezuidenhout et al., 2005).
conservation	A definition of *conservation* should explain that human activities impact on the environment.
need for conservation	The 'need for conservation' should be explained using the underlying idea that because humans benefit from biodiversity, we must protect biodiversity by limiting harmful human activities and promoting activities which sustain biodiversity.
loss of biodiversity	A decline in the numbers of different species, mainly due to human activities.
Threats to biodiversity	Habitat loss – the biggest threat to biodiversity. Involves the changing of natural habitats resulting in the habitat no longer being able to sustain the organisms that lived there or could involve the total destruction of habitats (bezuidenhout et al., 2005). Climate change - small changes in climatic conditions can have large effects on biodiversity. A change in temperature of six degrees can precipitate an ice age and a sharp decline in biodiversity (galbraith, 1993). Global warming (now being referred to as global change) is currently taking place due to unchecked co2 emissions, resulting in higher global temperatures, melting of glaciers, rising of sea levels, etc. Invasive species - alien species often invade new habitats because their spread is unchecked by natural predators or parasites. They can cause the displacement of indigenous species, thereby reducing biodiversity (bezuidenhout et al., 2005). Pollution - effects of pollution can cause habitat loss (e.g. Oil spills) or destruction of food chains (e.g. Use of insecticides). Overconsumption (over-hunting and/or overgrazing). Overuse or the incorrect use of resources like food and soil (e.g. Monoculture) by humans is leading to a depletion of natural resources, reducing the earth's ability to support a wide range of species.

Sources: Boyle and Senior (2002); Galbraith (1993); Bezuidenhout et al. (2005)

Appendix Y:

The *Pedagogical Strategies Checklist*

The software should include tasks which use a variety of levels of cognitive activity.		
The software should include some tasks which are situated within a meaningful, real-life context (Bain & McNaught, 1996).		
The software should represent knowledge in alternative ways.		
The software should include tasks which can be carried out co-operatively.		
The software should offer regular assessments that are interwoven with the instruction.		
The software should offer appropriate assessments with more than yes/no or right/wrong answers (Kennedy & McNaught, 1997).		
The assessments used should provide for prompt, regular and useful feedback to be given to the learner.		
The software should make provision for the application of skills in new contexts to promote the transfer of the use of the skills (Angelo, 1993).		

Appendix Z:

The *Interface Design Checklist*

Design aspect	Question	Yes	No	Evaluator's comment
Navigation	Is the navigation system simple with consistent navigation cues, allowing the user to move around with the minimum of difficulty?			
	Is there a mapping system in the package so that the user is able to determine which parts of the package they have used and which not?			
	Are control buttons with explanatory texts used rather than picture icons?			
Media integration	Does the use of different media provide conflicting messages?			

Appendix AA:

The *Frequency Count Checklist*

Criterion	Screen number							Subtotal for topic
	1	2	3	4	5	6	7	
1. Does the average number of words per line exceed 8 -10?								
2. Is there low density coverage of the screen (25 - 40%)?								
3. Has highlighting been used purposefully?								
4. Is the screen display balanced and symmetrical?								

Appendix AB:

Reeves and Harmon (1993): Ten dimensions for evaluating instructional multimedia and how they are used for evaluating interface design in this study

Reeves and Harmon dimension	What dimension refers to	Reason for using or not using dimension in this study
Ease of use	Relates to how easy the user interface is to understand and use	Expanded to "ease of use of interface" and used in this study as a way of summarising how easy the user interface is to understand. This summative dimension incorporates the dimensions of *navigational features, look of screen* and *media integration.*
Navigation (referred to as "*navigational features*" for this study)	The ability of the software package to help users' find their way through the package.	Used as an important contributor to the overall functionality of the package.
Mapping	The ability of the software to let the user know where they have been in the package and to show them where they have not been.	In this study "*mapping*" was included as a sub-dimension of navigation, since it has to do with how well the software package helps users to know where they are and what is available to them.
Media integration	Refers to how well the different media forms have been combined to work together in presenting information.	Used as a significant component of evaluating user interface design for multimedia packages like the one evaluated in this study.
Screen design (referred to as "*screen appearance*" for this study)	Reeves and Harmon describe screen design as a "*complex dimension*" relating to the "*visual aspects*" of a software package.	Used because the visual aspects of the software package formed an important part of the user interface.
Aesthetics	Refers to the "*beauty or elegance*" of the user interface.	Although not evaluated in the checklist, a comment on the aesthetics of the user interface will be delivered.
Knowledge space compatibility	Deals with the concepts and relationships in the users' 'knowledge space'. Can be interpreted as users' prior knowledge.	Not used. This dimension relates to content, which was evaluated in a separate category (instructional design) to interface design, so this dimension should not be evaluated in this section.
Cognitive load	The cognitive demands the user faces when integrating the content covered, the screen layout and the "*response options available*".	Not used. The content and pedagogical designs included in the software were evaluated in additional categories to interface design. This dimension cannot be fully evaluated as an aspect of interface design.
Information presentation	Whether the information contained in a software package is "*presented in an understandable form".*	"*Information presentation"* is evaluated as part of the pedagogical design of the software according to criteria for understanding content and not as an interface design dimension.
Overall functionality	Relates to how useful the package is in relation to the purpose for which it was intended.	Not used, since it was deemed inappropriate to evaluate the "*overall functionality"* of the software package after only evaluating the design of the user interface.

Appendix AC:

The *Multimedia Design Checklist*

Basic principles		
Design feature	**Present/ Absent**	**Reviewer's comment**
Multimedia software should use both pictures and words to aid learners' retention of knowledge.		
Multimedia software should have the descriptions or explanations accompanying pictures on screen at the same time (temporally integrated) and sufficiently close together (spatially integrated) so that learners do not have to divide their attention between the picture and the accompanying text.		
Multimedia software should use oral narration with pictures rather than printed text.		
Multiple formats of the same information must be used discerningly, e.g. a picture can be used to illustrate an aspect of a section of text. However, information should be presented using a single format when that format **fully** explains the concept. Additional formats of the same content could prove to be redundant.		
Multimedia software should introduce learners to new terms before the terms are used in a narrated animation to reduce the amount of processing required to understand the animation.		
Multimedia software should include only information that is relevant to the learning outcome for a section of work. Words, pictures and sounds that may distract learners' attention from the information to be learned should be omitted.		
Multimedia software should use signals such as headings and bold fonts to draw learners' attention to essential information.		
The style used to deliver both spoken and printed words in multimedia packages should be conversational rather than formal so that users can easily relate to it.		
Voices used for narration should be human (as opposed to machine synthesised) and should be recognisable to users (not have a foreign accent).		
Advanced principles		
Design feature	**Present/ Absent**	**Reviewer's comment**
Multimedia software should incorporate worked-out examples to teach new skills so that learners can use the example to learn how to apply domain-specific procedures to solve problems rather than applying general problem-solving techniques.		
Multimedia software should involve learners working on tasks in small groups to foster interpersonal interactions and promote knowledge construction.		
Multimedia software should facilitate learners actively in constructing their knowledge through activities which require learners to explain things to themselves, and learners monitoring their understanding of the material.		
Animation should be combined with learner interactivity so that learners can control the pace of the animation and revise parts of the animation according to their own needs.		
The navigational devices in instructional software must help learners to easily find their way through the package.		
Multimedia presentations must be designed to gradually replace high-structured formats (e.g. detailed instructions on how to complete a task or to develop a skill) with low-structured instructions to accommodate learners' increasing skill and knowledge levels. Learners with high prior knowledge may experience cognitive conflict when trying to integrate high-structured materials with schemas they have already constructed (i.e. their prior knowledge) leading to the expertise reversal effect.		

Appendix AD:

The completed *Curriculum Requirements Checklist* showing the extent to which the outcomes are addressed in the software package

The extent to which the outcomes required by the new curriculum have been explicitly stated as critical outcomes, developmental outcomes or learning outcomes so that it is **clearly** stated what goals learners are supposed to have achieved after completing the topic.	
Evaluator's comments ***No outcomes or goals are stated for any of the five topics.***	
The extent to which the software targets the *Life Science* learning outcomes	
	Evaluator's comments
Learning Outcome 1 – *the learner is able to confidently explore and investigate phenomena relevant to Life Sciences by using inquiry, problem solving, critical thinking and other skills.*	***This learning outcome is directed towards skills associated with investigative processes like planning and conducting investigations, analysing data and communicating the findings of investigations. Since there are no skills of this nature required in any of the five topics, these topics do not teach Learning Outcome 1.***
Learning Outcome 2 – *the learner is able to access, interpret, construct and use Life Sciences concepts to explain phenomena relevant to Life Sciences.*	***This learning outcome deals with science content knowledge.*** • ***In all five topics new knowledge is presented to learners (which would meet Assessment Standard 1 – the learner accesses knowledge).*** • ***Learners are required to interpret knowledge when completing some of the activities in the five topics (which would meet Assessment Standard 2 – the learner interprets and makes meaning of knowledge in Life Sciences).*** • ***Nowhere in the five topics are learners required to apply Life Sciences knowledge to explain everyday phenomena (as required by Assessment Standard 3 for this learning outcome).***
Learning Outcome 3 – *the learner is able to demonstrate an understanding of the nature of science, the influence of ethics and biases in the Life Sciences and the interrelationship of Science, Technology, indigenous knowledge, the environment and society.*	***This learning outcome focuses on promoting the learner's understanding of the interrelationship between science, the environment and society.*** • ***There is no evidence of any attempt in Topic 3 (How has man classified the world around him) to promote learners' understanding of these interrelationships.*** • ***Topic 124 – An ecosystem is a working organisation: This topic includes references to how humans use organisms and their products (which meets Assessment Standard 2 for this learning outcome).*** • ***Topic 132 – Types of pollution: There are references to the effect of waste on the human environment (sic) (specifically radioactive waste emitting harmful radiation for many years, although no detail of effects is given) and the effect of freons and space flight on the ozone layer and the effects of ozone depletion on humans.*** • ***Topic 133 – Species dying out: There are descriptions of the effects of human actions on different species and how these actions endanger species or have led to species going extinct.*** • ***Topic 135 – The nature necessary for living: This topic gives specific examples of how humans use organisms and their products (which meets Assessment Standard 2 for this learning outcome). This topic therefore addresses one of the three assessment standards for this topic even though it has been addressed to a very limited extent.***

