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Chapter 1: Introduction and orientation to the study

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1.1 Introduction

This study describes and documents the interaction between secondary school teachers and their context as they respond to multiple simultaneous changes in the school environment by innovating in their classroom practice, including innovating with information and communication technologies (ICTs). These interactions are described in terms of three critical processes: convergence, mutuality and extensiveness as defined by Sherry and Gibson (2005, p.6) which permeate the boundaries between different levels of a school system and are thus essential to the sustainability of innovations. This chapter will orientate the reader with regard to the study, starting with the background.

1.2 Background to the study

This section will describe five different but interlinked perspectives that constitute the background to the study and show how they inter-relate. These perspectives are what I have termed the educational-cultural perspective, the national policy perspective, the technology-transformation perspective, the school perspective and the researcher's perspective.

1.2.1 The educational-cultural perspective

Bruner (1996, pp.2-7) contrasts two opposing views of the mind. The computational approach sees the mind in terms of information processing, with distinctive inputs and outputs in which the flow of information supposes systematic outcomes. Culturalism, on the other hand, claims that the mind could not exist without culture, in that reality is "*represented by a symbolism shared by members of a cultural community in which a technical-social way of life is both organised and construed in terms of that symbolism".* Learning

and thinking are situated in this cultural setting. Culturalism has to do with hermeneutic meaning making whereas information processing is systematic. Culturalism asks about the *"enabling resources made available to people to cope"* … and is constantly *"concerned with constraints imposed on the process of education"* such as the organisation of schools and classrooms or teacher recruitment. Against this background Bruner (1996, p.67) describes the antinomies or contradictions that exist in education today. While it is the function of education to enable individuals to achieve their full potential its counterpart is that the function of education is to reproduce the culture that supports it to further economic, political and cultural ends. Bruner's arguments underlie the conundrum between the demands *for* ICTs and the demands *of* ICTs and set them within the cultural context of the school.

The demands for technology have seen schools worldwide investing in ICT infrastructure for almost two decades in response to the desire to equip students for today's global, collaborative and digital working environment. The demands of technology are that the affordances of ICTs will improve student, professional and organisational learning as well as assist in managing learning. However, such demands do not account for how each individual makes meaning or how a culture assimilates ICTs.

Sceptics such as Monke (1997, unpaged), Cuban (2001, p.132) and Oppenheimer (1997) highlighted the gulf between expectation and delivery of the value of ICTs in schools and brought the issues into the open. They criticised the wholesale introduction of ICTs into schools at great expense with little rational justification, and advocated instead evidence-based approaches to ICT implementation. Different ways of evaluating ICTs were explored by Means, Blando, Olson, Middleton, Morocco, Remz and Zorfass (1993); Roschelle, Pea, Hoadley, Gordin and Means (2000) and Windschitl (1998). Means *et al.* (1993, Ch.6b) cautioned that expectations of ICTs in transforming education could not be realised without a focus on the cultural aspects: curricular goals; compatibility with assessment; the need for teachers to collaborate; community involvement; and the need for ongoing pedagogical

as well as technical support. Roschelle *et al.* (2000, p.76) argued that, rather than focusing on effective ways of using technology resources, research should focus on understanding the mutual evolution of technological and pedagogical curricular innovations. Windschitl encapsulated this approach in his call for a new research focus:

> *'If the goal is to maximize the possibilities for student learning with technology, then a critical examination of the intersection of the affordances of information technology, pedagogy and learning is required"* (Windschitl 1998, p.28).

The question that arises from this perspective is how do schools assimilate ICTs into their culture and at the same time understand and implement the potential that they offer to both student and professional learning.

1.2.2 The national policy perspective

In South Africa since 1990 there have been simultaneous and ongoing national political and societal changes. Ensuing education policy changes culminated in the *Revised National Curriculum Statement* (DoE 2002) and resulted in a profoundly changed curriculum approach that has impacted every school and every teacher.

The most direct impact on South African teachers has been the series of curriculum changes under the new political dispensation since 1994. The draft *Curriculum 2001* became *Curriculum 2005* which was found to be too complex and resulted in the current *Revised National Curriculum Statement* (DoE 2002). Concurrent with curriculum development was the formulation of an ICT policy for education issued as *The Draft White Paper on e-Education* (DoE 2003). This ICT policy was influenced by South Africa's political and economic development, by curriculum change and by the rapid development of the Internet and digital technologies which all followed similar timelines since 1990. The *Draft White Paper* (2003, p.18) addresses four issues: to provide access to learning opportunities; to redress inequalities; to help improve the quality of learning and teaching; and to deliver lifelong learning.

The underlying belief was in the potential of ICTs to accommodate student differences in learning styles and remove barriers to learning by expanding opportunities and individualising learning experiences. According to the Draft Paper, in such a transformed environment there is a shift from "*teacher-centred, task-oriented, memory-based education (with technology at the periphery), to an inclusive and integrated practice where learners work collaboratively, develop shared practices, engage in meaningful contexts and develop creative thinking and problem-solving skills"* (Draft White Paper 2003, p.18). This paper has influenced the development or actions of various ICT initiatives in South African schools including, *inter alia*, SchoolNet, the NePAD initiative, Gauteng Online and the *Intel Teach to the Future* course as well as directly influencing individual schools.

Given the combination of radical curriculum change and approaches and the imperative to incorporate ICTs into schools the question arises of just how schools face this dual transformation and whether they are able to leverage mutual benefit from each.

1.2.3 The technology-transformation perspective

ICTs are commonly described as catalysts (Lemke & Coughlin 1998, p.15; Looi, Hung, Bopry & Koh 2004, p.92) which, if present, will lead to transformation of schools. In some cases they are even described as having the potential to revolutionise schools (Blasik, Williams, Johnson & Boegli 2003, p.44; Tearle 2003, p.579). Venezky & Davis (2002, p.10) counter the notion of ICTs as catalysts for transformation, arguing instead for ICTs as levers of transformation. They describe how a catalyst, in a chemical sense, speeds up a reaction whilst remaining unchanged itself, precipitating or causing a predicted change. ICTs, they argue, do not cause a predicted change. Their view is supported by Mehan, Hubbard and Stein (2005, p.353) who argue that the change brought about by introducing ICTs is not predictable, sometimes does not happen at all and may result in the opposite effect to what is intended as earlier research had shown. Instead, ICTs are

levers that can be applied to influence the *process* of change, but not the outcomes (Venezky & Davis 2002, p.10-14). Such leverage is one of many dynamic interactions in the complex system of a school and such unpredictability of outcomes is characteristic of complex systems (Davis & Sumara 2005, p.455). This notion of unpredictability is central to this study: if ICTs can influence process but not outcomes, it needs to be asked what those influences *are* and *how* they affect the process of change, and what the role of ICTs is relative to a specific context?

The problem of integration of ICTs does not necessarily arise from either the ICTs themselves or their implementation. The problem arises from the complexity of the learning environment in which they are intended to be implemented and in which they are expected to wield some degree of transformation in tandem with other transformation that is occurring. Transformation by its very nature implies sustainability: innovations that are not sustained, that do not become embedded, cannot transform either themselves or their environment. The challenge for a school is to maintain momentum in its transformation process on all fronts. For transformations to become embedded they need to be embraced and absorbed into classroom practice by teachers. However, there is no direct one-to-one correspondence between a policy decision to transform and the response of the teacher through altered practice. Rather, there are complex, contextual factors that affect a teacher's ability to change their practice. Each teacher is affected by and interacts with such contextual factors in a different way. What is required is an understanding of how teachers interact with these contextual factors and what role ICTs play in these interactions.

1.2.4 The school perspective

The school that is the case of this study is an independent boys' secondary school with a strong academic tradition situated in a South African urban area. The school operates in a complex partnership with a group of other schools with which it shares certain facilities, including its ICT network.

Major structural and policy changes have occurred in the school in response to the national political and curriculum changes as well as from following its own evolutionary path. The formal introduction of the new national OBE curriculum and its concomitant assessment requirements in Grade 8 (2004) and in Grade 10 (2006) was preceded by two years of experimentation by teachers in outcomes based learning strategies. This development saw the first collaborative attempts between departments, particularly between Science and Biology and between History and Geography which formed the basis of the two new Grade 8 and 9 learning areas of Natural Science and Human and Social Sciences respectively.

The introduction of the OBE curriculum was supported in 2001 by a fundamental policy change from exclusive practice, in which students were accepted into the school on academic merit alone, to inclusive practice in which each student was selected on his potential, including students with learning difficulties. From the start, the focus of inclusion was not only the small number of students with special educational needs, but the range of individual needs manifested by all students, requiring a differentiated approach to pedagogical practices. This policy change has been implemented in practice over the past eight years and has significantly influenced teaching practices, although the process is still ongoing. The change to inclusion was headed by a learning support specialist, specifically appointed to direct the process and with whom I collaborated significantly over the four years of her tenure.

Apart from inclusion (2000) and the change to OBE (2004) the school has faced various other inter-related transformation challenges: gender issues in amalgamating a monastic school into a partnership (1998); an extensive leadership and community service programme (2000) based on the notion of servant leadership[1]; a vertical house-based tutorial system in contrast to a horizontal grade-based system (1999); employment equity requirements and

[1] The term "Servant Leadership" was coined by Robert K. Greenleaf in *The Servant as Leader*, an essay first published in 1970. http://www.greenleaf.org/whatissl/

a strategic move towards greater diversity (2000). Apart from these ongoing transformations the post-1994 democratic changes in South Africa (1994) precipitated social adjustment impacting school culture, curricula and individual rights and the development of a formal transformation policy. Whilst some of these innovations involve ICTs, they are not dependent on ICTs, nor are they a result of the presence of ICTs. However, like ICTs, they are part of the many changes that have occurred in the last decade that have placed considerable demands on students, teachers and school management alike, impacting most aspects of school life and stirring debate that has tested the fundamentals of educational practice.

Adaptation to new curricula, the integration of ICTs, the adoption of inclusive principles into practice, the impact of gender equality and formal embracement of diversity are manifestations of the difference the school has tried to make in the face of multi-faceted change. Each teacher has had to try to understand and implement new ways of facilitating learning, to adapt to multiple simultaneous changes and to learn to collaborate with others. Each student has had to accept a degree of experimentation, to adapt to new ways of learning and contribute to the change process alongside teachers through reflection and interaction. The school as an organisation has had to adapt without ever losing sight of the fact that it must serve current students to the best of its ability and, as an independent school, the parents who pay for the education it provides. The context to which I refer is therefore the learning environment in which students, teachers and the school as an organisation are all learning as part of an ongoing and multi-faceted transformation process.

The school's adoption of ICTs began in the early 1980s and coincided with the building of a purpose-built new resource centre to replace the old single-room library, although the introduction of ICTs to the school and the development of the resource centre were not necessarily planned together. At first, a few Commodores were set up in a small processing room off the main library. At a later stage (c.1985) the lower floor of the resource centre was taken over by

a collection of stand-alone PCs (personal computers) which could accommodate a single class of approximately 25 students. The facility was then known as 'the computer room' and later as 'the lab'. When I arrived at the school in mid-1989, this facility was run on a part-time basis by mathematics teachers seconded to the role and was largely under-utilised. In 1991 I introduced a small Linux-based network of four computers to run the OPAC (Online Public Access Catalogue) and issue system. In 1993 the first stand-alone multi-media machine arrived in the library with the first CD-ROMs. Once a network manager was appointed in 1994 to introduce, *inter alia*, laptop technology, I observed the development of an extensive Windows-based network, early Internet and email access followed by fast bandwidth access for every student and teacher and a proliferation of ICTs in additional computer labs and, more recently, in classrooms. Throughout this development I became involved in supporting teachers and students from a curriculum point of view, but had no responsibility for technical support.

Whereas under-utilisation of the ICT lab facilities characterised the school's implementation of ICTs in the 1990s, much as it had done elsewhere (e.g. Kramer, Walker & Brill 2007, p.530; Tinio 2003, p.13; UNESCO 2004, p.75), this problem was gradually displaced by more complex problems. These now include a seemingly insatiable demand for ICT facilities and subject specific solutions; conflict with the mobile technology generation of students; rapid multi-media and social-networking developments of ICTs requiring complex and expensive upgrades, plagiarism controls and network security as well as diffusion of ICT integration across a larger student population, a new curriculum and more diverse teaching staff. The integration of ICTs in this school can therefore not be considered as an isolated area of study. It is necessary, in the detailed study of its particular context to determine the relative position of ICT integration against the complexity of the organisation. It is also necessary to understand the demands placed on teachers grappling with implementing the ongoing changes outlined above within the complexity of the context.