Appendix AE:

Analysis of the types of activities used in the five topics (from the *Curriculum Requirements Checklist*)

Description of activity		Activity type*	Learning outcomes the activity is judged to meet	The extent to which the activity involves mental engagement with the task	The extent to which learning is activity-based (i.e. conceptual development arises from the activity)
Classification activities	*Classification activity in which pictures have to be sorted into terrestrial or aquatic organisms, or organisms which spend lots of time in the air. No cues are given about how many organisms should be placed in each category or the fact that some terrestrial organisms can be used twice (in the terrestrial category and the air category).*	*Text-based activity/ analysis task/ classification*	*These activities could meet Learning Outcome 2, Assessment Standard 2 (the learner interprets and makes meaning of knowledge in the Life Sciences) if the activity taught learners about the use of distinguishing features for classifying organisms. However, not only is this skill not specifically explained, but it is difficult for learners to grasp the use of distinguishing features in classification because the activity allows organisms to be placed in two categories.*	*It involves comprehension (understanding instructions) and application of a concept in a new situation. The task will involve thinking, providing it does not become a trial-and-error task.*	*These activities have the potential to be activity-based, since the learner is required to classify pictures of organisms before they are told how scientists do it. In their current form, however, they fail to be activity-based because the software only accepts correct answers. This means that learners can use a trial-and-error method to complete these tasks without any learning taking place.*
	Classification activity in which pictures of organisms have to be grouped according to how the organisms move. No cues are given about how many organisms should be placed in each category, although the text indicates that some organisms could belong to more than one group.				
	Classification activity which involves selecting pictures (from a selection which include a wolf, an elephant, a reindeer and a variety of wild cats) which belong to the cat family.				
Read, listen and record activity	*The activity involves the learner listening to an audio track of a fact being read to them and then being required to repeat the fact out loud into a microphone to be recorded.*	*Communication activity/ oral/ reading into a microphone when using a computer*	*This activity meets Learning Outcome 2, assessment standard 1 – the learner accesses knowledge in the Life Sciences*	*Since the activity involves the memorisation and recall of facts, any learning that takes place as a result of the activity is likely to be rote learning.*	*Whilst the learning does involve an activity, it is not activity-based. The activity is limited to the recall of facts, requiring learners to illustrate what they are able to recall rather than discovering how to do something new. Illustrative tasks create less opportunity for conceptual development than inquiry-based ones.*

* see Appendix V for typology of activities that can be carried out on computer (adapted from Mashalaba & Sanders, 2003)

Appendix AF:

Summary of relevance of content in the five topics (from the *Curriculum Requirements Checklist*)

Categories of relevance	Topic 3 (*How has man classified the world around him?)*	Topic 124 (*An ecosystem is a working organisation)*	Topic 132 (Types of pollution)	Topic 133 (Species dying out)	Topic 135 (The nature necessary for living)
Relevance to the South African context	*The content on 13 out of the 16 screens (81%) uses examples of organisms that are found in South Africa and hence relevant to the South African context. The remaining three screens contain some examples that perhaps would not be familiar to most South African learners.*	*Three out of the 7 screens make use of South African examples, which contribute to making the content relevant to the South African context. The other four screens make general statements applicable in all contexts.*	*The content on all of the screens uses examples found in South Africa.*	*The content on most of the screens (3/5) uses examples that could be applicable to South Africa and are hence relevant to the South African context. The remaining two screens contain some examples that perhaps would not be familiar to most South African learners, but could offer the potential for learning new content.*	*The content on most of the screens (4/5) uses examples that could be applicable to South Africa.*
Relevance to learners' real life experiences and situations	*Most of the content (13 of the 16 screens) is likely to be relevant to learners' real life experiences, through the use of South African examples.*	*The use of South African examples on the first three screens would make the content relevant to learners' real-life experiences and situations.*	*Three out of the five screens have content relevant to learners' real life experiences, probably because of the large proportion of South African examples used in the content.*	*Three out of the five screens have content relevant to learners' real life experiences because of the use of South African examples.*	
Linkage to learners' prior knowledge	*Content on 15 of the 16 screens can be linked to learners' prior knowledge. The remaining screen contains an inappropriate analogy which is not explained (a Russian nesting doll).*	*Most of the content could be linked to learners' prior knowledge.*	*All five screens in this topic could be linked to learners' prior knowledge.*	*All of the content could be linked to learners' prior knowledge, even where the examples used are not specifically South African.*	*All of the content could be linked to learners' prior knowledge, even where the examples used are not specifically South African.*

Appendix AG:

Description and analysis of assessment activities in the five topics (from the *Curriculum Requirements Checklist*)

Topic	Description of assessment	Type of assessment*	Cognitive abilities covered by the assessment**	Learning outcomes and assessment standards addressed in the assessment
Topic 3 (*How has man classified the world around him?*)	*There is a list of names of organisms which must be sorted into groups of vertebrates, invertebrate, mammals, insects and those that live in an aqueous habitat.*	*Text-based activity/ analysis task/ data-response activity/ classification task*	***Knowledge** and **comprehension** of the features of the different organisms.*	*LO2 AS1 (Learners access their own knowledge to be able to recall the relevant information).* *LO2 AS2 (Learners interpret and make meaning of their knowledge of how organisms can be classified into groups, based on the organisms' features).*
	Six questions in which learners must identify the odd one out in a list of organisms.	*Text-based activity/ analysis task/ simple close-ended task/ identifying the odd one out*	***Knowledge** and **comprehension** of information to identify the odd one out.*	*LO2 AS1 (Learners access their own knowledge to be able to recall the relevant information).* *LO2 AS2 (Learners interpret the question and make meaning of their knowledge to be able to identify the odd one out).*
	Given a list of the hierarchical levels of taxa (kingdom to species) and a jumbled list of the terms used to classify humans (e.g. hominid), learners must classify humans from kingdom down to species.	*Text-based activity/ completion task*	***Knowledge.***	*LO2 AS1 (Learners access their own knowledge to be able to recall the relevant information).*
	Learners are given a list of names of organisms to sort into 5 groups that include "perform photosynthesis", "produce spores", "produce seeds" and "make fruit".	*Text-based/ analysis task / simple close-ended task/ matching names to descriptions.*	***Knowledge** of the organisms, **comprehension** of what features the different organisms have and **application** of knowledge to match names to descriptions.*	*LO2 AS1 (Learners access their own knowledge to be able to recall the relevant information).* *LO2 AS2 (Learners interpret the question and make meaning of their knowledge to be able to carry out the simple matching task.)*
	Given a list of descriptions, learners have to match organism names to the descriptions.	*Text-based/ analysis task / simple close-ended task/ matching words to descriptions.*	***Knowledge** of what features the different organisms have.*	
	Learners must supply the phylum, subphylum and class for 5 organisms	*Text-based/ completion task / complete the table*	***Knowledge**.*	*LO2 AS1 (Learners access knowledge to supply the taxonomic levels).*
	Learners are given a list of words from which they must choose the correct term to complete sentences.	*Text-based / completion task/ fill-in-the-blank*	***Knowledge**.*	*LO2 AS 1 (Learners access their own knowledge to be able to recall the relevant information).*