This school has not been selected as a case study because it is an example of ICT best-practice, but rather for its typicality in relation to similarly resourced schools (without benefaction) globally. Despite the considerable ICT infrastructure at the school, there has been no associated revolution[2] (Blasik *et al.* 2003, p.44; DfEE 1997, p.4) but rather a somewhat unsteady continuum of change in classroom practice with erratic rather than wholesale innovation. Primarily, the school provides a research opportunity because of the richness of the interactions resulting from the complexity of its transformation process and the depth of the data that can be drawn on. From a purely practical point of view, my familiarity with the school over a long period of time as well as the demands that the school makes on me, limiting time for contact with less accessible organisations, are also significant factors in the case selection.

1.2.5 The researcher's perspective

It is incumbent on a qualitative researcher to systematically reflect on how self affects the ongoing flow of everyday life and is affected by it (Rossman & Rallis 2003, p.10). It is therefore important to this study that my perspective as a participant-researcher is understood.

In my role as teacher-librarian at the school, I am an intermediary between students, teachers and the organisation on the one hand and information, resource materials and technology on the other hand. I have had the opportunity over my twenty-year tenure to work closely with school management, ICT administrators, teachers and students alike. I am responsible for anticipating, providing and supporting the resource needs of management, teachers, students and the wider curriculum of the school. In the library-as-classroom I am an observer, co-teacher or crutch in interactions between teachers and students on issues of technical support, differentiated learning design, and challenges to thinking as teachers and students alike

[2] *Revolution = any complete change of method or conditions etc; revolutionise = to alter a thing completely (Oxford Study Dictionary)*

grapple with new curricula, systems, concepts, technologies, challenges and approaches. I collaborate and co-teach with teachers in the design and integration of thinking and information skills. As an ICT innovator[3] I have been involved in the design of scaffolds, assessment formats, reporting structures and most recently, have introduced and begun implementing the *Moodle* online learning management system. I am therefore involved on a daily basis with the challenge of what works and what does not work. It is inevitable that through these interactions I have heard, contributed to and reflected upon the stories - the triumphs and the frustrations - of the individuals I have encountered.

This study developed out of these experiences at the school as well as informal reading and research on the nature of the implementation and integration of ICTs in the whole school context. As my reading progressed I realised, as other researchers have, that ICT integration is inextricably bound to curricular and organisational transformation and that an understanding of what is effective in the integration of ICTs would also require understanding the wider transformation context with which ICTs are intertwined. Reading deeper into these issues brought sharper focus to concepts such as student learning and understanding, information literacy, teacher beliefs and professional learning and what these meant in a transforming environment.

My formal research into ICT integration began in 2003 as an exploration of the relationship between the effective integration of ICTs and transformation in the secondary school. A link between effectiveness and evidence-based practice emerged from the search for definitions and links between ICT effectiveness and reform or transformation[4] became evident from the literature (Means *et al.*1993, Ch.Ia; Peck, Cuban & Kirkpatrick 2002, p.51; Roschelle *et al.* 2000, p.77; Windschitl 1998, p.28). The literature did not agree on the criteria for effective integration of ICTs and suggested that research still needed to

[3] Innovator/inventor as a level of ICT competency as identified by Dwyer, Ringstaff & Sandholtz (1991, p.49)
[4] The interpretations of 'reform' and 'transformation' are clarified in Chapter 2, Section 5.1, p.77.

establish such criteria (Finger, Jamieson-Proctor & Watson 2003, p.1; Pang, Kim and Kim c.2000, p.1). Therefore, as far as could be established, effective integration of ICTs into the curriculum relied on:

- the understanding of the learning environment and how effective student learning occurs
- the level and intensity for which teachers are prepared through professional development practices and support
- the links between policy and practice
- the configuration of the ICT infrastructure, appropriate classroom support and the role of management.

The 2003 study therefore explored a range of criteria that had not necessarily been identified as a unified range for the specific purpose and attempted to understand what relationships might exist between them. A preliminary analysis of the responses from teachers and management revealed *inter alia*:

- complex relationships between different contextual factors
- relationships between teacher perceptions of their own competency levels and their understanding of their students' competencies in using ICTs
- the effects of school structure and structures on teachers' ability to integrate ICTs and sustain innovative strategies.

Through the process of reading more deeply into the literature around ICT integration and teacher innovation the wider I discovered the field to be. It was important for me to peel away further layers to get to the core and relevance of the research problem. I felt also that it was important to remain open-minded in view of what might have been published in the interim. I deliberately reviewed the recent literature pertaining to ICT integration and transformation and allowed my thinking to take its course without revisiting, after a considerable time-lapse, the existing study. The existing study was then set aside.

The literature path emerged as a dynamic network with little linearity in which the concepts of ICT integration, curriculum development, transformation of the learning environment, teacher practices and context were interwoven with complexity theory and innovation theory, eventually drawing together the concepts of complexity, ICT integration, innovation and context. Of particular significance to me in this literature network has been the work of Windschitl on the intersection of the affordances of ICTs, pedagogy and learning (1998, p.12; Clarke, Bossange, Erb, Gibson, Nelligan, Spencer, and Sullivan (2000) on *The Dynamics of Change in High Schools* which led me into complexity; Sherry *et al.'s* work on innovation (Billig, Sherry & Havelock 2005; Sherry, Lawyer-Brook & Black 1997; Sherry & Gibson 2005); Hargreaves and Fullan on educational change (Fullan 2001; Giles & Hargreaves 2006; Hargreaves & Goodson 2006) and, more recently, Beetham and Sharpe (2007, p.7-8) on learning design in *Rethinking Pedagogy for a Digital Age*.

Questions raised by the literature interacted with my observations of day to day experiences: I was reading the literature through the lens of the practitioner and applying increasing amounts of theory to my thinking about practice. My challenge was to draw theory and practice together and this study is the response to that challenge.

1.2.6 Towards a research focus

The focus of this study evolved from the questions that arose from the consideration of the perspectives described above:

- **Educational-cultural perspective:** *The question that arises from this perspective is how do schools assimilate ICTs into their culture and at the same time understand and implement the potential that they offer to both student and professional learning.*
- **National policy perspective:** *Given the combination of radical curriculum change and approaches and the imperative to incorporate ICTs into schools the question arises of just how schools face this dual*

transformation and whether they are able to leverage mutual benefit from each.

- **Technology-transformation perspective:** *Rather, there are complex, contextual factors that affect a teacher's ability to change their practice. … What is required is an understanding of how teachers interact with these contextual factors and what role ICTs play in these interactions.*
- **School perspective:** *The integration of ICTs in this school can therefore not be considered as an isolated area of study. It is necessary, in the detailed study of its particular context to determine the relative position of ICT integration against the complexity of the organisation. It is also necessary to understand the demands placed on teachers grappling with implementing the continuum of changes outlined above within the complexity of the context.*
- **Researcher's perspective:** *How do I find a focus that draws theory and experience together?*

Distilling these multiple perspectives into a focus that encapsulates the essence of the problem has been an iterative and emergent process much like the complexity that it aspires to describe. How was I to adapt and maintain coherence of the problem and the process in the face of ever changing realisations (Davis & Sumara 2005, p.455)? Defining the problem and the questions that arise from it has been much like *'nailing jelly to a tree*[5]*.* The book of this title, coincidentally to do with computers, crossed my path within the first few days of my tenure at the school, but the phrase has remained cached in my memory ever since and captures aptly the challenges of zooming in on the essential. What was missing from the broader view was the teacher's perspective and hence my decision to focus on the teachers stories of how they innovate in the face of change and the relation of ICTs to their context. This focus is described in the next sections.

[5] Willis, J. & W. Danley (1981) Nailing jelly to a tree. Beaverton OR: Dilithium Press.

1.3 Statement of purpose

The purpose of this research is to explore and describe how teachers in a specific context innovate in the face of complex simultaneous changes and in particular how they innovate with ICTs in relation to that context.

1.4 Research problem and objectives

The research focus derived from the questions that emanate from the above perspectives is to establish how teachers are able (or unable) to innovate in practice and how they are able (or unable) to sustain innovative use of ICTs relative to demands for them to innovate across the multiple facets of complex changes within secondary schools. The research problem is therefore to understand the context of ICTs in teacher innovation in secondary schools. This research therefore explores the contextual interactions that affect innovation and ICT innovations in particular.

The problem is addressed by exploring how teachers innovate, including how they innovate with ICTs, in terms of the interactions that enable or inhibit the sustainability of their personal innovative practices and determining to what extent these interactions are context specific. The interactions are examined in terms of the three critical processes – convergence, mutuality and extensiveness – as defined by Sherry and Gibson (2005, p.6) and which derive from innovation theory.

However, this study is not limited to the positive convergence of resources that enable and sustain teacher personal innovations in the context, but also describes how negative factors converge to constrain such innovations. I have termed this convergence of negative factors 'disconvergence' and use the term 'convergence' in its positive sense. The interplay between convergent and disconvergent factors defines the context.

Case studies are studies of singularities (LeCompte & Preissle 1993, p.332). The objective of this research is therefore firstly to understand the singular,

unique case which is the focus of this study. Understanding the dynamics of sustaining innovations in the complex environment of a secondary school and particularly the role played by ICTs will benefit the school that is the focus of this contextual study and allow it to more effectively channel the uncertainty (Lissack 1999, p.120-121) that arises from complex interactions.

This study does not claim that the phenomena of this particular context are generalisable to other schools whether similar to this one or not; rather it will describe the effects of the context on teacher practice. All schools, and not only those in South Africa, face multiple complex global changes and there is a recognised need for research into context-specific factors (Breuleux 2001, p.7; Mumtaz 2000, p.335; Sherry 2002, p.211; Sikes 1999, p.x; Tearle 2004, p.347). The study may therefore be of interest to a wider audience in addressing these complex factors. In use, this study may be compared to other similar studies on contexts or the sustainability of ICTs in schools and thereby contribute to a wider purpose. The study may also be relevant locally in view of the expectations of delivery on outcomes of the rollout of ICTs to schools in parts of South Africa (Gauteng online[6]) and Africa (NePAD initiative[7]).

1.5 Research question

The research question derived from the above is:

> *How do teachers innovate in the face of complex, simultaneous and ongoing changes and, in particular, how do they innovate with ICTs amidst such changes?*

[6] Gauteng online is currently equipping each public school in the province with a 25-workstation computer laboratory to be used for curriculum delivery in order to attain the main outcome of the Government's White Paper: *"Every South African learner in the GET and FET bands will be ICT capable (that is, use ICTs confidently and creatively to help develop the skills and knowledge they need to achieve personal goals and to be full participants in the global community) by 2013."* http://www.gautengonline.com/pilot_project.htm

[7] 600 000 schools in Africa are to be connected via a satellite network *'in a bid to help schools produce maths and science whizz-kids'.* The e-School initiative of the New Partnership for Africa's Development (NePAD), aims 'to equip all African primary and secondary schools with information technology apparatus such as computers, and to connect them to the internet'. http://www.schoolnetafrica.net

This question was broken down into a number of sub-questions which evolved over time during the course of the research. The purpose of the sub-questions was to reveal the interplay of interactions. Given the dynamic and unpredictable nature of interactions within complex contexts, as these interactions emerged during the analysis stage, the relationships between the different terms used to describe the context influenced the questions in an iterative way. The sub-questions that finally emerged were:

- *How do organisational interactions influence teachers' ability to innovate and to sustain innovation in practice?*
- *How do collegial and professional interactions influence teachers' ability to innovate and to sustain innovation in practice?*
- *How do ICTs influence teachers' ability to innovate and to sustain innovation in practice?*
- *How do leadership interactions influence teachers' ability to innovate and to sustain innovation in practice?*

The study argues that by understanding the whole-school context, the relative role of ICTs in the secondary school can be better understood.

1.6 Scope and context of the study

The understanding of context from a teacher's point of view involves the interaction of policy and practice. Policy dictates the direction and detail of change, but does not account for how a teacher responds to that change. The teacher's response is at a personal level: how they[8] grapple with personal innovation and creative ideas to interpret and implement the requirements of policy, how they use available resources and how they collaborate with others to change and improve their practice. In order to understand these dynamics, this study draws on innovation theory (Ch. 2, Section 2.4, p.56) and complexity theory (Ch. 2, Section 2.6, p.88).

[8] For ease of reading this study will use 'they' and 'theirs' rather than 's/he' and 'his/hers' to imply gender equality when both are referred to.

This research was conducted between 2006 and 2009 in the independent boys' secondary school in South Africa in which the researcher is employed. The school first implemented computer technology in the early 1980s and currently has an extensive network serving computer laboratories, the resource centre, classrooms and management and administration services. Teachers are expected to be computer literate[9] and familiar with basic Microsoft applications, email and the school administration system. The school has a highly prescriptive policy on the purchase, management and control of access to both ICTs and to ICT-based information sources. On the other hand there is no specific policy regarding use of ICTs or the way ICTs are to be integrated into classroom practice, nor is there a policy on the further training or development of teachers in such use of ICT. At the same time, simultaneous changes are happening in the school requiring significant changes in teacher practices. This research therefore describes the relationship between teacher innovation, context and ICTs at a particular juncture in which multiple simultaneous educational changes were occurring through documenting the experiences of teachers. The next section will describe the methodology used to conduct the study.