Topic	Description of assessment	Type of assessment*	Cognitive abilities covered by the assessment (Bloom et al., 1956)	Learning outcomes and assessment standards addressed in the assessment
Topic 124 (*An ecosystem is a working organisation*)	*Questions 1 & 2*	*Text-based activity/ analysis task/ simple close-ended task/ multiple choice*	***Comprehension** to be able to select the correct answer.*	*LO2 AS1 (Learners access their knowledge). LO2 AS2 (Learners interpret and make meaning of their knowledge.)*
	Question 3	*Text-based activity/ completion task/ supply the term*	***Comprehension** of the related knowledge to be able to supply the term.*	
	Question 4	*Text-based activity/ analysis task/ simple close-ended task/ multiple choice*	***Comprehension** to be able to select the correct answer*	
	Question 5	*Text-based activity/ analysis task/ simple close-ended task/ multiple choice*		
	Question 6	*Text-based activity/ completion task/ supply the term task*	***Comprehension** of the related knowledge to be able to supply the term.*	
	Screen 13	*Text-based activity/ completion task/ complete the table*	***Comprehension** of the related knowledge and **application** of that knowledge is required to complete the table.*	
Topic 132 (*Types of pollution*)	*Question 1*	*Text-based activity/ completion task/ fill-in-the-blank*	***Comprehension** of the related knowledge to be able to answer the question.*	*LO 2 AS1 (Learners access their own knowledge to be able to recall the relevant information). LO2 AS2 (Learners interpret and make meaning of their knowledge in order to supply the missing word).*
	Question 2	*Text-based activity/ review task/ answering review question*		
	Question 3	*Text-based activity/ completion task/ fill-in-the-blank*		
	Question 4	*Text-based activity/ analysis task/ simple close-ended task/ multiple choice*	***Comprehension** and **application** of knowledge to be able to select the correct answer*	
Topic 133 (*Species dying out*)	*Question 1*	*Text-based activity/ analysis task/ simple close-ended task/ multiple choice*	***Comprehension** and **application** of knowledge to be able to select the correct answer*	*LO2 AS1 (Learners access their own knowledge to be able to recall the relevant information). LO2 AS2 (Learners interpret and make meaning of the information given to be able to choose the correct answer).*
	Question 2	*Text-based activity/ review task/ answering review question*	***Comprehension** and **application** of the related knowledge is required to identify the three causes of pollution from the list given.*	
	Question 3 & 4	*Text-based activity/ analysis task/ simple close-ended task/ multiple choice*	***Comprehension** and **application** of knowledge to be able to select the correct answer.*	
	Question 5			
Topic 135 (*The nature necessary for living*)	*Questions 1 – 7: multiple choice*	*Text-based activity/ analysis task/ simple close-ended task/ multiple choice*		

*see Appendix V for typology of activities that can be carried out on computers (adapted from Mashalaba and Sanders, 2003)

Appendix AH:

Examples of poor grammar usage in the five software topics (taken from language and terminology usage section of the *Content Coverage Checklist*)

Content in software	Possible interpretation(s)/ improvement
The instruction for one of the sorting activities in Topic 3, reads "*Try for yourselves to…"*.	***A better form of expression would be "Try to group the … by yourself" or simply "Group the following organisms according to …".***
You have already learnt the common features of living organisms, as well as their cell structure. You can therefore see that the world of living organisms can be regarded with a certain unity, at least with regard to these two features (screen 2, Topic 3).	***The reference to cell structure being a unifying feature is unclear, as some of the most distinctive differences between living organisms occur at the cellular level, e.g. plant vs. animal cells; prokaryotic vs. eukaryotic cells. The latter reference required a greater degree of clarity as to which level of cellular structure was being regarded as the unifying feature, which was most likely to be the fact that all living organisms are composed of cells. It is also unclear what "two features" are referred to in the second sentence***
"vertebrates of aqueous habitats" (screen 23, Topic 3).	***This phrase would be easier to understand if it read "aquatic vertebrates".***
An ecosystem is referred to as "*functioning as a certain whole"* (screen 2, Topic 124).	***This could be interpreted as "functioning as a unit".***
There is reference to the "separateness of an ecosystem" being "determined by whether it constitutes a functioning whole" (screen 2, Topic 124),	***It is not clear what the "separateness of an ecosystem" means. It could be interpreted as questioning where the boundary of an ecosystem is. The whole reference could be interpreted as the capacity of an ecosystem to survive being determined by whether it can function independently of other ecosystems.***
There is reference to the "*elements and mechanisms"* of nature (sub-screen to screen 5, Topic 124),	***This phrase could be interpreted as referring to the "organisms (elements) and the biological processes of nature (mechanisms)" or the "biotic (elements) and abiotic components (mechanisms) of nature".***
The forest biome is described as being "*tall and multi-level in character"* (sub-screen to screen 6, Topic 124*)*.	***This phrase could be interpreted as "forests are made up of tall trees with many levels of tall trees" or "this biome displays many levels of vegetation, including tall trees".***
The lack of trees on the steppes is explained as being due to "the alternate occurrence of a series of ecological factors, like hot, dry summers and long, severe winters" (sub-screen to screen 6, Topic 124).	***This clumsy statement could have been more clearly worded as "The lack of trees on the steppes is caused by the prevailing climatic conditions of hot, dry summers and long, severe winters".***
Desert landscapes are described as being "*sometimes very diversified"* (sub-screen to screen 6, Topic 124*)*.	***Possible interpretations are that "desert landscapes are very different from each other" or "deserts sometimes contain a wide range of diverse species".***
There are numerous clumsy phrases used in relation to biomes on the sub-screens to screen 7 (Topic 124) e.g. "*multi-level"*, "*low structure"*, *"low two-layer structure",* "*complex two-layer structure"* and *"developed layer structure"*.	***"Low structure" is taken to mean that the plants there grow close to the ground, but it is not clear what is meant by "multi-level", "two-layered" or "complex low structures".*** ***Also, while "layered structure" is taken to mean that the vegetation grows to different levels, it is not clear what is meant by "developed layer structure".***
There is reference to "*a distinct group of numerically dominant species"* in temperate forests (sub-screen to screen 6, Topic 124*)*.	***This could have been expressed in simpler and more easily understood language as, possibly, "a group of species that grow in high numbers in temperate regions".***

Content in software	Possible interpretation(s)/ improvement
The tundra is described as a biome that is "*very active in summer, inactive in winter"*.	***It could be taken to mean that "the organisms in tundra regions are very active in summer but inactive in winter " or that "most of the growth and reproduction of plants and animals takes place in the summer".***
The sclerophyllous forest is described as being "*short"*.	***This could mean that the sclerophyllous forest has low growing trees.***
Park forests and savannah regions are described as "*ecosystems of intermediate structure"* and to be formed by "*scarcely growing trees"*.	***These clumsy phrases could have been combined into the more succinct "these biomes have only a few trees of medium height".***
"*cumulation of poisons in a food chain*" (screen 4, Topic 132)	***The Oxford Advance Learner's Dictionary does not contain the word cumulation. "An accumulation" would have been a more accurate form of expression.***
There is reference to the "*major factor groups*" of pollution (screen 5, Topic 132).	***This phrase could simply have read "major types of pollution".***
"*Among species becoming extinct the majority are the species of the most numerous systematic groups (minor plants, nematodes, insects) inhabiting the tropical zones and characterized by small species ranges*" (screen 2, Topic 133).	***The entire statement is difficult to interpret because of the juxtaposition of the following clumsily worded phrases:*** • *The phrase "the most numerous systematic groups" could be interpreted as* – *"species consisting of large numbers of organisms", although this does not make any sense without an explanation of why these particular groups are at a greater risk of being wiped out.* *OR* – *that these species comprise most of the groups in tropical zones.* • *The clumsily worded phrase "small species ranges" should probably read "narrow species ranges".*
"*Extinction affects every species*" (screen 6, Topic 133).	***This statement occurs on the Remember screen of Topic 133, which summarises the main points for the topic. The statement could mean that "all species are in danger of going extinct" or that "all species are going extinct".***
There is reference to a "*catastrophic rate of extinction of many species of many groups*" (screen 6, Topic 133).	***This phrase also occurs on the Remember screen of Topic 133. The clumsily worded "many species of many groups" could simply have read "many species".***
"*expanse of the human economy*" (sub-screen to screen 3, Topic 135)	***This phrase should read "expansion of human economic activity" to make sense in the context in which it is used. "Expanse" refers to the vastness of the human economy.***
"*very predatory*" (sub-screen to screen 3, Topic 135)	***This phrase incorrectly suggests that there are degrees of predation as in "slightly predatory" or "very predatory".***

APPENDIX AI:

The completed *Pedagogical Strategies Checklist*

Pedagogical design feature	Used/ not used	Evaluator's comment
The software should clearly outline the goals the learner is supposed to achieve.	*Not used*	*No goals are stated for any of the five topics evaluated (see completed Curriculum Requirements Checklist, Appendix AD).*
The software should include tasks which actively engage learners. Such activities will have the potential to allow the construction of knowledge through the learner thinking and reflecting on what they are doing and developing their own explanations for what they observe.	*Used, but ineffectively*	*Active engagement is taken to mean the learner is involved in activities which engage them mentally as well as physically.* *An analysis of the activity types used in the software package showed that* • *a limited number of activities (ranging from 8% of the main screens for Topic 124 to activities on 16% of the screens in Topic 3) and activity types (two out of a possible 30) were used (see Chapter 5, Table 22, page 167).* • *the two types of activities used were judged unlikely to promote learners constructing their own knowledge (see Chapter 5, Table 22, page 167).*
The software should include some tasks which are situated within a meaningful, real-life context.	*Not used*	*None of the activities or assessment tasks are situated within a meaningful, real-life context which could make the tasks more relevant to the learner, thereby promoting learning.*
The software should present the information to be learnt in small chunks.	*Used effectively*	*The information in the five topics tends to be organised in small units, with between one and three units or chunks of information per screen.*
The software should include tasks which use a variety of levels of cognitive activity.	*Used, but ineffectively*	*The activities and assessment tasks used in the software make use of the lower-order cognitive levels given by Bloom in his taxonomy of cognitive objectives. Learners are required to* ***recall knowledge*** *and* ***display their comprehension of knowledge,*** *with limited requirements for learners to use the cognitive level of* ***application of knowledge*** *(which means that learners apply their knowledge in new situations). There are no opportunities to use the highest levels of cognitive abilities as listed in Blooms' taxonomy, namely the skills of analysis, synthesis and evaluation.*
The software should represent knowledge in alternative ways.	*Used, but ineffectively*	*The purpose of this strategy is to make allowances for differences in learning styles between individuals. Beyond presenting information in different forms because it combines pictures and text, the software makes no provision for accommodating different learning styles.*
The software should include tasks which can be carried out co-operatively.	*Not used*	*None of the tasks requires co-operation between individuals.*
The software should offer appropriate assessments with more than yes/no or right/wrong answers	*Not used*	*An analysis of the assessment activities in the five topics (see Appendix AG) shows that all involve right/ wrong answers. To illustrate the point, the software makes extensive use of multiple-choice questions, which are either right or wrong:* • *In Topic 124, 4 of the 6 (67%) questions are multiple-choice questions.* • *In Topic 133, 5 of the 6 (83%) questions are multiple-choice questions.* • *In Topic 135 all 7 questions are multiple-choice questions.*