1.7 Research methodology, design and process

This section will introduce the research methodology, design and the process that are described in detail in Chapter 3.

1.7.1 Research design

The overall research design is illustrated in Figure 3.2 (Chapter 3, Section 3.4, p.113) and outlined below.

1.7.2 Research approach

To describe the experiences of teachers in context I chose to use a naturalistic, qualitative approach based within the subjective-interpretive

[9] A requirement to this effect is included in the advertisements for all teaching posts

paradigm and conducted as a case study that seeks out specific phenomena. Qualitative research is appropriate to the description and interpretation of human experience (Cohen, Manion & Morrison *et al.* 2000, p.22) in which the voice of the participant rather than that of the researcher should come to the fore. I chose to use a case study design as, in the words of Nisbet and Watt (1984, p.78) and in keeping with complexity theory, a case study *"is more than the sum of its parts"*. Sturman describes a case study as *"the generic term for the investigation of individual, group or phenomena"* and explains:

> *"The distinguishing feature of a case study is the belief that human systems develop a characteristic wholeness or integrity and are not simply a loose collection of traits. As a consequence of this belief, case study researchers hold that to understand a case, to explain why things happen as they do, and to generalise or predict from a single example requires an in-depth investigation of the interdependencies of parts and of the patterns that emerge"* (Sturman 1994, p.61).

Qualitative case studies are appropriate to naturalistic, context-specific settings (Patton 2002, p.39) in which the researcher is involved and immersed (Golafshani 2003, p.600) and through interpretation retells the stories of the participants. The approach to this research is therefore from a post-modern point of view foregrounding socially constructed knowledge through a series of interviews and based on experience and insight of a personal nature. The study views the teachers, the organisation and the researcher as learners involved in the construction of knowledge.

1.7.3 Unit of analysis

The unit of analysis is a group of ten teachers and three members of the school leadership from Wilding[10] College who were interviewed in groups or individually. The group was determined by convenience sampling (Cohen *et*

[10] Wilding College: pseudonym for the school

al. 2000, p.103) due to the busyness of the teachers and the practicalities of finding common free time.

1.7.4 Data collection, transcription and analysis

Consistent with qualitative case studies this research employs multiple methods such as interviewing, observation and gathering documentary evidence in a systematic way (Rossman & Rallis 2003, p.179). Standardised open-ended interviews which allowed the voices of the teachers to come through were the primary format. These were supported by informal observation as well as documents that were used to verify data where or when necessary.

Teachers were interviewed singly or in pairs and the questions adjusted to accommodate their specific subject area. Interview data was recorded on video tape in order to obtain an accurate record of the teachers' stories and in order to note more closely the effects of body language, expression or gesture. I transcribed the interviews personally into a tabular format in a word document as part of my process of understanding what had been said.

Consistent with naturalistic research the analysis of the transcribed data employed inductive reasoning (Cohen *et al.* 2000, p.4). In the analysis phase I employed descriptive coding with each segment of data analysed and coded in detail. Codes were recorded in a table and assigned to a category within a broad area or recurring theme and refined throughout the process of analysis. These categories and broad themes were used to describe the findings. To retain the cohesiveness of each teacher's story in writing up the findings, I organised them by interview and then by theme using the selective approach (van Manen 1990, p.79) for formulating analytic statements. These statements were illustrated by graphics in order to compare the different dynamics relevant to each subject area that each teacher represented. Similarities and comparisons were drawn using the themes derived from the codes.

1.7.5 Trustworthiness

Issues of reliability and validity are viewed in terms of the social and linguistic construction of reality rather than a positivist view of knowledge as a map of an objective reality (Kvale 2002, p.300). These issues are therefore dealt with in terms of the post-modern view of trustworthiness replacing the traditional view of validity and reliability. Trustworthiness incorporates integrity, honesty, authenticity, dependability, accuracy, balance and appropriateness. Such trustworthiness is assessed by how well the study conforms to standards for acceptable and competent practice and whether it meets standards for ethical conduct with sensitivity.

1.8 Ethical considerations

Ethical considerations are closely tied to matters of trustworthiness. This study has been conducted in terms of the school research policy, the university's ethic's policy and individual rights to privacy, reflected in the as ethical clearance certificate (Appendix 1.2). Teachers were invited to participate, assured of anonymity as far as possible and signed agreements in terms of the principles of informed consent. Respondent checks were used for the transcriptions and preliminary findings.

1.9 Limitations

Common limitations of case studies are that results may not be generalisable, it is difficult to cross check for data selectivity or bias and that, as it involves the researcher as a participant in the process, the interpretations will always be subjective (Nisbet & Watt 1984, p.76).

This study does not centralise ICTs but focuses on the context in which they are integrated. It is not a longitudinal study, but looks instead at a transverse period in time although my interpretation is influenced by the period of time I have spent in the context. This study does not claim generalisation to the full context, rather it shows how the combination of factors affects each individual in a unique way. The school is not a typical South African school, but many of

the issues that it grapples with are typical. It is typical of schools with an accessible ICT infrastructure necessary to this study.

1.10 Literature control

A comprehensive literature study was undertaken prior to and as part of this study. Literature on the theoretical concepts of complexity and innovation as well as that on ICT integration was pursued in depth in order to identify the focus of the research topic. This study responds to calls for further research into the context of ICT use such as that of Windschitl (1998) and others identified in 1.4 above. Further literature was sought out where necessary to elucidate issues around factors raised by the teachers.

1.11 Definition of key concepts

The following definitions of key concepts are used in this study:

Table 1.1: Definition of Key Concepts

Concept	Explanation	Further reference
Complexity theory	Understanding of the interaction of parts rather than of the parts themselves.	Chapter 2, Section 2.6, p.88
Convergence	In its literal sense, convergence means to come to the same point. As a critical process in innovation it implies the same. Convergent factors are those that align or come to a point with a positive effect.	Chapter 2, Section 2.5.2 p.84
Disconvergence	Disconvergent factors are those that come to a point or align with a negative effect on innovation.	
Extensiveness	Extensiveness refers to the extent to which an innovation reaches across all levels of a school system	Chapter 2, Section 2.5.2 p.84
Generative use of ICTs (c.f. representational use of ICTs)	Using ICTs to construct new ideas e.g. note-taking to restructure or synthesise rather than to record.	Hokanson & Hooper (2000, p.544, Table 1)

Concept	Explanation	Further reference
ICTs	Information and Communication Technology: "*ICT is the combination of networks, hardware and software as well as the means of communication, collaboration and engagement that enable the processing, management and exchange of data, information and knowledge"* (DoE 2003, p.16).	Chapter 2, Section 2.3.1, p.34
Innovation • **Product innovation** • **Process innovation**	Innovation is the introduction of something new that is intended to be useful. To implement a product innovation requires a paradigm shift while process innovation involves modifications of existing processes (Whitehurst 2009)	Chapter 2, Section 2.4, p.56
(the) Leadership	The principal and deputies at the school	
Learners and students:	'Learner' is a term that has arrived with the new curriculum. However as the teachers in the interviews still referred mostly to students than learners, the term 'students' is preferred in this study. Where the term learner occurs in a quote, it is retained. The term student also reads more comfortably as e.g. in 'student learning' as opposed to 'learner learning'.	
Learning environment	The classroom and wider school environment and what it offers.	
Mutuality	Mutuality refers to the need for a common benefit of the innovation to either side of a boundary.	Chapter 2, Section 2.5.2, p.84
Participant researcher	A researcher that is part of the context that is the focus of the research; an insider.	
Professional development	Development of the individual, not necessarily core task-related, more to do with values and attitudes.	

Concept	Explanation	Further reference
Professional learning	Teacher learning that occurs on the job or that is specifically designed to enable the core processes of the job.	Chapter 2, Section 2.4.4, p.69
Representational use of ICTs (c.f. Generative use of ICTs)	Automation of standard procedures e.g. email, calculation, looking at images c.f. creating images or websites, problem-solving through collecting and analysing data.	Chapter 2, Section 2.3.1, p.35. See: Hokanson & Hooper (2000, p.544, Table 1)
Secondary school	Grades 8-12; also known as high school; the phase between primary and tertiary education.	
Students	see learners	
Teacher librarian	The teaching/academic role of the librarian in the school as opposed to the administrative role.	see Appendix 1.1 for description of the role.
Teacher	The person with responsibility for student learning. Used in this study to imply all aspects of the role, including facilitation.	
Transformation	Desired condition as a result of change processes in policy and practice.	Chapter 2, Section 2.5, p.78

1.12 Outline of the study

This study consists of the following Chapters:

Chapter 1: Introduction and orientation to the study

Chapter 1 has provided a general introduction to the study. The background has been described from differing perspectives and illustrates the derivation of the research question. An orientation is provided to the methodology and design of the study and includes definitions of key concepts.

Chapter 2: Review of the literature and conceptual framework

This chapter provides an overview of the literature. It shows how the conceptual framework derives from the broader literature on ICTs and the theoretical literature on complexity and innovation.

Chapter 3: Research methodology, design and process

In this chapter the research methodology, design and process are explained and described in detail. Included are descriptions of how issues of trustworthiness (validity and reliability), ethical issues and the limitations of the study were dealt with.

Chapter 4: Findings: Organisational interactions and their effect on teachers' practice

The chapter looks specifically at interactions between mandated changes and teachers' ability to innovate in practice in the face of mandated changes, seeking evidence of convergence or disconvergence. The chapter introduces the school and the main themes identified in the analysis of data, and then describe the effect of mandated changes on teachers' ability to innovate.

Chapter 5: Findings: Collegial and professional interactions and their effect on teachers' practice

This chapter describes the collegial and professional interactions at Wilding College and their effect on teachers' ability to innovate, seeking evidence of mutuality. The chapter provides a brief overview of professional learning communities; describes the formal networking structures to which the school is linked and describes the collegial and professional relationships as a theme that emerged from the interview data.

Chapter 6: Findings: ICT interactions and their effect on teachers' ability to innovate

Against the background provided in the previous two chapters, this chapter describes how the presence of ICTs affects teachers' ability to innovate.

Chapter 7: Findings: School leadership and its effect on teachers' ability to innovate

This chapter describes the perspective of the school leadership on interactions that enable or inhibit innovation and the integration of ICTs.

Convergent and disconvergent interactions in the relationship between teachers and the school leadership are described.

Chapter 8: Discussion of the findings; conclusions and recommendations

This chapter draws together and compares findings of Chapters 4-7 with the views expressed in the literature. Conclusions are drawn and recommendations made.

1.13 Summary of Chapter 1

This chapter has provided a general introduction and outline to the study. The background has been described from differing perspectives and shows how the research question is derived from these. The justification for the naturalistic qualitative approach using a case study methodology within a subjective-interpretive paradigm is outlined. The design and process of the study as well as issues of trustworthiness, ethical issues and limitations of the study are outlined. The following chapter will review the literature relevant to this study and show the derivation of the conceptual framework.

Contents

Chapter 2: Review of the literature and conceptual framework

Chapter 2

Review of the literature and conceptual framework

2.1 Introduction

This chapter will review and draw together the literature relating to the integration of ICTs in secondary schools in relation to innovation in and transformation of whole school contexts. The review will show the complexity of contextual interactions that enable or inhibit teacher innovations, including innovations with ICTs, as identified in the literature. The review will also define and describe the concepts associated with ICT integration and innovation and show their inter-relationships as illustrated in Figure 2.1. The chapter will conclude by showing how the development of the conceptual framework derives from the literature and guides the study.

The literature search evolved from an initial exploration of the relationship between the concepts of 'integration of ICTs into the curriculum' and 'transformation of the learning environment' in secondary schools. Initial reading revealed the link between the two concepts and the fact that one could not be described without reference to the other, recognising their interdependence. Further and deeper examination of the literature indicated that the relationship between these two concepts is further complicated by other factors within the immediate or classroom environment, the school environment, and the national, educational and global environments. Recent research on either or both of the two concepts refers to complex contexts, complexity or the application of complexity theory in understanding the current secondary school environment in which ICTs are being or attempting to be integrated. The focus of the literature search therefore shifted from only that of the relationship between the two concepts within secondary schools to that of the relationship specifically within secondary school environments as manifestations of complexity. Secondly, the path of research on ICTs leads

into the study of innovation and innovation theory which itself is closely tied to complexity theory.

This review will begin with the literature on ICT integration and show the development of the conceptual pathway from ICT integration to innovation theory and then to complexity theory.

2.2 Searching the literature

The initial general reading for this study was conducted largely through web searches using Google scholar and its citation feature to identify journal articles, conference presentations of research and research reports that covered one or more aspects of ICT integration and transformation. An in-depth approach then followed to locate more recent research articles published between 2003 and 2006 using the Academic Search Premier (ASP) and ERIC databases. Using Boolean operators, the following combinations of search terms and their semantic alternatives were employed:

Table 2.1: Literature search terms

ICTs (information and communication technology/ies)/computers/technology	and	reform/ transformation
ICTs (information and communication technology/ies)/computers/technology	and	secondary/ high schools
ICTs (information and communication technology/ies)/computers/technology	and	integration/implementation
ICTs (information and communication technology/ies)/computers/technology	and	innovation/sustainability of innovation
innovation/sustainability of innovation	and	secondary/high schools
secondary/high schools	and	reform/ transformation
innovation/sustainability of innovation	and	complexity theory

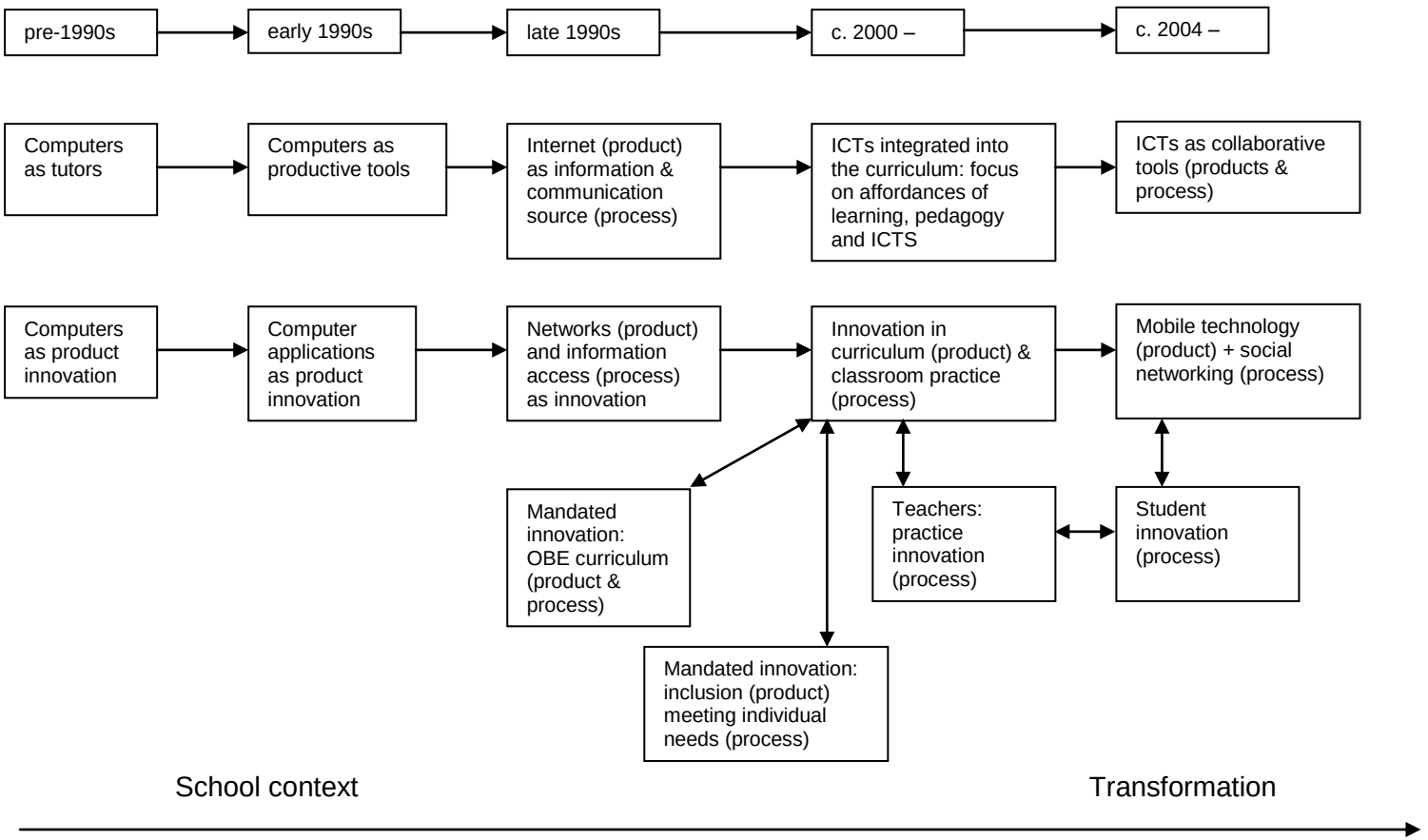


Figure 2.1: Relationship between ICTs and innovation

The search was also broadened by combining 'schools' and related key terms (see Appendix 2.1) and narrowed to specific topics using combinations of concept or aspect keywords. The searches on these terms and their combinations resulted in a collection of abstracts which were scanned for appropriateness and rejected or downloaded electronically. More recent and therefore embargoed issues of journals that could not be accessed electronically were accessed in printed format from the University Academic Information Service. The considerable collection of books available in the university library was also consulted, particularly for the methodology.

Citations that led deeper into the post-2000 literature were followed where appropriate. Such citations led not only to articles but also to an ever-expanding range of journals that cover the broad topic of ICTs in education. Apart from consulting the cited articles directly, certain cited journals were accessed by title and followed backwards from 2006 to 2000 to identify relevant articles. This returned a further large number of articles which had not been netted by the original search. This discrepancy is attributed to the fact that any search is dependent on the human factor as well as nuances and inconsistencies in allocating keywords by the indexer. By following the broad path from the citations, the extent of the field was more evident than by narrowing the search from citations only. Owing to the number and variety of journals that cover the field of technology and ICTs in education there may be omissions. However, this divergent field provides an extensive and lively range of research while at the same time hampering the search for convergent findings (Lagrange, Artigue, Laborde & Trouche 2001, p.3).

In each article research issues were identified and tabulated in a format that could be manipulated to create links between related issues in different articles. This review therefore synthesises recent literature with reference made to earlier work (articles and books) only where such works provide the origin, or enhance the definition, clarity or context of a concept.

Ex post facto reading to keep abreast of the literature has been maintained throughout the course of this study, not on a systematic basis but as part of my role as an intermediary between the school as an organisation and information sources. Where relevant articles were sourced by this means they have been interwoven into the narrative of this chapter, some as recently as June 2009. As a study of the broader context the range of literature is extremely broad. However, in some instances, literature relating to specific factors that have come to light in the findings (e.g. use of mobile technology, leadership approaches) has been targeted to gain a clearer understanding of their implications.

2.2.1 Recently completed research in the field

A search of the Scirus ETD database for 2000-2006 revealed over 11,000 theses and dissertations mentioning instructional technology in their abstracts, indicating the immense interest in the field of ICTs. This number was reduced by limiting the search to those abstracts containing the words 'secondary schools' and 'contexts', but the number reduced only to some 8,000 studies. Many of these dealt with specific aspects of instructional technology such as teachers' conceptions of learning, contexts such as rural schools, subject areas such as mathematics or roles such as that of technology teachers. Reducing the search to those which included the word 'context' in the title indicated three studies, none of which were relevant to the effect of context on teachers in school situations. The single study that appeared to be highly relevant was that of Chen (2006) entitled *"Investigating the Influences of Teacher Belief and Contextual Factors on the Technology Integration of Taiwanese High School Teachers"*. Chen used a qualitative approach to investigate the beliefs of 10 Taiwanese teachers.

Chen's approach (p.157) was based on Zhao, Pugh, Sheldon and Byer's contention (2002, p.484) that the innumerable studies on contextual factors that affect teachers ability to integrate ICTs are limited in that they do not identify the characteristics of such factors, their applied contexts and the

relationship amongst the factors. Chen therefore investigated the effect of such factors on teacher beliefs *and* [my italics] technology integration. Chen's findings indicated that teachers need opportunities to investigate their own beliefs and practices and to explore new instructional strategies with ICTs in order to improve teaching and learning.

This study differs from that of Chen in three ways. Firstly it explores how the different contextual factors, *including* teacher beliefs interact, specifically seeking evidence of convergence, mutuality and extensiveness amongst the interactions. Secondly, it looks at how these interactions affect teachers' ability to innovate with ICTs within the context. Lastly, the contexts of a Taiwanese public school and an independent school in South Africa are different. However, the two studies will together contribute to a knowledge base on contextual factors and ICT integration.

A study found to have some relevance to the topic of innovation and ICTs was that of Thomas (2006). However, he took a retrospective approach, examining the problems associated with a specific large-scale implementation project at provincial level in South Africa.

Another study is the mini-dissertation of Morgan (2001), a quantitative study that investigated the integration of computers in a South African secondary school from the technology perspective. The purpose of her study was an attempt to discover "*if the implementation of CAE*[1] *was feasible and even desirable in the South African context through an investigation and description of a working CAE programme in an ideal South African school situation*".

Morgan found that integration at the school was successful at levels of school policy, provision of technology resources and positive attitudes of teachers and learners. She recommended increasing IT staff in order to increase teacher training in methods of integrating ICTs into the curriculum and

[1] CAE = Computer Assisted Education, similar to CAI or CBI using computers as a direct means of delivering curriculum (e-learning).

providing teachers with incentives for reskilling. However, although Morgan initially presumed the school situation to be ideal, she had limited access to the school, did not receive the co-operation of the principal and intended the study as a *"summative evaluation not intended to change the practice or contribute to the development of the already implemented program".*

2.3 The integration of ICTs into the curriculum

This review will first address the literature on ICT integration followed by that on complexity and innovation as this sequence traces the pathway followed through the literature. However, the body of literature is not linear; instead it forms a network or web of inter-related connections. This review has therefore been structured in an attempt to show these interconnections.

The review follows a broadly chronological path in order to demonstrate the evolution of the concepts, the formation and clarity of their definition and their implications and interdependence. Embedded in the chronological approach are references to the types of research (meta-analysis, individual case studies etc) and the foci of research (organisations, schools, teachers and ICTs) used to understand the concepts.

2.3.1 ICT terminology

Terminology used to refer to the use of computers and related technologies in schools has changed along with the rapid evolution of such technologies. The terms 'ICTs' and 'integration' therefore require elucidation. Earlier studies referred to the hardware as 'computers' and sometimes inferred the use of computers by the broader term 'technology'. With the proliferation of networked access and peripherals in schools from the mid 1990s the term 'information and communication technologies' or ICTs evolved to incorporate the communication aspect that Internet connectivity, email and multi-media provided. ICTs became the accepted term in general use in Australia (Kearns & Grant 2002), the UK (OFSTED 2003) and Canada (BCED 2002). However ICTs, although commonly accepted, is not a universal term (Finger *et al.*

2003, p.2). The USA based International Society for Technology in Education (ISTE 2002) prefers the term ECT (educational computing and technology). In South Africa 'ICTs' is used in both the Draft e-Education White Paper (DoE 2003) and the SITES[2] report on South Africa (Howie, Muller & Patterson 2005, p.xi). The Draft White Paper defines ICT as follows:

> "[ICT is] *the convergence of information technology and communication technology. ICT is the combination of networks, hardware and software as well as the means of communication, collaboration and engagement that enable the processing, management and exchange of data, information and knowledge" (*DoE 2003, p.16).

This study uses the parameters of this definition of ICTs to mean both the hardware and the means it provides.

Similarly, as the focus shifted from computers to the pedagogical aspects, terms such as 'computer-assisted instruction' (CAI) or 'computer based instruction' (CBI) (Alessi & Trollip 2001, p.4) were displaced by references to the 'integration of ICTs into the curriculum'. The integration of ICTs in schools is a wide field with many interpretations of both terminology and intent (Finger *et al.* 2003, p.6). 'Integration' is defined as the combining or formation of constituent parts into a whole (Oxford Study Dictionary[3]). For ICTs, this definition suggests that to integrate ICTs they are not seen as a separate entity alongside other curricula components, but become a constituent part of the curricula components themselves. However, a theoretical definition does not imply consistency of application or understanding of the concept in practice. Integration differs from implementation which is defined as the process of putting into effect (OSD). Fullan (2001, p.69) describes implementation as *"the process of putting into practice an idea, program or set of activities and structures new to the people attempting or expected to*

[2] SITES = Second Information Technology in Education Study
[3] Oxford Study Dictionary will be referred to as OSD.

change". Implementation is therefore taken to mean the more physical aspects of introducing and putting into effect of computers although, as interpreted by Tearle, implementation can include integration as described in her words *"implementation into working practice"* (2003, p.579). Richardson (2000, p.3) uses both implementation and integration interchangeably. Other terms used in the context include infusion (Akbaba-Altun 2006, p.186; DoE 2003, p.16; Lan, He, Ouyang, Zhonghai & Bao 2000; Peck *et al*. 2002, p.472), diffusion (Venezky 2004, p.3), uptake (Cox, Preston & Cox 1999); assimilation (Mioduser, Nachmias, Tubin & Forkosh-Baruch 2003, p.23); and penetration (Anderson & Becker 2001, p.13). Sometimes these terms are used exclusively but are often used interchangeably with integration. Tearle suggests that the meaning of such terminology be scrutinised through further research (Tearle 2003, p.279).