<table>
<tr><th>Pedagogical design feature</th><th>Used/
not used</th><th>Evaluator's comment</th></tr>
<tr><td>The software should provide a motivational learning environment through the selective and effective use of multimedia elements such as audio and video and/ or the use of elements like animation, where appropriate, to gain the learner's interest and attention.</td><td>Used, but ineffectively</td><td>

The software uses colourful and attractive photographs. The number of screens in the five topics with photographs (excluding the Remember "read and record" activity screens and the assessment screens for each topic, which are less likely to have images on them) are as follows:

<table>
<tr><th>Topic</th><th>Screens with photographs (out of total number with images)</th></tr>
<tr><td>3 – How has man classified the world around him?</td><td>72/76 (59/72 full-screen)</td></tr>
<tr><td>124 – An ecosystem is a working organisation</td><td>28/32 (17/28 full-screen)</td></tr>
<tr><td>132 – Types of pollution</td><td>15/17 (6/15 full-screen)</td></tr>
<tr><td>133 – Species dying out</td><td>8/10 (1/8 full-screen)</td></tr>
<tr><td>135 – The nature necessary for living</td><td>15/15 (9/15 full-screen)</td></tr>
</table>

Audio and video inserts are used in the software, but their limited use means that they are not very effective in gaining users' attention. The number of screens with audio inserts ranges from 3 out of 77 screens (4%) for Topic 3 to 5 out of 11 screens (45%) for Topic 133. No video inserts are used in Topic 3, while Topic 133 has video on 3 out of the 5 screens which have audio inserts.
Animation is used, but is limited to a single repetitive animation of a heron grabbing a fish in Topic 124, which proved to be distracting and annoying rather than motivational.

</td></tr>
<tr><td>The software should offer regular assessments that are interwoven with the instruction.</td><td>Used ineffectively</td><td>At the end of each topic, there are assessments based on the content in that topic. While the assessments do occur regularly, they are not interwoven with the content of each topic.</td></tr>
<tr><td>The assessments used should provide for prompt, regular and useful feedback to be given to the learner.</td><td>Used, but ineffectively</td><td>Although prompt feedback could be accessed at the end of each activity via the "activity report" for that activity the feedback offered was not useful for learners. As discussed (in Chapter 5, page 169) the activity reports give learners' scores for an assessment task as 100% correct or 100% wrong. No explanation is given why the learner's answer was incorrect, so learners are not able to understand why their answers were wrong.</td></tr>
<tr><td>The software should make provision for the application of skills in new contexts to promote the transfer of the use of the skills.</td><td>Not used</td><td>No skills were explicitly taught in any of the topics). The main skill required was interpreting diagrams, but since most of graphics in topics 3 (94%) and 124 (75%) were photographs there was little opportunity for this skill to be developed.</td></tr>
</table>

Appendix AJ:

The section of the completed *Interface Design Checklist* dealing with text design

<table>
<tr><th>Question</th><th>Yes</th><th>No</th><th>Evaluator's comment</th></tr>
<tr><td>Is the style of the typeface easy to read?</td><td>✓</td><td></td><td>All topics: font resembles Arial. The font style is easy to read.</td></tr>
<tr><td>Is the variation in styles of typeface used effectively and for a specific purpose?</td><td>✓</td><td></td><td>The following variations in typeface are used:
• The font size is 11 for main text and 12 for titles, which allows users to distinguish between headings and text.
• A bold font has been used for screen titles and for labelling images.
• Italics have been used
– to emphasise the names of biomes on screen 6, Topic 124.
– for image headings, although this has not always been used consistently, e.g. the heading for the image on screen 5, Topic 3 is not in italics.
– for the instructions for activities and assessments in some topics (e.g. Topic 3), but not in others (Topics 124, 132, 133 and 135).</td></tr>
<tr><td>Have upper case letters been used for purposes of emphasis only?</td><td>✓</td><td></td><td>Upper case letters have only been used for labelling of graphics to denote a hyperlink in the graphic.</td></tr>
<tr><td>Is the text appropriately aligned on the screen with respect to
• justification?
• kerning?
• leading?</td><td></td><td>✓</td><td>• The ideal situation is for text to be left-justified, as full justification in narrow columns leads to irregular spaces between words. In four of the 5 topics the text is left-justified (Topics 3, 132, 133, 135) but in Topic 124, the text found inside elliptical shapes is not always left-justified. Instead the text has been wrapped inside the shapes to give an oval edge to the text (screen 7, Topic 124). On some screens (see screens 2 and 5, Topic 124) text adjacent to images has been wrapped around the images creating an irregular left-hand edge to the text.
• Kerning has been carried out to improve the appearance of text, as there are no awkward spaces between kerning pairs (e.g. v and e).
• The text does not appear cramped, nor do the ascenders in one line touch the descenders from the previous line, so the leading appears appropriate.</td></tr>
<tr><td>Is the number of words per line appropriate (not exceeding 8 – 10)?</td><td></td><td>✓</td><td>The number of screens in the five topics where the number of words per line exceeds 8-10 is as follows:
<table><tr><th>Topic</th><th>Screens* with more than 8-10 words/ line</th></tr><tr><td>3 – How has man classified the world around him?</td><td>31/85 (36%)</td></tr><tr><td>124 – An ecosystem is a working organisation</td><td>26/38 (68%)</td></tr><tr><td>132 – Types of pollution</td><td>15/21 (71%)</td></tr><tr><td>133 – Species dying out</td><td>9/15 (60%)</td></tr><tr><td>135 – The nature necessary for living</td><td>14/21 (67%)</td></tr></table>*The number of screens includes main screens and sub-screens.
In all 5 topics the percentage of screens with an appropriate number of words per line is less than 75%. One out of the 5 topics has fewer than half of the screens having an appropriate number of words per line (Topic 3 - 36%). The screens which contribute most to the inappropriate number of words per line are the full screen photograph screens, where the text is very small so more words can be fitted in per ..</td></tr>
<tr><td>Is screen appropriately covered with text and graphics to not appear crowded?</td><td>✓</td><td></td><td>In all 5 topics all of the screens had appropriate screen coverage.</td></tr>
<tr><td>Have highlighting techniques been used purposefully to draw attention to main points?</td><td>✓</td><td></td><td>The following highlighting techniques are used:
• Titles, menus and image headings in different colours to the text.
• In all 5 topics hypertext is in a different colour to the remainder of the text to draw attention to it (e.g. screen 7, Topic 3). Hypertext is either in orange (e.g. screens 3 and 10, Topic 133) or in red (e.g. screen 7, Topic 3) versus the green or white of the rest of the text.
• Underlining is only used once, to draw attention to the name of a kingdom (screen 15, Topic 3). However, since only one of the two names of kingdoms on that screen has been underlined, the purpose of the underlining is not clear.
• Flashing symbols are used on screen 2, Topic 124, but the purpose of the flashing symbols is not clear. The user is meant to click on capitalised words above and below the flashing symbols, not the actual symbols.</td></tr>
</table>

APPENDIX AK:

The completed section of the *Interface Design Checklist* dealing with the screen layout

Question	Yes	No	Evaluator's comment
Is there sufficient white space in the structure of the display to make the display easy to read?	✓		*While there is sufficient "white space" on all screens, the presence of the watermarks on the main screens makes the screens very busy and often proves distracting.*
Does the display come across as balanced and symmetrical?	✓		*The display is balanced and symmetrical across all topics.*
Is there consistency in the appearance, location and function of screen elements like textual signals and cues?		✓	*A number of inconsistencies in the appearance and function of screen elements were evident in the software. These have been discussed under the 'Use of icons' section (see page 187 of Chapter 5).*
Is the layout logically organised (top to bottom/ left to right sequencing)?	✓		*For all topics the layout was found to be logically organised, except for the first screen of Topic 3. This screen has the content on the left of the picture. For the other four topics the layout is more logical because the picture is on the left and the content on the right.*

Appendix AL:

The section of the completed *Interface Design Checklist* dealing with the use of graphics and images

<table>
<tr><th>Question</th><th>Yes</th><th>Some</th><th>No</th><th>Evaluator's comment</th></tr>
<tr><td>Are the images simple and clear?</td><td></td><td>✓</td><td></td><td>Most of the images used in the topics are photographs. All photographs are simple and clear. The table below shows the number of non-photographic images that are simple and clear in the five topics.

<table><tr><td>Topic</td><td>No. of simple and clear images</td></tr><tr><td>3 – How has man classified the world around him?</td><td>4/4 (100%)</td></tr><tr><td>124 – An ecosystem is a working organisation</td><td>1/4 (25%)</td></tr><tr><td>132 – Types of pollution</td><td>1/2 (50%)</td></tr><tr><td>133 – Species dying out</td><td>1/1(100%)</td></tr><tr><td>135 – The nature necessary for living</td><td>No images are used in this topic.</td></tr></table></td></tr>
<tr><td>Have the key components of images used for purposes of explanation been clearly labelled?</td><td></td><td>✓</td><td></td><td>None of the photographs have any labelling since they are used mainly for attentional and/or illustrative purposes rather than explanatory purposes. The table below is a summary of the non-photographic images that have been labelled in the five topics.

<table><tr><td>Topic</td><td>No. of labelled images</td></tr><tr><td>3 – How has man classified the world around him?</td><td>4/4 (100%)</td></tr><tr><td>124 – An ecosystem is a working organisation</td><td>1/4 (25%)</td></tr><tr><td>132 – Types of pollution</td><td>1/2 (50%)</td></tr><tr><td>133 – Species dying out</td><td>0/1(0%)</td></tr><tr><td>135 – The nature necessary for living</td><td>No images are used in this topic.</td></tr></table></td></tr>
</table>

<table>
<tr><th>Question</th><th>Yes</th><th>Some</th><th>No</th><th>Evaluator's comment</th></tr>
<tr><td>Do the images have a clear instructional or motivational benefit?</td><td></td><td>✓</td><td></td><td>

Photographic images:

- ***Some photographs have been used without accompanying text, but they have a motivational benefit because they attract users' attention and make the screens more interesting. The photographs on the first screens of each of the five topics would fall into this category.***
- ***Other photographs accompany text (like the photographs on many of the sub-screens in the package). These photographs have both a motivational and an instructional benefit. The motivational benefit would derive from the photographs making the text more interesting for users. The instructional benefit would be that the photographs illustrate some aspect of the text.***

Non-photographic images:

The table below gives the number of images for each topic that have clear instructional or motivational benefits.

<table>
<tr><th>Topic</th><th>No. of images with clear benefit</th></tr>
<tr><td>3 – How has man classified the world around him?</td><td>2/4 (50%)</td></tr>
<tr><td>124 – An ecosystem is a working organisation</td><td>1/4 (25%)</td></tr>
<tr><td>132 – Types of pollution</td><td>1/2 (50%)</td></tr>
<tr><td>133 – Species dying out</td><td>1/1(100%)</td></tr>
<tr><td>135 – The nature necessary for living</td><td>No images are used in this topic.</td></tr>
</table>

</td></tr>
</table>

Appendix AM:

The section of the completed *Interface Design Checklist* for the use of colour in the software

<table>
<tr><th>Question</th><th>Yes</th><th>No</th><th>Evaluator's comment</th></tr>
<tr><td>Is there sufficient contrast between the letters and the background for easy legibility?</td><td></td><td>✓</td><td>The number of screens in the five topics with good legibility is shown in the table below. Three of the five topics have high percentages of screens (more than 80%) with good legibility, but two of the topics have less than 75% of their screens with good legibility.
<table>
<tr><td>Topic</td><td>No. of screens with good legibility</td></tr>
<tr><td>3 – How has man classified the world around him?</td><td>78/85 (92%)</td></tr>
<tr><td>124 – An ecosystem is a working organisation</td><td>33/38 (87%)</td></tr>
<tr><td>132 – Types of pollution</td><td>20/21(95%)</td></tr>
<tr><td>133 – Species dying out</td><td>9/15 (67%)</td></tr>
<tr><td>135 – The nature necessary for living</td><td>15/21 (71%)</td></tr>
</table></td></tr>
<tr><td>Has colour been used to highlight text or graphics without the use of colour being distracting?</td><td></td><td>✓</td><td>The table below shows the number of screens where colour has been used for highlighting text and graphics without being distracting. In each of the five topics there are screens on which the use of colour for highlighting is distracting.
<table>
<tr><td>Topic</td><td>No. of screens where the use of colour is not distracting*</td></tr>
<tr><td>3 – How has man classified the world around him?</td><td>25/26 (96%)</td></tr>
<tr><td>124 – An ecosystem is a working organisation</td><td>18/21 (86%)</td></tr>
<tr><td>132 – Types of pollution</td><td>12/14 (86%)</td></tr>
<tr><td>133 – Species dying out</td><td>13/14 (93%)</td></tr>
<tr><td>135 – The nature necessary for living</td><td>11/12 (92%)</td></tr>
</table>
*Screens which have only photographs and accompanying text have been excluded because the colour on these screens has not been used for the purposes of highlighting.</td></tr>
<tr><td>Is there a consistent colour coding scheme?</td><td></td><td>✓</td><td>All 5 topics show the same use of colour for screen menus.
<u>Within a topic</u> there is consistency in the use of colours for screen titles and image headings.
There is a lack of consistency <u>across topics</u> in the colours used for coding screen titles and image headings. Topic 3 differs from the colour scheme used in the other four topics.</td></tr>
<tr><td>Are there any red-green or yellow-blue colour combinations?</td><td>✓</td><td></td><td>Two topics have screens with red-green combinations:
Topic 132 has 3/21 screens (14%) with red-green combinations.
Topic 133: 1/15 screens (7%) with red-green combinations.
Topics 3, 124 and 135 do not have any screens with red-green or yellow-blue colour combinations.</td></tr>
</table>

Appendix AN:

Completed *Multimedia Strategies Checklist* for evaluating the use of basic multimedia principles that can be used to enhance learning

Design feature	Guidelines followed (✓) or infringed (X)	Reviewer's comment
Multimedia software should use both pictures and words to aid learners' retention of knowledge.	✓	***The software uses pictures to augment both text and narration. However, the use of both pictures and words is not sufficient to ensure effective learning. The pictures and words must be used in ways that aid learners' retention of knowledge. There are two of the ways in which pictures and words are used in the software that could increase the extraneous cognitive load required to understand the picture and text combinations:*** • ***The software makes extensive use of photographs on the sub-screens in the five topics, but the photographs are not temporally and spatially integrated with the text on these screens.*** • ***In another checklist, two of the five topics were found to have pictures: 75% of the pictures in Topic 124 and 50% of those in Topic 132 were difficult to interpret.***
Multimedia software should have the descriptions or explanations accompanying pictures on screen at the same time (temporally integrated) and sufficiently close together (spatially integrated) so that learners do not have to divide their attention between the picture and the accompanying text.	x	***In addition to the lack of spatial and temporal integration of the photographs and text combinations on the sub-screens in the five topics (see previous row), there is also a lack of integration of the combinations involving audio inserts). In the section on 'media integration' it was reported that more than 50% of the audio combinations used in the five topics are not effectively integrated.***
Multimedia software should use oral narration with pictures rather printed text to avoid overloading the visual system and allow more efficient processing of information in the auditory and visual systems.	x	***Oral narration is more often combined with text than with pictures in the software. In 10/23 cases audio inserts are used with text compared to 6/23 cases where oral narration is used with pictures. In 7/23 cases, oral narration is not used in conjunction with either pictures or text (as previously discussed, the picture on the screen is replaced with a 'pink' screen when the audio insert plays). This means that more than a third of the audio inserts are not accompanying anything, making the purpose of their use questionable.***
Information should be presented using a single format when that format fully explains the concept. Additional formats of	x	***Where audio inserts are denoted by the "Listen" icon, the audio message reads the text message. Since the audio delivers the same message as the text, one or other of the two formats would have sufficed. There are 5/23 of these redundant combinations in the five topics.***

the same content could prove to be redundant.		
Multimedia software should introduce learners to new terms (called "*pre-training*") before the terms are used in a narrated animation. This will reduce the amount of processing required to understand the animation.	x	***The only narrated animation in the five topics uses the term "niche". The printed text above the animation supplies a definition for the term, which could be regarded as an attempt at offering pre-training. Unfortunately the definition proffered is vague so that any attempt at pre-training is not effective. The concept of niche is defined as being "composed not only of the habitat of a given species, but also the nutrition and life habits of individuals". It is the reference to the "life habits' of individuals which is vague. The audio message does little to clarify the concept for learners, because it suggests that the concept of niche is determined by the "eating habits" – another vague term – of organisms.***
Multimedia software should only include information that is relevant to the learning outcome for a section of work. Words, pictures and sounds that may distract learners' attention from the information to be learned should be omitted	x	***The main feature that could distract learners' attention from the information to be learned is the widespread use of diffuse watermarks on the screens. These watermarks reduce the legibility of text and affect the interpretation of graphics (as discussed for the "biome map", see Figure 61, page 200), both of which could distract learners' attention.***
Multimedia software should use signals such as headings and bold fonts to draw learners' attention to essential information.	✓	***The software makes use of bold fonts and headings to draw attention to essential information, but the inconsistent use of these signals (e.g. the use of capital letters to draw attention to diagram labels to be clicked on in some topics and not in others) means that these signals have not been used effectively.***
Voices used for narration should be human (not machine synthesised) and should be recognisable to users (not have a foreign accent).	✓	***The narrative voice is easily understood.***
The style used to deliver both spoken and printed words in multimedia packages should be conversational rather than formal so that users can easily relate to it.	✓	***There is an attempt in the software to adopt an informal conversational style of delivering words. However, the preponderance of awkward phrases, especially in printed text, makes the writing style come across as clumsy rather than conversational.***