Brackett (2000, p.3) defines ICT integration in the context of practice, distinguishing between functional, integrative and transformative practice. "*Functional practice"* or reproductive learning uses representational ICT tools to enhance students' learning outcomes and automate traditional classroom processes. "*Integrative practice"* is an integral component of broader curricular reforms, which changes not only *how* students learn but *what* they learn, including the development and redrafting of ICT artefacts. "*Transformative practice"* is doing things that would be impossible without harnessing the affordances of ICTs (Brackett 2000, p.30). In transformative practice ICTs become an integral component of the transformation of the school structure and organisation (Bialobrzeska & Cohen 2005, p.32; Finger *et al.* 2003, p.3; Fluck 2004, p.6; Rodrigo 2003, p.95; Yuen, Law & Wong 2003, p.166). For the purposes of this study 'integration' is understood to refer to ICTs as an integral part of curricular use and teachers' working practice.

The terms interaction/s[4], innovation/s, change/transformation/reform and complexity were found to be recurring in the literature relating to ICT integration and the question of the relationship between these concepts arose. However, these terms relate more logically to the theoretical aspects and are therefore included in the sections on innovation theory (p. 56) and complexity theory (p. 87) from which the conceptual framework is derived.

Having established a working definition of the concept of ICT integration this review will now investigate the literature pertaining to ICT integration considering firstly, developments in the 20th Century and then in the 21st Century borrowing from Brackett's terminology of functional, integrative and transformative practice.

2.3.2 The 20th Century: Functional practice

The use of computers in classrooms in the 20th Century was characterised by functional or reproductive learning uses to automate traditional classroom processes. Research reports on the use of computer-based technologies in education began appearing in the 1970s (Fouts 2000, p.*i*) although Coulson had published a report entitled *Computer-based instruction* in 1968, presupposing the use of computers in education by that time. The computer was first perceived as a technological product innovation and education attempted to harness its power to calculate and process. Earliest reports focused on the use of computers as tutors or surrogate teachers (Fouts 2000, p.*i*) by automating learning processes in a mechanical way. Research in the 1980s and early 1990s on the use of ICTs in schools focused on quantitative analyses (e.g. Lazarowitz & Huppert 1993) and meta-analyses (e.g. Kulik & Kulik 1991) of computer-assisted instruction intended to prove that the use of computers increased student achievement levels in contrast to traditional methods of performing similar tasks. Later reports focused on student use of computers as tools (word processing, spreadsheets etc) to automate traditional productive learning processes (Fouts 2000, p.*i*). With the advent of

[4] Interact = 'to have an effect on each other' (OED)

email and the Internet in schools from the mid-1990s computers provided potential access to unlimited resources and communication with fellow students as well as practitioners in all fields, supporting constructivist approaches to student-centred learning in contrast to instructivist teaching with behaviourist expectations (Hokanson & Hooper 2000, p.543).

The earliest questioning of the value of educational computing appears to date back to Hyer (c.1960 cited in Counts 2004, p.59). More recent sceptics such as Monke (1997), Peck, Cuban and Kirkpatrick (1986), Cuban (2001) and Oppenheimer (1997) highlighted the gulf between expectation and delivery of the value of ICTs in schools and brought the issues into the open. Whilst such sceptics were not against ICTs per se, they criticised the wholesale introduction of ICTs into schools at great expense with little rational justification, advocating instead evidence-based approaches to ICT implementation (Cuban 2001, p.150-151; Monke 2007, p.9; Peck, Cuban & Kirkpatrick 1986, p.54; Oppenheimer 1997, p.1).

Different ways of evaluating ICTs were explored by Means *et al.* (1993); Roschelle *et al.* (1999) and Windschitl (1998). A national study was conducted on behalf of the United States Department of Education by Means *et al.* (1993) on the relationship between technology and education reform. They identified many different projects that provided challenging instruction promoting collaborative involvement in authentic multidisciplinary tasks. Their recommendations (1993, Ch.VIb) focused on curricular goals, compatibility with assessment, the need for teachers to collaborate, community involvement and the need for ongoing pedagogical as well as technical support. They also highlighted the role of business (1993, Ch.6c) in providing technology to schools, but cautioned that such provision did not ensure that transformation using technology happened. Means *et al.* (1993, Ch.VIa) concluded, however, that ICTs fail in many instances as instruments for transforming schools because of the ways in which they are implemented: either by adaptation to traditional teaching methods or because they are

confined to inaccessible laboratories, attributing the failure to inflexibility of traditional school structures. Rather than focusing on effective ways of using technology resources, research should focus on understanding the mutual evolution of technological and pedagogical curricular innovations (Roschelle *et al.* 2000, p.10). This approach was encapsulated in a call for a new research focus:

> *"If the goal is to maximize the possibilities for student learning with technology, then a critical examination of the intersection of the affordances of information technology, pedagogy and learning is required"*. (Windschitl 1998, p.28)

In the 1990s large scale projects such as the Apple Computers of Tomorrow (ACOT) (Dwyer 1994); Centre for Applied Special Technology (CAST 1996) and the Software Information Industry Association series of studies (SIIA 2000) led the way to different approaches to ICT use and subsequent research, but these were largely studies funded by businesses that provided the technology and training to a small sector of schools to specifically enable integration or ICT use. While these studies were valuable in gaining an understanding of the potential of ICT integration, they did not account for the challenges that the majority of unsupported schools face in integrating ICTs.

A comprehensive study of teaching, learning and computing concluded that teachers' philosophy and practice impacted their use of the Internet for teaching and learning (Becker 1999 cited in Ravitz, Becker & Wong 2000, p.55). In a further analysis of the same data reported on by Becker (2001), the validity of large scale surveys is questioned. Becker (2001, p.26) concludes that:

> *"Large-scale surveys of teachers, such as the one providing data for this analysis, can only provide suggestions about the kinds of forces that lead teachers to use resources like computer technology to*

different extents and in different ways. The numerical precision of these descriptions and analyses should not be mistaken for certitude."

Similar doubts on studies of the use of computers in education were cast by Fouts (2000, p.29). He describes these studies as generally non-experimental, ex post facto in design and reliant on *"various multivariate statistical analyses in an attempt to control for confounding variables to isolate the technology variable",* and traditional measures of achievement. According to Fouts, in some studies the increase of computers and related technology is also coupled with a wide range of other school reforms that makes it very difficult, if not impossible, to isolate the technology component to imply any type of cause and effect relationship.

Both Becker and Fouts are sceptical of surveys and statistical analyses in understanding the pedagogical challenges that teachers face. If the outcomes of such approaches could *"not be mistaken for certitude"* then what approaches could be used to determine the challenges that teachers face? While there was a plethora of significant research reported on extensively in academic journals, in commissioned reports, in professional journals, at conferences and in the popular press, there was no agreement on either the effectiveness of ICT use in schools or on the validity of the research itself. The argument was against research that isolated ICTs from their contexts.

The 20th Century was therefore largely characterised by functional use of computers. Research studies focused on means of recording small improvements in student learning targets that were anticipated to arise from the automation of traditional learning practices. However, the limitations of this were already being recognised towards the mid 1990s at which stage the focus started shifting towards more integrated practice and an emphasis on the pedagogical aspects of ICT use.

2.3.3 The 21st Century: Towards integrative practice

Integrative practice is an integral component of broader curricular reforms, which changes not only *how* students learn but *what* they learn, including the development and redrafting of ICT artefacts (Brackett 2000, p.30).

Prior to the Millennium there was acknowledgement of the necessity to focus on pedagogy and educational goals rather than the technology itself. Teachers were commonly aware of the imperative to be technologically literate, but insufficient resources were being allocated to the pedagogical needs of integrative practice. Anderson and Becker (2001, p.3) revealed the disparity between spending on ICT hardware and spending on the support of teachers in using ICTs in the classroom: only 20% was allocated to support, 7% to software and the rest to hardware. They concluded that, without concomitant spending on support, technology purchases would go largely unused. However, Anderson and Becker measured support in terms of expenditure on technology support staff and not on other forms of investment in teacher development such as release time for planning new approaches. Spector (2001, p.7) suggests similarly that problems associated with lack of training and preparation are sidelined by demands to acquire and implement new technologies, identifying short-sighted policy and planning as the underlying cause of such problems. Without training in the pedagogical aspects of using ICTs as well as the potential that ICT applications could offer, teachers continued to perceive and use ICTs in traditional ways.

Following his research on schools in Silicon Valley, Cuban argued that the majority of teachers still used ICTs to "*sustain existing patterns of education, rather than to innovate"* (2001, p.134) and that the promise of fundamental change through the integration of ICTs had not been realised (Peck, Cuban & Kirkpatrick 2002, p.478). In an effort to contextualise the use of technology appropriately, Roschelle *et al.* (2000, p.76) called for the focus to shift from computers to the *how* and *what* of student learning with computers. They identified twenty-one major studies on the effectiveness of computers as learning tools. From these studies Roschelle *et al.* (2000, p.90) identified

challenges to implementation such as the need for appropriate teacher support, curriculum modernisation, student evaluation and assessment and capacity for change. However, of the twenty one studies, five assessed gains in student learning from kindergarten to high school and only one study dealt with secondary schools specifically and then only with science process skills.

Other factors identified from recent literature that affect ICT integration are teacher beliefs and attitudes, teacher demographics, systemic and physical constraints, the degree of involvement of school leadership, formality of structures and socio-cultural dimensions.

Amongst those that have written on teacher beliefs and their effect on the integration of ICTs are Albion (2003); Hennessy, Ruthven and Brindley (2005) and Otto and Albion (2002). Teacher beliefs are dependent on a variety of factors: some are external, others are internal.

Age is a significant factor in teacher attitudes towards ICTs Albion (2003, p.2). Albion borrows Prensky's (2001, p.1) terminology that distinguishes between *"natives"* or the student generation born into the age of ICTs and *"immigrants"*, those teachers who have had to adapt to the presence of ICTs and may or may not eventually feel at home with them. Albion's research compared beliefs of graduating teacher education students in both 1991 and 2002 and concluded (2003, p.7) that young graduating teachers in 2002 rated their comfort with using ICTs much higher than the earlier group. However, as revealed by an Australian government study (Senate Employment Education and Training References Committee 1998; Ewing 2003, p.30); the average age of Australian teachers was above 46, which means that a significant percentage were unlikely to have had exposure to computer use as students. Similar demographic patterns characterise the teaching fraternity elsewhere, including South Africa (Peltzer *et al.* 2005, p.63). If practicing teachers' pre-service exposure to ICTs is limited to younger graduates, then their exposure

to all other transformation practices is likely to be similar. However, there is a contradiction in age factors in that the baby boomer[5] generation of teachers is:

> *"… in general numerically dominant and often most politically influential group in their schools throughout their careers. They were formidable forces of change and also, especially later, of resistance to it"* (Hargreaves & Goodson 2006, p.24).

It could be argued from such demographic patterns that exposure to ICTs at a pre-service age is a critical factor in determining teacher competency in using ICTs which might then affect their ability or willingness to integrate ICTs into the curriculum. However, Peck, Cuban and Kirkpatrick (2002, p.478) showed in their Silicon Valley studies that this is not the case and that in fact a high percentage of teachers are competent users irrespective of age. Instead they identify structures that limit collaborative cross-pollination of innovative ideas: access only to laboratory models of ICT use, time constraints resulting from both teacher workload and timetabling, technology defects and unsupportive assistance patterns as well as competing educational priorities. In a similar UK study conducted over a range of schools, Hennessy *et al.* investigated "*teachers' perceptions of the contribution made by using ICT, its impact on subject pedagogies, and the extent to which ICT is integrated into classroom practice in these areas"* (2005, p.166). Opportunistic access to computer labs, lack of reliable resources, lack of time and lack of control over the learning process as well as pressure to use ICTs were identified as constraints to integration. Lack of support and collective experience were found to limit teachers' comfort and confidence in using ICTs with students. Teachers believed in the transformational potential of ICTs, but their beliefs were tempered by caution arising from the need to enhance the learning process (Hennessy *et al.* 2005, p.181).

[5] Baby boomers are the generation born between after World War II that resulted in a peak in births between 1946 and 1959. This generation is now retiring.

The involvement of school leadership in the integration of ICTs is critical (Breuleux, Laferrière, & Lamon 2002, p.10; Otto & Albion 2002, p.3; Sharma 2005, p.53; Staples *et al.* 2005, p.305). School leadership needs to understand the difference between traditional and productive use of technology and the differing implications of each. Acquisition of ICTs is fundamental, but should not be privileged over professional development; rather they should be planned for and happen simultaneously (Staples *et al.* 2005, p.306). This point is emphasised by Staples *et al.* in their call for *"a nuanced understanding of what it means to provide leadership and professional development at a school site"* (p.305-306). The beliefs that a principal holds have a significant impact on the culture that supports the creative integration of ICTs for teaching and learning and determine the interpretation of the vision for learning through either action or inaction (Otto & Albion 2002, p.4). Otto and Albion's argument support the contention that the resulting school culture has a greater effect on the adoption of ICTs by teachers than the influence of ICTs on educational reform.

Since approximately 2004 mobile technologies e.g. mobile phones, i-pods as reported by, for example, Batchelor (2007); Botha (2006); Brown (2005); Kukulska-Hulme and Traxler (2005); Wishart, McFarlane and Ramsden (2005) and social networking web applications e.g. *Facebook*, *Youtube*, *My Space* and *Flickr* have impacted the patterns of ICT use, particularly by students. Attention is now focusing on how such technologies are being incorporated into practice and the effect of such technologies on classroom practice, for example, Attwell (2007), Bryant (2006) and Lorenzo, Oblinger and Dziuban (2006).

The focus has shifted from the functional use of computers towards integrative practice, but the response of schools to the professional learning that needs to take place to fully integrate ICTs as part of a transformative process has not yet been realised.

2.3.4 21st Century: Integrative practice

Windschitl's work (1998, 2000) had had *"a very significant impetus"* in prompting research questions on ICTs in education (Kuiper, Volman & Terwel 2005, p.286). Subsequent to Windschitl's call for *"a critical examination of the intersection of the affordances of information technology, pedagogy and learning"* (1998, p.28), there has been more focus on the pedagogical aspects rather than the technological aspects of ICT integration.

Table 2.2: Aspects of ICT integration

Aspect	Authors
Barriers to or influences on ICT integration	Mumtaz (2000); Selwyn (1999); Lenard (2005)
Teacher beliefs that influence the use of ICTs	Albion (2003); Otto & Albion (2002); Hennessy, Ruthven & Brindley (2005); Hernández-Ramos (2005); Ilomäki, Lakkala, & Lehtinen (2004); Webb & Cox (2004); Zhao & Cziko (2001); Kirk & Macdonald (2001); Van Braak (2001).
The success of ICT integration and the ability of ICTs to reform education	Blasik *et al.* (2003)
Counter-claims of the ability of ICTs to reform education	Baggott la Velle, McFarlane & Brawn (2003)
Analysis of trends in integration of ICTs in specific countries	Ali & Proctor (2005); Rodrigo (2003); Kangro & Kangro (2004); Pang, Kim & Kim (c.2000); Looi, Hung, Bopry & Koh (2004); Mioduser, Nachmias, Forkosh-Baruch & Tubin (2004); Ilomäki *et al.* (2004); Soule (2003).
Large scale studies looking at integration across a broad spectrum of schools	PISA study (Bielefeldt 2005) in Europe; SITES study (Quellmalz & Kozma 2003) of ICTs in twenty-three countries, including South Africa
Large scale statistical analyses	Anderson & Becker (2001); Bielefeldt (2005)
Meta-analyses	Venezky (2004)
In-depth case studies	Baggott la Velle *et al.(*2003); Matheos, Daniel & McCalla (2005); Staples Pugach & Hines (2005)
Teacher strategies	Hennessy, Ruthven & Brindley (2005)

According to Finger *et al.* (2003, p.1) there has been limited research into ICT integration to date. Finger et al acknowledge that there is still difficulty in

defining what ICT curriculum integration comprises and how it can be effectively measured. However, contrary to their claim of a dearth of literature in the field, a comprehensive body of literature on ICT integration was located and found to cover various aspects of the topic as illustrated in Table 2.2.

There is also an increasing body of evidence of integration of specific ICTs into specific learning areas which are summarised in Table 2.3 below.

Table 2.3: Table of ICT integration into different subject areas

Subject	ICT Tool	Author
Sciences	Multi-media, data loggers, simulations, and virtual modelling and micro-worlds	Baggott La Velle *et al.* (2003); Cox, Abbott, Webb, Blakeley, Beauchamp & Rhodes (2004a); Cox *et al.* (2004b); Wilson, (2005); Webb (2005)
Mathematics	Interactive graphing	Godwin & Sutherland (2004); Crisan, Lerman & Winbourne (2007)
History	Internet multi-media provides excellent primary and secondary sources	Hillis & Munro (2005); Hills (2008)
Geography	Geographic Information Systems (GIS); Google Earth	Morgan & Tidmarsh (2004); Turner (2006)

Various studies were located that explore general issues relating to curriculum integration such as those suggested by Baggott la Velle *et al* (2003, p.197). According to Finger *et al.* (2003, p.1) the key to understanding the notion of integrating ICTs into the curriculum is the curriculum itself. Huffman and Rickman (2004, p.36) show optimism about the ability of ICTs to transform teachers, students and institutions, pointing out that "*it is imperative to remember that technology integration begins in the classroom with the teacher"*. However, they stress (2004, p.39) that integration is the focus to avoid technology becoming an "*add-on to the curriculum instead of an element of the curriculum"*. Dede (2000, p.282-283) explored the emerging influences of ICTs on the curriculum and suggests a number of innovative

ways in which ICTs can be integrated to enhance learning while Hokanson and Hooper (2000, p.533) argue the need to focus on the process of using ICTs in the classroom in a generative way rather than in a representational way. Rodrigo (2003, p.120) endorsed the call for educational goals to advocate the integration of ICTs into subject areas and to specifically exclude the development of computer-related skills as ends in themselves. Rodrigo's study focused on secondary schools, challenging claims that ICTs are themselves enablers that optimise student-centred pedagogical methods and fundamentally change the way education is conceived and delivered to students (2003, p.95). She found that, although teachers believed in such potential of ICTs, the reality of what they were able to achieve was far removed from their expectations.

The relationship between school culture and the integration of ICTs into the curriculum was explored by Staples, Pugach & Himes (2005). They advocate an alignment between the curriculum and the school mission, along with teacher leadership, as key to integrating ICTs. Staples *et al.* (2005, p.307) point out how traditional professional development encourages teachers to develop their practice within traditional structures and familiar contexts. When ICTs are introduced, teachers and principals need to toggle between the traditional and the unfamiliar in more complex ways. While technology first and foremost serves the curriculum, considerable time and effort needs to be invested in acquiring and learning to use ICTs in order for it to serve the curriculum. A curriculum-related vision is essential to keep ICTs appropriately focused. To achieve this end the technology leadership, supported by school leadership, must have a strong curriculum focus aligned with technical expertise. In cases where both the technology leader and the principal are focused on acquisition, teacher leadership of the curriculum aspect is essential. Using qualitative methods Staples *et al.* explored three cases and were able to provide a greater understanding of the *"complex interplay of curriculum, technology, and professional growth and development activities"* (2005, p.307). Staples *et al.* suggest that their study was able to illustrate

"unvoiced subtleties" associated with ICT integration. As a result of their study, they recommend (2005, p.307) that further research should investigate areas such as:

- decision making processes for technology purchases and the role of curriculum in these decisions,
- alignment between technology and the curriculum and
- the connection between technology and curriculum in the process of professional development.

Staples *et al.* conclude that professional development required for successful integration of ICTs must be aligned with curricular development:

> *"To be integrated successfully, there must be a clear understanding that technology creates a new layer for professional development. […] What seems critical for this to happen, however, is a deep understanding of how technology relates to curricular goals, how professional development must be layered to embrace both technology learning and curricular alignment in relationship to one another, and how carefully constructed professional development can support technology's most judicious use"* (Staples *et al.* 2005, p.308).

An example of curricular use of ICTs that illustrate the problem of how ICTs are integrated is provided by Baggott la Velle *et al.* (2003, p.187-197) who describe a case study of a Science unit. They found that despite student preferences for the approach used, there was little evidence of the students' understanding of the unit concepts. In their example, the teacher had used computer simulation instead of a lab practical to exclude inconsistencies and noise, rather than to use it as a new way of supporting student understanding. Baggott la Velle *et al.* suggest that it is not only the teacher's competency and confidence in using ICTs that is important, but that their understanding of how ICTs can support and enhance the learning task is vital. They argue that socio-constructivist approaches and cognitive tools embedded in ICTs,

together with pedagogical content knowledge are essential to the transformation that enables understanding. They advocate uses that allow students to "*explore, develop, express critically and redraft ideas and concepts"* (p.196) rather than using ICTs as a sterilised form of lab work. Transformation needs to take place in the teachers' knowledge and understanding, for example, knowing which applications to use and when, and how to differentiate to accommodate student's individual capabilities and characteristics. It is recommended that research should give careful consideration to productive pedagogies, the relationship between developing technologies and subject content, reflective and evidence-based practice, knowledge management practices that make knowledge of new developments accessible to teachers and, finally, finding alternatives to the pressures of accountability that might release creative opportunities (Baggott la Velle *et al.* 2005, p.197).

Staples et al and Baggott la Velle therefore concur on the need for professional development to focus on the learning process. To enable transformative practice that incorporates both technological and pedagogical aspects requires an emphasis on designing for learning.

Recently, Beetham and Sharpe in the introduction to their jointly edited *Rethinking Pedagogy for a Digital Age*, propose that bridges between technology and the transformation of education need to be built through *"a reconsideration of the pedagogical practices that underpin education"* (2007, p.1). Even by 2007 then, such bridges were still envisioned as a future occurrence and not something that has been achieved. Beetham and Sharpe examine the nature of pedagogy in the light of the change of focus from an emphasis on teaching content to passive recipients to one of active participation by unique learners in the learning process, arguing that pedagogy embraces the active learning process; the preparation, scaffolding and facilitation of that process and reflective practice (2007, p.2-3). In the context of the digital age these aspects of pedagogy that were previously

taken for granted become much more visible necessitating a much greater emphasis on the design of the learning process. At the same time as the approach to learning becomes more systematic, the creative, contingent and unpredictable nature of classroom interactions needs to be accommodated and the relationship between teacher and student is paramount (2007, p.7-8).

It would appear that the focus of ICT integration research has shifted to the balance between technology and pedagogy and that professional development issues are starting to receive the attention they require. However, few research studies have focused on the contextual variables that impact this relationship between ICTs and the curriculum. The study conducted by Staples *et al*. explored the relationship in three elementary schools. These schools were also supported by a publicly funded tertiary partnership. A similar study investigating the case of secondary schools is thus indicated. Further, the case of an unsupported school might also provide a differing perspective. Curriculum issues and professional development issues are issues of context and not of ICTs themselves. The following section will therefore review studies of context in relation to ICT integration.

2.3.5 Integration of ICTs in context

It is apparent from the above that the studies of the integration of ICTs cannot be separated from their contexts. Studies of ICTs in contexts include, *inter alia*, those of Clarke *et al*. (2000); Dede (2000); Doig (2005); Looi *et al.* (2004); Plomp (2006); Tearle (2003; 2004) and Venezky (2004).

Tearle's (2004) work is significant in that her approach is a single whole school case study in which she considers the process of implementing the use of ICTs across the school for teaching and learning as a special case of implementing change. Tearle derived a conceptual framework model from the literature on change management and ICT implementation and tested her case study against this model. Her model (2004, p.345) is illustrated as concentric circles containing the influences on the ICT implementation process. The intention of her model was *"to offer a useful focus from which to*

consider planning a strategy for the introduction of ICT, or reviewing an existing one" (2004, p.348). As such it is a valid model. At the centre of her model is the use of ICTs in practice. According to the model, practice is affected by individual characteristics and competencies (attitudes, skills, beliefs and ICT knowledge and understanding) which, in turn are affected by the implementation process. The implementation process is determined by characteristics of the whole school context (2004, p.336).