Appendix AO:

Completed *Multimedia Strategies Checklist* for the five topics of the advanced multimedia principles that can be used to enhance learning

Design feature	Guidelines followed (✓) or infringed (X)	Reviewer's comment
Multimedia software should incorporate worked-out examples to teach new skills so that learners can use the example to learn how to apply domain-specific procedures to solve problems rather than applying general solving-problem techniques.	X	*No skills were taught in the software package, so no use was made of worked-out examples to teach learners domain specific skills. One area in which worked out examples could have been used is in conjunction with the drag-and-drop sorting activities in Topic 3 – How has man classified the world around him? Worked out examples could have been used to highlight the use of appropriate features when classifying organisms. However, for this activity to introduce the skill of classification, the activity should not have been designed to reject incorrect answers so that it could not be completed by trial-and-error.*
Multimedia software should involve learners working on tasks in small groups to foster interpersonal interactions.	X	*The software package does not make provision for collaborative learning.*
Multimedia software should facilitate learners playing an actively in constructing their knowledge through activities which require learners to explain things to themselves and learners monitoring their understanding of the material.	X	*The low level of mental engagement required by the activities and assessment tasks in the software package provides little opportunity for learners to actively construct knowledge. Many of the tasks can be completed by trial-and-error. The limited feedback the software package provides to learners and the lack of capacity for learners' results to be recorded after a log-on session means that there is little opportunity for learners to monitor their understanding of the material.*
Animation should be combined with learner interactivity to so that learners can control the pace of the animation and revise parts of the animation according to their own needs.	X	*The only animation used in the five topics does not make use of interactivity.*
The navigational devices used in a multimedia package must help learners to easily find their way through the package.	X	*The many problems relating to the use of icons (e.g. the absence of text labels for the icons and the use of non-intuitive symbols for control buttons) would make it frustrating for users to find their way through the package. In addition, the software package does not use a site map. Wikipedia (2009) describes a site map as a list of all the pages that learners can access, usually organised in hierarchical fashion. The software uses a contents page, much like that found in a book, to display the different units and topics of content. The hyperlinks, which open additional pages and the complicated system of screens and sub-screens could have been displayed as a site map for each unit of content. This might have made the package easier to navigate. In the absence of a site map, the software is organised much like a reference book with hyperlinks.*
Multimedia presentations must be designed to gradually replace high-structured formats (e.g. detailed instructions on how to complete a task or to develop a skill) with low-structured instructions to accommodate learners' increasing skill and knowledge levels. Learners with high prior knowledge may experience cognitive conflict when trying to integrate high-structured materials with schemas they have already constructed (i.e. their prior knowledge) leading to the expertise reversal effect.	X	*There is no evidence of any attempt to replace high-structured formats with low-structured instructions. The simple and unchallenging activities and assessment tasks show no progression in the level of difficulty through the five topics. The underlying problem is that the content for the section biodiversity is disconnected: it occurs in three different units and five different topics. There is thus little evidence in the instructional design of the software package to avoid the expertise reversal effect.*

Appendix AP:

Questionnaire 1: Background information

Teachers' technology usage questionnaire 1

Answers marked with a * are required.

Hi!

I am conducting research into teachers' use of technology. Please complete this questionnaire on your technology usage, which is the first in a series of questionnaires. All information relating to your identity and your answers is confidential.

1. Name: *

2. Gender *

- Male
- Female

3. Age *

- 20-29
- 30-39
- 40-49
- 50-59
- 60-65

4. Which one of the following statements best describes how you feel about using computers?

- I feel uncomfortable using computers
- I feel mostly uncomfortable using computers
- I feel mostly comfortable using computers
- I feel comfortable using computers

5. Please check any of the statements which describe how you were using technology in your subject before digidays were introduced in January of this year:*

- [ ] Before digidays I used word processors to produce materials for use with my learners
- [ ] Before digidays I used spreadsheets to produce materials for use with my learners
- [ ] Before digidays I used on-line (WWW) resources to find materials relevant to my curriculum
- [ ] Before digidays I used presentation software (e.g. PowerPoint) within my classroom
- [ ] Before digidays I used presentation hardware (e.g. a data projector) within my classroom
- [ ] Before digidays I used e-mail to contact colleagues and experts both inside and outside of the school
- [ ] Before digidays I used e-mail to communicate with parents and learners
- [ ] Before digidays I used technology to maintain student records (e.g. Pencilbox)
- [ ] 

6. Approximately how many times would you say you used computers during lessons before digidays?*

- ( ) Several times daily
- ( ) Once a day
- ( ) Once a week
- ( ) Once a month
- ( ) Only when needed

Thanks for taking the time to answer the questionnaire!

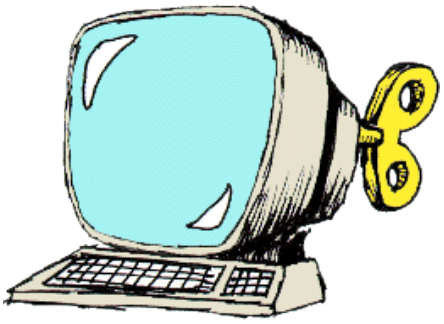
Appendix AQ:

Questionnaire 2: Teachers' computer use inside and outside of school

Teachers' computer use questionnaire 2

Answers marked with a * are required.

Thank you for taking the time to complete the second questionnaire on your computer use. It should take about 10 minutes to fill out. Remember that your answers are confidential. Your identity is only required so that you can be followed through the series of questionnaires.



1. Name: *

2. What subjects do you teach?
*

3. How long have you been teaching at this school?*

- Less than 1 year
- 1-5 years
- More than 5 years

4. How competent would you say you are at using a computer, in general?*

- Not very competent
- Fairly competent
- Highly competent

5. Indicate how confident you feel about using each of the computer programmes or applications listed below.*

	Confident	Not confident
Internet	☐	☐
email	☐	☐
Search engines like Yahoo! or Google	☐	☐
Microsoft Word	☐	☐

Microsoft Excel	☐	☐
PowerPoint	☐	☐
Adobe	☐	☐
Facebook	☐	☐
Twitter	☐	☐
MySpace	☐	☐
Blogger	☐	☐

6. How did you learn to use computers?*

- ○ I don't know how to use a computer
- ○ I taught myself
- ○ I was taught by somebody else
- ○ I attended training courses
- ○ Other (Please Specify)

7. If you were taught to use computers by somebody else, was this person

- ○ someone in your family
- ○ a colleague at this school
- ○ a colleague at another school
- ○ Other (Please Specify)

20. When would you try a new computer application? *

- When a new application that is relevant in my field is available.
- When I'm convinced that there's some benefit to using a new computer application.
- When I've seen others using a new computer application, and see that it is useful or nice.
- When most of my colleagues are using a new computer application and I don't want to be the only one not using it.
- I'm reluctant to try new computer applications.
- Other (Please Specify)

Thanks for your time.

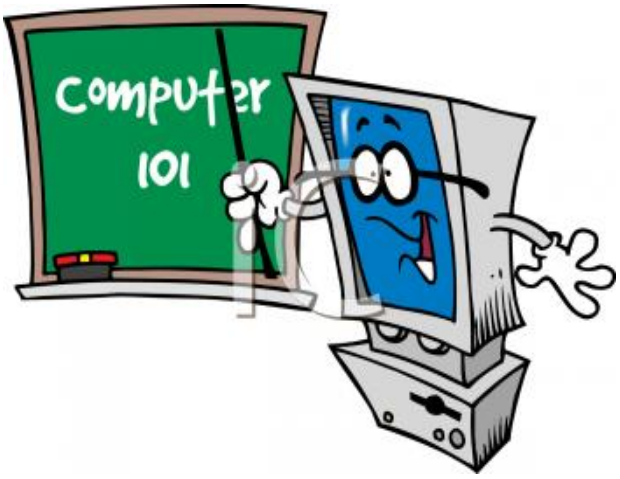
Please contact me if you have any comments or queries:
Ann George
082 870 9199
robinann@telkomsa.net

Appendix AR:

Questionnaire 3: Teachers' levels of innovativeness

Teachers' computer use questionnaire 3

Answers marked with a * are required.



1. Name: *

The questions to be answered are based on the following scenario.

A new computer programme that could be useful in the teaching of your subject has been released onto the market. You have just become aware of this programme.