Whilst Tearle recognises the influences of the different elements on ICT practice, her model assumes the centrality of ICTs. It is this *centrality* of ICTs in studies of ICT integration that remains unchallenged. Secondly, Tearle's research was based in an education system that has a National Curriculum for ICT implementation, an imperative that teachers in those schools need to be accountable for (Tearle 2003, p.581) whereas in South Africa, although there is a national policy on ICT integration, there is no national ICT curriculum. A further aspect of Tearle's study is that the chosen case exemplified not only ICT implementation but was an exemplary school in other ways as well i.e. it was chosen for its success in implementing ICTs. While the choice of case was entirely appropriate to Tearle's intentions, her model and its test case do not address the situation in schools at large which, by Tearle's own admission, form by far the majority of schools (2004, p.340). If her model was to be applied to schools at large they might give a measure of the discrepancies between the ideal and the school, but not necessarily account for those discrepancies. Tearle admits that her model does not show how the various factors interact, nor does it illustrate the relative importance of each feature or the complexity of the whole situation (2004, p.344). Tearle also acknowledges that individual characteristics accounted for the fact that *"the underlying messages behind the theoretical framework and case study findings were markedly different"* and that there was little evidence in the case setting of what difference teacher beliefs made (2004, p.347). The question of the interaction of such factors and their relative importance remains.

It is important to understand the difference between, on the one hand, integration in purpose built environments or projects supported commercially with the expressed intention of accelerating integration and, on the other, trends in schools in general that are not necessarily subject to such advantage. Purpose built environments may provide a vision or model of what is achievable with ICTs, but do not account for the reasons why the majority of schools do not achieve such success with integrating ICTs.

Similar to Tearle's study, Dede's (2000) study, whilst contextualising ICT integration in whole school environments and complexity, focuses on exemplary projects that *"illustrate the potential of computers and telecommunications to convey higher-order skills and knowledge"* (p.282). According to Dede ICT integration requires a:

> *"… complex implementation process that includes sustained, large-scale, simultaneous innovations in curriculum; pedagogy; assessment; professional development; administration; organizational structures; strategies for equity; and partnerships for learning among schools, businesses, homes, and community settings"* (Dede 2000, p.282).

A further study was conducted in two New Zealand schools by Doig (2005). However, the schools were once again exemplary in that they were qualified as *"designated character"* schools set up *"to be foundationally different from traditional schools through opportunities to explore radical innovation"* (2005, p.*i*) rather than incremental change. Doig questions what makes for radical innovation in schools and how the use of ICTs is implicated in innovation in schools. Doig's use of the term "*incremental change"* (2005, p.34) as opposed to "*radical change*" is pertinent. It is incremental change (Whitehurst 2009, p.1; Clarke *et al.* 2000, p.7), or continuous change that happens in small steps that characterises the majority of schools, that is, schools that are not exemplary cases.

Plomp (2006, p.7) refers to the international SITES studies (see Section 2.3.1, p.34) as reported by Pelgrum and Anderson (1999). Again, the SITES schools were purposefully selected. The selected cases had *"to represent the innovation aspirations of each country rather than what was already going on in many classrooms"*. The criteria were that ICTs had to be utilised and pedagogic practices had to show innovative trends, although the definition of innovation was left to each country to determine. Also, although Plomp's report is dated 2006, the original studies were conducted prior to 1998 and, given the rapid development of ICTs, may no longer reflect the current situation. However, of interest in Plomp's account is that pedagogical innovation plays a role.

An important study that looked at whole-school issues is the meta-analysis based on 94 OECD[6] case studies as reported by Venezky (2004). The purpose of the OECD studies was to understand the relationship between ICT and educational innovation. Venezky acknowledges the significant educational changes that were happening at the end of the 1990's. Such changes were from individualistic towards collaborative learning, from reproduction of information to higher-order thinking skills, and from rote learning of content to in-depth study. To achieve these goals, a wide range of professional development, collaborative community, curriculum revision and learning facilitation strategies were being implemented in some countries, whilst other countries relied on standards and their relevant performance assessments. At the same time the provision of ICTs to schools was proliferating, although not evenly, and varying degrees of staff development in ICT use was provided. The OECD studies explored the relationship between *"the successful implementation of educational innovation and successful installation and use of ICT"* (2004, p.5). By exploring this relationship, these studies came closer to contextualising ICTs. However, the multiple studies synthesised in the OECD report were conducted prior to 2000 and more

[6] Organisation for Economic Co-operation and Development

recent research taking further educational and technological developments into account is indicated.

Looi *et al.* (2004) describe research conducted in Singapore on ICT innovations intended to enhance the critical and creative capacity of that country's human resources. Key areas of Singapore's IT Masterplan II 2003-2007 are *"to use IT to enhance the connections between the curriculum, instruction, and assessment methods"* and to *"stimulate thinking and creative endeavour among learners"* through engaged learning (2004, p.92). The ICT infrastructure and adequate training for learner-centred ICT integration are identified as fundamental and ICT is seen as a catalyst for capacity building for the knowledge era. In order to achieve their goal of transforming learning the Singaporean education ministry set up an experimental Learning Sciences Lab (LSL). The purpose of this was to enable educators *"to go back to the basics of understanding learning from scientific and interdisciplinary perspectives".* The goal of the lab was that:

> "… *ideas and concepts related to learning interactions and teaching pedagogies can be prototyped and implemented in classrooms and schools. Through a continuous spiral process of experimentation and exposing school leaders, teachers, and students to workable ideas and developed prototypes, LSL provides those individuals with experiences that can transform mindsets toward empowered learning and lifelong learning"* (Looi *et al.* 2004, p.92).

The Singapore example is one that demonstrates innovation in its approach to ICT integration at a national level in a well-resourced country. The theoretical framework described by Looi *et al.* (2004, p.93) places emphasis clearly on the *learning* rather than the ICTs and is based on the concepts of situated cognition and communities of practice. Their theoretical framework derives from three sets of related pairs of issues:

- Epistemologies of teachers coupled with designing for learning (teachers' perspective)
- Meaning-making for learners coupled with learning technologies (students' perspective)
- Scalability and sustainability coupled with school policies and practices (schools' perspective) (2004, p.92).

The value of the Singapore initiative (which, at the time of this review, was still underway and not yet finally and fully evaluated) is that, although the earlier phase concentrated on the provision and support of ICTs, the subsequent phase removes the centrality of ICTs and places the emphasis clearly on learning at a student, professional and organisational level across a national context within a wider purpose of building capacity in critical thinking skills. It is this focus that is considered to be paramount in ICT integration research. However, not all countries have access to such facilities and support and the question of integration and transformation in schools in general, without access to such experimental facilities, remains.

The study of Vermont schools by Clarke *et al.* (2000) is a study of complex innovations rather than a study of ICTs. However, ICTs played a part in the changes brought about in each of the case studies that Clarke *et al.* describe. Clarke *et al.* concluded that:

- interactions between all five levels of school organisation (student, teacher, system, district and state) need to be aligned and *"adapt a shared "vision" with each interaction"*
- *"interactions between individuals across organizational lines fuel the change process"*
- ongoing change is fuelled by student-teacher interactions
- interactions between policy and districts *"create structures that support continuing growth"* and
- *"failure to adapt at any level starves the rest of the organization of resources necessary to change"* (2000, p.156)

Clarke *et al.*, as participant observers, investigated and described a single innovative case within each of four different secondary schools and each case was described in relation to its context. Patterns of innovation within the context of school transformation emerged. The resultant transformation of the context is described in the following way:

> *"[P]artners engaged in a reform initiative continuously adapt to each other, changing in ways that allow the initiative to "grow" in strength and coherence. When change began to generalize within a school, interactions among many individuals occurred in increasingly complex patterns. In these interactions, no individual or system component could remain stable while others changed. The change process could not be controlled from any single vantage point. Growth in classrooms, programs, schools, and school systems must be mutual growth, we concluded, providing all participants with the sense that they benefit personally to the extent that others benefit from their work. Systemic change therefore depends on increasing the energy of interactions across organizational lines so that growth occurs among many connected efforts. This then supports the evolution of a common sense of direction at all levels of the organization."* (Clarke *et al.* 2000, p.55)

In this way, Clarke et al bring together the concepts of context, innovation and complexity as pointers to transformation.

2.3.6 Summary of section 2.3

This section has traced the development of the concept of ICT integration, provided definitions and demonstrated how the concept has been explored in various studies. Encountering, in particular, the report on Clarke *et al.*'s study brought to mind the importance of *"a commonality of being"*[7], of the

[7] *As described by a New Zealand teacher I interviewed in 2001: "One of the strengths of the school is the sense of people working together. When people need a hierarchy its there, but the fact of the matter*

importance of good collegial relationships and partnerships. It also led the literature path into the theoretical underpinning of innovation and complexity theory. The first of these two theoretical concepts, innovation theory, and its relationship to school contexts, to ICTs and to complexity theory will be reviewed in the next section.

2.4 Innovation theory

A broad definition of innovation is the introduction of something new that is intended to be useful (Whitehurst 2009, p.1). Two critical dimensions of innovation are:

Effective <----------> Ineffective

Process <----------> Product

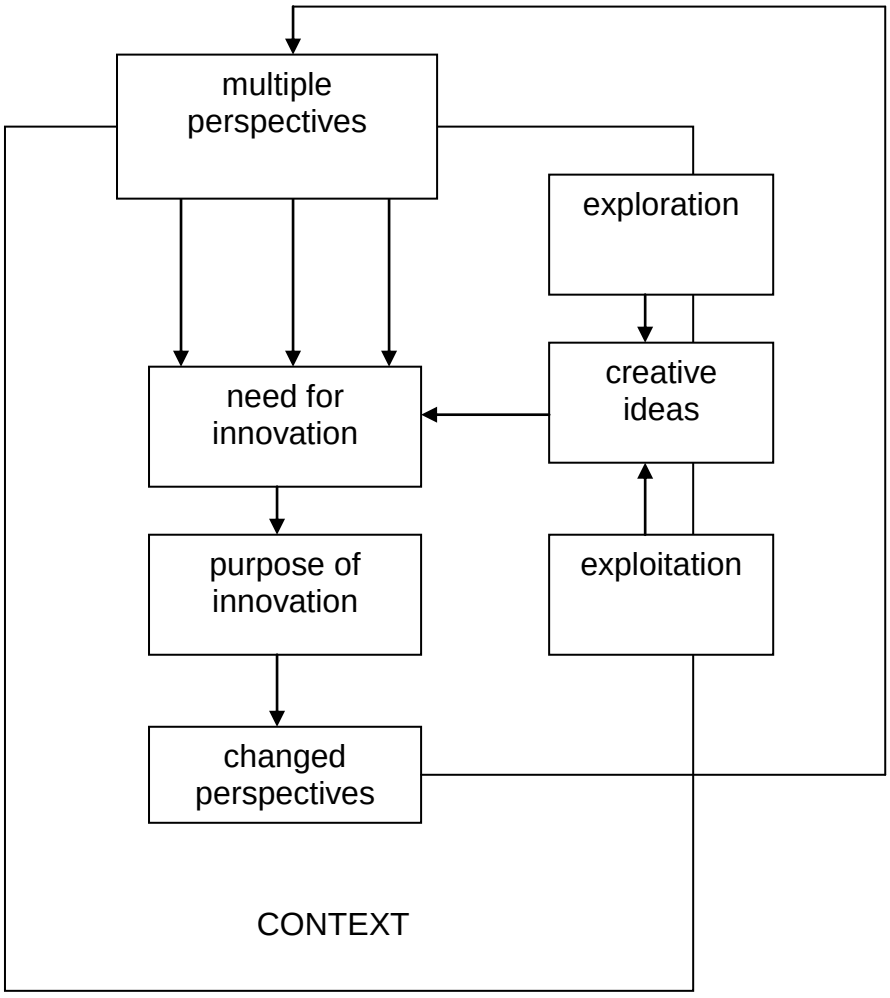
Whitehurst (2009) explains that effective innovations enhance desired outcomes, whereas ineffective innovations do not. To implement a product innovation requires a paradigm shift while process innovation involves modifications of existing processes. The aim of process innovation is to improve the efficiency, productivity or functionality of existing products. Process innovation is usually incremental and occurs over a period of time. The practice, the outcome, and the improvement to be achieved by a process innovation should be evident and clearly related (2009, p.1-2). Implementing ICTs in schools is a product innovation whereas using it in transformative ways (Brackett 2000, p.30) is process innovation. Schools need to pay more attention to process innovation (Whitehurst 2009 p.7).

The concept of innovation in the abstract may be distinguished from particular innovations (Glatter, Castle, Cooper, Evans & Woods 2005, p.384). Abstract innovation may be defined as *"learning to do things differently in order to do them better"* (Hargreaves 2004, p.6). A particular innovation is *"a significant change in processes, provision and/or organisation intended to help meet*

is that […] it's a very friendly place, a commonality of being, a sharing place. It's a strength. […] There's a lot of resource sharing and co-operation".

educational goals more effectively or to promote new goals" (Glatter 2005, p.384). Glatter *et al.* (2005, p.389) refer also to *"strategic innovations"* and *"specific innovations"*. Strategic innovation is the implementation of top-down reform, which needs to be matched with specific, significant sub-innovations of smaller scope and focus *"mainly on one or two of process, provision or organisation"* (Glatter *et al.* 2005, p.390). A specific innovation must introduce something new to the particular context, have consequences that are *"noteworthy, highly valued and relevant to the priorities of the organisation"* and be *"connected to the larger strategic innovation"*. In the case of South African schools the new curriculum would be an example of strategic innovation and how a teacher responds by changing their practice would be a process innovation in the sense intended by both Whitehurst and Glatter.