*Please select the option to each question which would **MOST ACCURATELY MATCH YOUR RESPONSE**, were you to find yourself in this scenario.*

2. How are you likely to have become aware of the new programme?*

- I probably heard about it because THE SCHOOL HAS IT AND MANY OF MY COLLEAGUES ARE USING IT.
- I probably FOUND OUT ABOUT IT MYSELF. I am constantly looking for new computer programmes I can use in my teaching.
- I am most likely to have become aware of the programme when it became A SCHOOL REQUIREMENT TO USE IT.
- I am most likely to have HEARD ABOUT IT FROM SOMEONE ELSE and wanted to try it out.

3. How would you find out whether the programme could be useful in your teaching?*

- After hearing about it, I WOULD TEST IT -- WHEN I HAD TIME -- to decide whether or not it would be useful in my subject.
- I WOULD NOT TRY TO FIND OUT WHETHER IT COULD BE USEFUL for it as I

know what works well in my subject.

- I would probably find out WHEN THE SCHOOL REQUIRES US TO USE IT, and I have to try it.
- I would wait until the programme had been TESTED AND RECOMMENDED BY SOME OF MY COLLEAGUES.
- As soon as I found it, I WOULD IMMEDIATELY EXPERIMENT with it to find ways of using it in my teaching.

4. Once you are convinced the programme could be useful, how soon would you start using it in your teaching?*

- I would CREATE AN OPPORTUNITY TO TRY IT OUT IMMEDIATELY with my class to see if it works.
- I would WAIT UNTIL THE SCHOOL REQUIRES ME TO USE IT, as I am cautious about using new programmes.
- I would only start using it ONCE OTHERS HAD TRIED IT AND TOLD ME HOW IT WORKED.
- I am NOT LIKELY to use a new computer programme in my teaching.
- I would start using it at the EARLIEST SUITABLE OPPORTUNITY where I could fit it into my teaching schedule.

5. How likely are you to need help with using the new programme? *

- I would NEED SOMEONE TO SHOW ME HOW TO USE THE NEW PROGRAMME AND HELP AS PROBLEMS AROSE.
- I will DEFINITELY NEED LOTS OF HELP AS I STRUGGLE WITH LEARNING NEW THINGS on a computer.
- I WOULD ONLY NEED HELP IF THE PROGRAMME IS VERY COMPLICATED. I usually figure out computer issues myself.
- I am HIGHLY UNLIKELY TO NEED ANY HELP. I am usually the one helping others.
- I would probably ONLY NEED TO BE SHOWN HOW TO USE THE PROGRAMME ONCE, then I would be fine on my own.

Appendix AS:

Questionnaire 4: Teachers' computer use before and after the innovation

Teachers' computer use questionnaire 4
Answers marked with a * are required.

Thank you for taking the time to complete the fourth questionnaire on your computer use, which involves responding to 19 items. It should take about 10-15 minutes to fill out. Remember that your answers are confidential. Your identity is only required so that you can be followed through the series of questionnaires. If you would prefer to complete a paper form of the questionnaire please contact me.

1. Name: *

Section A

Please indicate how many times, on average, you carried out each of the computer tasks described in this section BEFORE digidays were introduced at the school and your **current** usage AFTER digidays.

For administrative purposes

2. For various administrative tasks (e.g. recording marks, entering comments for reports, and stocktaking) *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

3. Communicating with **parents** for administrative purposes (e.g. about a learner's progress, or responding to queries) *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

4. Communicating with **colleagues** for administrative purposes (e.g. setting test dates or discussing syllabus requirements) *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

5. Communicating with **colleagues** to improve the quality of teaching (e.g. sharing ideas/materials) *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

6. Communicating with **learners** for administrative reasons (e.g. about submitting work) *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

For lesson preparation

7. For preparing instructional materials (i.e. worksheets, handouts, tests, etc.) *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

8. Using the internet to search for lesson resources (e.g. animations, videos or exam papers) *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

9. Creating **basic** multimedia presentations (text and pictures) for use in lessons *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

10. Creating **complex** multimedia presentations (with music, animations, hyperlinks to external material, etc.) for use in lessons *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

For presenting work

11. **Showing** multimedia presentations in lessons (e.g. PowerPoint shows) *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

12. Posting learners' work or lesson resources on the internet (e.g. using Twitter, Facebook, Moodle or a personal website) *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

Section B

Please indicate, on average, how many times you assigned **LEARNERS** the following computer tasks BEFORE digidays and how often you currently assign these tasks (AFTER digidays)

For promoting knowledge

13. Getting learners to use drill-and-practice programmes (based on question-and-answer interactions) for learning content *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

14. Asking learners to use subject-specific programmes that deliver content *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

15. Requiring learners to access reference material on CD-ROMs or the internet (e.g. for assignments) *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

16. Getting learners to use basic games for learning vocabulary or terminology *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

17. Consulting with appropriate people (e.g. authors) via e-mail or internet to gather information (e.g. for assignments) *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

For promoting understanding

18. Requiring learners to use subject-specific programmes which have interactive tasks which get them to think and act *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

For promoting higher order cognitive skills (analysis, synthesis, evaluation)

19. Requiring learners to use more complex games which involve higher-order cognitive skills *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

20. Getting learners to use simulations involving higher-order cognitive skills (e.g. to track and graph trends) *

	never	a couple of times a year	about once a month	about once a week	about once a day
Before digidays	☐	☐	☐	☐	☐
After digidays	☐	☐	☐	☐	☐

Appendix AT:

Teacher interview schedule for Phase 2 of study

eason(s) why information is required	Justification for information required	Main questions	Follow-up situations or probe questions
Subject(s) taught			
To obtain background information on the teachers being interviewed.	Teacher background is necessary in order to be able to describe the group of teachers being interviewed.	*Let me start off by asking you about what you teach. (Only to be asked if I don't know what subject the teacher teaches.)*	
		1. What subject(s) do you teach?	
Computer literacy			
To obtain background information on the teacher's computer literacy.	Will provide insight into teacher's level of computer literacy. May provide insight into the teacher's attitudes using computers.	*It would help me understand your situation if you gave me some background information about how you learnt to use computers and how comfortable you are around computers.*	
		2. How competent would you say you are at using a computer, in general?	• Would you describe yourself as highly competent, moderately competent or not very competent when using computers? • Why do you describe yourself as ' … '?
		3. How have you learnt to use the computer?	*Ask the following probe questions, if necessary* • Did you teach yourself? Did somebody else teach you? If so, who? OR • Have you had formal computer training? What sort of computer training have you had? Where was the training? OR • Have you had in-service training or have you attended any training courses? • What training have you had? • How useful was the training?
		4. How confident are you about using computers, in general?	• Are there any programmes that you feel particularly confident about using? Which are they? What makes you feel confident about using that/ those programme(s)? • What sorts of things are you comfortable doing on computer? *Prompt with* • For example, how do you feel about having to load programmes? Please explain.
		5. How do you feel about using computers?	*If the teacher responded to the first questionnaire, then say "In the questionnaire you responded to you described yourself as '….'.*

eason(s) why information is required	Justification for information required	Main questions	Follow-up situations or probe questions
			Follow up with • What did you mean when you described yourself this way? *If the teacher did not respond to the first questionnaire omit the preamble and probe further, if necessary, with* • Why do you describe yourself this way? *If they seem unsure about what is being asked, rephrase as follows:* How comfortable are you about using computers?
Computer use			
To establish the nature and extent of the teacher's computer use. To identify any factors which are specific to a particular subject that may affect teachers using computers in their lessons.	Will provide insight into how the teacher uses computers and what they use computers for. Will provide an idea of how much the teacher was using computers in lessons before being required to use Moodle for DigiDays. May provide insight into the extent of the teacher's interpersonal network and their level of innovativeness. To establish what factors teachers feel affect their use of computers in their particular subject.	*Now tell me a bit about how you use computers.* 6. When did you first start using computers?	*If they seem unsure about what is being asked, rephrase as follows:* • Tell me a bit about how you first started using computers, and what you used them for. *Possible probes:* • What do you use computers for, outside of schoolwork? • *If they seem unsure, ask* • What programmes do you use outside of schoolwork? *Probe for use of any the following applications not mentioned by the respondent. Start the questions with* "How do you feel about using...?" *For each application the respondent uses, probe for how often the application is used, per month or per week.* *Prompt further for specific applications as given below:* ➢ *e-mail. If "yes", prompt further with:* o Do you communicate with learners from the school via email? How often would you say? Can you give me an example of something you have communicated about? Have you emailed or received email from a learner or group of learners for any other reason? When was this and what was it about?

eason(s) why information is required	Justification for information required	Main questions	Follow-up situations or probe questions
			○ Do you communicate with parents from the school via email? How often? About what? ○ Have you corresponded with colleagues from other schools via email? How often? Do you ever correspond with them about schoolwork? Give me an example of the sorts of things you email colleagues about. ➢ *Internet. If "yes", prompt further with:* ○ *What do you use the Internet for? May need to prompt with 'searches?' and 'Internet banking?'* ➢ *blogs* ➢ *social networking sites like* Twitter *and* Facebook ○ Do you communicate with learners from the school on any social networking sites? ○ Do you communicate with colleagues from the school on any social networking sites?
		7. Did you use computers for schoolwork before DigiDays?	*If respondent answers "no" go to question 9.* *If the teacher responded to the questionnaire, proceed as follows:* • In the questionnaire you responded to, you described yourself as using computers '*(insert as appropriate)* ' during lessons, before DigiDays. What sorts of things were you using computers for in lessons? *If necessary, prompt with* • What other programmes have you used? How have you used them in lessons? **OR** *Probe for use of any the following applications not mentioned by the respondent. For each application the respondent uses, ask how confident the respondent feels about using it and ask for an example of how they would use it in a lesson.* ➢ *word-processing packages, e.g. Microsoft Word* ➢ *spreadsheets, e.g. Excel* ➢ *PowerPoint,*

eason(s) why information is required	Justification for information required	Main questions	Follow-up situations or probe questions
			➢ *subject-specific software,* ➢ YouTube *videos* ➢ *search engines, e.g. Google, Yahoo, Ask* *If the teacher did not respond to the questionnaire, ask the questions below and then go to question 10.* • How long would you say you were using computers in your teaching before DigiDays? • How many times a month would you say you typically used computers during lesson, before DigiDays. *If often, bring it down to per week, if seldom, extend it to per term.* • What programmes were you using? *Probe for use of any the following applications not mentioned by the respondent. For each application the respondent uses, ask how confident the respondent feels about using it and ask for an example of how they would use it in a lesson.* ➢ *word-processing packages, e.g. Microsoft Word* ➢ *spreadsheets, e.g. Excel* ➢ *PowerPoint,* ➢ *subject-specific software,* ➢ YouTube *videos* ➢ *search engines, e.g. Google, Yahoo, Ask*
		8. Can you give me an example of a lesson, before DigiDays, which used computers and which you thought was successful?	• What do you think made the lesson successful? • Can you describe a lesson using computers that you thought did not go well? • What do you think caused the lesson not to go well? *Follow up question:* • Have you ever set an interactive lesson? *If respondent answers "yes", ask the follow up questions below. If the respondent is not sure what an interactive lesson is, explain and then pose the following questions, after re-asking the previous question.* • What made the lesson interactive?

eason(s) why information is required	Justification for information required	Main questions	Follow-up situations or probe questions
			• How did learners respond to the lesson?
		9. What were the reasons you were not using computers in your lessons?	*If they seem unsure about what is being asked, rephrase as follows:* • Can you think of specific factors that would have made you less likely to use computers in your lessons?
		10. What would you say are the major factors affecting your use of computers for teaching your subject?	*If respondent has difficulty formulating an answer, the following prompt questions may be asked:* • What factors encourage you to use or to attempt to use computers in your lessons? • What factors discourage you from using or attempting to use computers in your lessons? *If necessary, probe:* – computer access, – lack of knowledge about what is available and how it can be used – time available – amount of technical support – suitability / quality of software the teacher uses

Appendix AU:

Sign test calculations for 19 tasks

Probability table for calculations

Difference	Probability of obtaining difference
0	0.000000002
1	0.000000054
2	0.000000756
3	0.000006806
4	0.000044240
5	0.000221198
6	0.000884794
7	0.002907179
8	0.007994743
9	0.018654400
10	0.037308801
11	0.064442474
12	0.096663712
13	0.126406392
14	0.144464448
15	0.144464448
16	0.126406392
17	0.096663712
18	0.064442474
19	0.037308801
20	0.018654400
21	0.007994743
22	0.002907179
23	0.000884794
24	0.000221198
25	0.000044240
26	0.000006806
27	0.000000756
28	0.000000054
29	0.000000002

	Type of use	Number of increases	Number of decreases	Number of zeroes	Number of positive changes	Number of negative changes	Two-tail *p*- value
Teacher use	completing administrative tasks	5	0	24	17	12	0.4583
	communicating with parents	6	0	23	17	11	0.3616
	communicating with colleagues	6	1	22	17	12	0.4583
	communicating with colleagues about teaching	8	1	20	18	11	0.2649
	communicating with learners	18	0	11	23	5	0.0014
	preparing worksheets	5	0	24	17	12	0.4583
	conducting Internet searches	8	0	21	18	10	0.2005
	creating basic *PowerPoints*	13	0	16	21	8	0.0241
	creating complex *PowerPoints*	10	1	18	19	10	0.1360
	using *PowerPoints* in lessons	12	1	16	20	9	0.0614
	posting work on Internet	21	0	8	25	4	0.0001
Learner use	consulting with appropriate people via the Internet	8	1	20	18	11	0.2649
	accessing reference material on the Internet	13	1	15	20	8	0.0428
	using drill-&-practice software	15	1	13	21	7	0.0161
	using subject-specific software for accessing content	13	0	16	21	8	0.0241
	playing basic educational games	11	0	18	20	9	0.0614
	using interactive subject-specific software	17	0	12	23	6	0.0023
	playing complex games	10	0	19	19	9	0.0987
	using simulations	10	0	19	19	9	0.0987

Appendix AV:

Sign test calculations for the changes in 19 tasks, for 26 teachers who showed changes

Probability table for calculations

Difference	Probability of obtaining difference
0	0.000001907
1	0.000036240
2	0.000326157
3	0.001848221
4	0.007392883
5	0.022178650
6	0.051750183
7	0.096107483
8	0.144161224
9	0.176197052
10	0.176197052
11	0.144161224
12	0.096107483
13	0.051750183
14	0.022178650
15	0.007392883
16	0.001848221
17	0.000326157
18	0.000036240
19	0.000001907

Teacher	Number of increases	Number of decreases	Number of zeroes	Numbe. of positive changes	Number of negative changes	Two-tail *p*-value
2	11	2	6	14	5	0.0636
3	6	0	13	12	6	0.2632
7	1	0	18	10	9	1.0000
15	1	0	18	10	9	1.0000
16	15	0	4	17	2	0.0007
17	17	0	2	18	1	0.0001
18	7	0	12	13	6	0.1671
19	16	0	3	17	1	0.0004
20	4	0	15	11	7	0.5034
21	6	0	13	12	6	0.2632
22	13	0	6	16	3	0.0044
23	1	0	18	10	9	1.0000
24	7	0	12	13	6	0.1671
25	16	0	3	17	1	0.0004
27	2	0	17	10	8	0.8238
29	5	0	14	12	7	0.3593
30	7	0	12	13	6	0.1671
32	3	0	16	11	8	0.6476
33	9	0	10	14	5	0.0636
34	17	0	2	18	1	0.0001
35	7	0	12	13	6	0.1671
36	7	5	7	10	8	0.8238
37	4	0	15	11	7	0.5034
38	12	0	7	15	3	0.0118
39	9	0	10	14	5	0.6476
40	6	0	13	12	6	0.2632

Appendix AW:

Scoring guide for lesson plans that use technology resources

Scoring Guide for Lesson Plans That Use Technology Resources

	5	4	3	2	1	0	Comments
Standards/ Learning Objectives	Curriculum standards and learning objectives are specific and focused, intentionally driving the use of technology.		Curriculum standards and learning objectives are correlated to technology uses.		Curriculum standards and learning objectives are superficial uses of technology.	No demonstration of curriculum standards and learning objectives connected to the use of technology.	
Curriculum Linking with Technology Uses	Curriculum linking creates unique content learning benefits. Content learning experiences/benefits are extended and would be impaired or impossible without the use of technology.		Curriculum linking adapts or varies present student learning or work. Content learning experiences or benefits are enhanced but possible without the use of technology.		Curriculum linking provides "topics" for technology skills or uses. Content learning incidental—student uses primarily to learn/practice technology skills.	Curriculum linking is incidental to technology use. Content learning not focused. Technology uses are mostly supplemental, or to provide fun/motivation activities.	
Cognitive Tasks	Task requires synthesis and evaluation of information. Going beyond existing understanding to create own original position or product. Knowledge creation is expected.		Task requires analysis of information and/or putting together information from several sources to demonstrate an understanding of existing knowledge.		Task requires little analysis and is focused on simplistic tasks or concepts using a single source. Cookie-cutter, look-alike products are likely to develop.	The task has little relevance to content learning.	
Assessment Practices	Student product assessed on content as well as the effective, appropriate use of technology to promote or communicate the learner's understanding. * Students designed assessment tools.		Assessment focused on technical aspects of student-produced materials. * Students are partners in designing assessment tools.		Assessment focused on completion of task or project * Students are informed or guided by an assessment tool designed by teacher	There is no evidence of assessment of student technology use	
Preparation for Learning Tasks	* Extensive preparation expected (i.e. story-boarding, web-mapping, outlining). * Students are expected to critically select appropriate resources.		* Adequate preparation is expected. * Teacher organizes multiple resources for students to use.		* At least one preparation task is expected. * A single resource is identified and assigned for student use.	* Preparation tasks are missing or weak. * No resource-gathering is identified or expected.	
Overall Focus of Technology Use	Technology uses primarily "Transforming." Task creates new learning stories with new tools.		Technology uses primarily "Integrating." Task creates same learning stories with new tools.		Technology uses primarily "Literacy." Task creates technology skill stories.	Technology uses are primarily organized as a peripheral activity at this time. Task creates no learning stories other than technology use.	