Figure 2.2: The flux and change of innovative processes



A basic assumption of innovation within a system is that the system needs to be improved in some way. Such an assumption is subjective, arising from the perspective and interests of different stakeholders (Assié-Lumumba 2004, p.73). Glatter *et al.* (2005, p.385) raise three questions about the nature of innovation: its novelty, its effectiveness and its size. Innovations are context-dependent: what is new in one context may not be so in another. Innovation is generated through exploration, but can also be the result of exploitation of other's ideas. To be effective, an innovation needs to have a purpose and to have been implemented in practice to a certain extent, while its success will depend on the particular perception of it. Change occurs in very small steps, evolving gradually, therefore an innovation does not have to be on a large scale, but the *"continual flux and change"* of organisational complexity plays a role (Glatter *et al.* 2005, p.386). These ideas are illustrated in Figure 2.2.

2.4.1 Innovation, change and reform

The terms innovation, change, transformation and reform are sometimes used interchangeably in the literature. These terms need clarification and the relationships between them established.

Innovation is defined as *"a change that is new relative to the organization that is adopting that change"* (Lane 2001, p.12). Innovation can be either top-down or bottom-up. Top-down innovation is associated with mandated or policy change and reform (OECD 2000, p.54). Bottom-up innovation is the change in practice that responds to mandated change. However, small scale creative changes can occur in response to problems or challenges that are not necessarily related to larger scale actions (Hargreaves 2000, p.54), but occur as instances of *"localised experiment and renewal"* (OECD 2000, p.43). In such cases, the change is new relative to the individual. Hargreaves (2000, p.54) argues that apart from top-down policies there should also be policies that direct innovation at school level.

The notion of innovation is commonly regarded as beneficial but innovations such as the gun or the guillotine belie such an axiom (Cros 2000, p.65). Similarly, reform and change, sometimes associated with conflict, can have negative associations (Cros 2000, p.66). The term educational change as used by Hargreaves & Goodson (2006, p.4) implies either positive or negative transformation over time, whereas the normative use of reform implies only positive change Labaree (2006, p.161).

An organisation lacking innovation is deemed conservative. Based on the OECD/CERI[8] study, Cros (2000, p.65) identifies four ideas that constitute the innovation paradigm in education:

- the idea of the new and novel as a form of creativity, newness
- the idea of addressing unmet social needs and values; a measure of carrying out reform and guaranteeing quality; optimising and energising
- the issue of power; innovation introduces uncertainty into centre/periphery relations
- the idea of change; changing behaviour, attitudes, approaches and ways of thinking; appearing in situations of transition or questioning

If innovation is continual, burnout and a return to routine will result. In order to avoid such retrogression, innovation needs to become institutionalised or part of the culture of the organisation in which it occurs. Sustainability of innovation therefore implies institutionalised or ongoing innovation (Cros 2000, p.67).

Common notions about innovation are questioned by Milton (2005). She asks whether policy can be innovative, suggesting that government reform and educational innovation are different. There is a paradox between the need that the knowledge-based society has for a culture of innovation and the need of the knowledge economy for a successful educational foundation. Milton suggests that little attention is paid to *"how we do education itself"*. A further question that she poses is: *"If innovation is a significant change in how we do*

[8] OECD/CERI = OECD Centre for Educational Research and Innovation

things, then when does what has changed become the way we do things all the time? In other words, if truly transformational when does the work cease to be an innovation?" Milton argues that the need for change is often recognised, but thinking about ideas for educational innovation does not run deeply enough: *"common beliefs and faulty assumptions about central concepts of intelligence, instruction, motivation and intention, if unexamined, limit the likelihood of significant change in educational practice"*. When such myths are challenged, the reaction is either to reject the new ideas as wrong or to graft them onto the older mental models. However, to transform educational practice it is essential to reassess assumptions (2005, p.2-7).

Multiple perspectives and interpretations of innovation therefore exist, particularly within the context of change or reform in schools. However, for the purposes of this study innovation is used in the sense of a bottom-up incremental process of beneficial changes in teacher practices at a particular time and in a particular context as a response to multiple simultaneous, top-down, mandated, policy-based changes.

Having established a working meaning of the term innovation, the next section will address the diffusion of innovations or how they spread.

2.4.2 The diffusion of innovations

According to SAITIS[9] (2002 p.10), Rogers is the recognised authority on diffusion. He defines diffusion as *"the process by which an innovation is communicated through certain channels over time among the members of a social system"* (Rogers, 1995 p.5). Rogers continues by acknowledging that diffusion is a form of communication that conveys new ideas between individuals with the intention of reaching a mutual understanding. His definition implies that:

[9] South African Information Technology Industry Strategy Project

> *"… [c]ommunication is a process of convergence (or divergence) as two or more individuals exchange information in order to move toward each other (or apart) in the meanings that they give to certain events"* (Rogers 1995, p.5) and that
>
> *"… [d]iffusion is a kind of social change, defined as the process by which alteration occurs in the structure and function of a social system. When new ideas are invented, diffused, and are adopted or rejected, leading to certain consequences, social change occurs"* (Rogers 2005, p.10).

Rogers applies the term diffusion to both the spontaneous, unplanned spread of new ideas and diffusion that is directed and managed. Thus the main elements identifiable in each diffusion process are the innovation, communication channels, time and the social system in which the innovation diffuses (p.10). The components of Rogers' diffusion model are summarised in Table 2.4 below from the SAITIS (2002, p.10) table.

The terms innovation and technology are often conflated. A technology may be defined as *"a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome"* (Rogers 1995, p.12). A technology usually has a hardware or tool aspect and a software component that consists of the information base for the tool. Using a computer as an example Rogers illustrates the obvious relationship between a tool and how it is used. However, Rogers argues that the social embedding of a technology is not as visible as its tool aspects. A technological innovation creates uncertainty in the minds of the adopters about whether it will work or not for the given need. The decision to use an innovation occurs through an information-seeking process designed to lessen the uncertainty (Rogers 1995, p.12-13).

Table 2.4: Components of the Classical Diffusion Model (adapted from SAITIS 2002 p.10)

Component	Definitions/Generalisations
Typical Diffusion Pattern	Process starts out slowly among pioneering adopters, reaches "take-off" as a growing community of adopters is established and the effects of peer influence arise, and levels off as the population of potential adopters becomes exhausted, thus leading to an "S-shaped" cumulative adoption curve.
Innovation Characteristics	Innovations possess certain characteristics (relative advantage, compatibility, complexity, trialability, observability) which, as perceived by adopters, determine the ultimate rate and pattern of adoption.
Adopter Characteristics	Some potential adopters are more prone to innovate than others, and can be identified as such by their personal characteristics (education, age, job tenure etc.). Adopters can be usefully classified according to where they adopt relative to others (innovators, early adopters, early majority, late majority, laggards.)
Adoption Decision Stages	The adoption decision unfolds as a series of stages, flowing from knowledge of the innovation through persuasion, decision, implementation and confirmation. Adopters are predisposed towards different kinds of influence (e.g., mass market communication versus word-of-mouth) at different stages.
Opinion Leaders and Change Agents	The actions of certain individuals (opinion leaders and change agents) can accelerate diffusion, especially when potential adopters view such individuals as being similar to themselves.

Besides Rogers' model of diffusion, Cros (2000) identifies a range of contemporary forms of innovation diffusion or generalisation which recognise the complexity of innovation. Amongst these is the social interactionism model. Cros explains that, in this model, the interplay of influences and individual decisions and their effects are key. Given and received information is recomposed in the mind of each individual. Communication networks, and particularly personal networks, are key to social influence. Social participation is reassuring and fosters the development of the innovation. Conflicts and

crises also play a role as do conformity, power relations, minorities and social pressure (Cros 2000, p.70-74).

Communication is essential to diffusion and clusters or networks are key to the communication of creative ideas. Lewis and Romiszowski (1996) investigated the relationship between networking and learning organisations in education. They recommended at the time that further research was required to explore the optimum mix of networking and other learning activities as well as the decision making factors that influence the level of support given to innovations (1996, Section 4.1.2). Networking is common in business practice and its principles should also apply to schools. Networks are the means of diffusing innovations. Whilst interaction in networks is mostly informal, it is part of an organisation's larger knowledge management strategy for knowledge creation (Steiner 2004, p.1). Steiner identifies clusters and networks or social technologies as a regional development tool as well as a means of co-operative knowledge creation and diffusion between regional structures and individual companies. Clusters and networks are *"the result of an evolving process shaped by policy activities and entrepreneurial behaviour responding to new challenges"* (2004, p.4). While Steiner argues that to be excluded from clusters or networks exacerbates the economic divide (2004, p.2) in a business sense, to be excluded in an educational sense would have similar effects over a knowledge divide.

The most important spill-overs occurred at the proverbial 'waterhole', training sessions and seminars, through the appointment of new staff and on-the-job learning (Steiner 2004, p.9). Within networks similar levels of thinking linked joint research and development activities, management learning through improvement of routines and procedures and marketing through development of new products together with clients. The clusters therefore played the role of learning organisations. Within the different clusters, there was variation in the degree of collaboration. Some shared and created knowledge in an informal way, some in a more organised way and others working on research

and development together with tertiary institutions (Steiner 2004, p.8-10). If applied to schools, the same principles apply. It is imperative for teachers to have access to and make use of clusters or networks in order to remain updated with creative ideas rather than have to rely on their own resources. Schools, as learning organisations, need to optimise interactive learning within such clusters to encourage the diffusion of innovative ideas.

2.4.3 Innovation and schools

Schools are required to respond as organisations to policy change. Innovations are diffused within a school as follows:

> *"A ministry of education or a municipal or regional equivalent can request or require teachers to teach in specified ways but this will not guarantee that they, in fact, behave as desired. The school principal will attempt to enforce such an administrative request with greater or lesser enthusiasm and teachers will demonstrate the same variability in following the directions of the principal. Thus, it is important to understand how innovations in education come to be adopted or rejected by teachers"* (Venezky & Davis 2002, p.20).

Organisational innovation is *"substantive planned change in a school system to solve a problem, without regard for whether the change resulted in the adoption of novel or traditional procedures"* (Venezky 2004, p.5). This view contrasts with that of Clarke *et al.* (2000, p.17) who state that changes in larger systems force new innovations to emerge, that is, change needs to occur first. Venezky is describing innovation as planned organisational change whereas Clarke *et al.* describe innovation as resulting from change. Venezky states that *"where teaching innovations occurred, most of the major components of planned change were present"* (2004, p.10). These differences aside, either way, both Venezky and Clarke *et al.* recognise the dynamic interplay between change and innovation, innovation and change. What is not clear from the literature is the *cycle* of innovation and change, that

is, whether change (a condition) supports innovation, or whether innovation (a changed learning process) results in change.

There is a difference between the acquisition of an innovation and its deployment (Venezky & Davis 2002, p.22). Venezky and Davis provide examples of staff acquiring good personal ICT skills, but not integrating them into the teaching and learning process because of either lack of professional development in this area, or lack of appropriate infrastructure or access to it. They argue that where such a differential gap is large then policy predictions will be false. Accordingly, diffusion could refer to a variety of aspects: to teachers' ICT competencies, to their classroom practices with ICTs or to the use of ICTs for professional and community purposes. Venezky & Davis also identify the difference between diffusion into the organisational structure of a school and diffusion into its pedagogical structure (2002, p.22).

The problem with innovation in schools is the proliferation of *"disconnected, episodic, fragmented, superficially adorned projects"* which cause overload (Fullan 2001, p.21). Similarly, Cros (2000, p.69) challenges the idea of innovation in schools asking what it is that those who wish to disseminate innovations want to achieve. She argues that an innovation cannot be transposed without a recurrence or renewal of the process. Each individual has to *"re-invent a new way of working together in a socially constructed space"*. In a sense she is linking to Sherry and Gibson's mutuality in that if there is convergence, then there needs also to be a mutual benefit for the innovation to take hold.

Innovation does not necessarily follow from policy changes and particularly in secondary schools: where innovation occurs it is as likely to counter trends as to support trends (Glatter *et al.* 2005, p.382). Glatter *et al.* attribute this to the dominant grammar of the secondary school and argue that structures for the evaluation and dissemination of innovation need to be established (2005, p.383). Innovation requires not only ideas, but consistent planning, evaluation

and dissemination (OFSTED, 2003, p.69) particularly as in schools, compared to corporate organisations, risk is a far more significant factor (Glatter *et al.* 2005, p.383).

Three aspects of innovation need to be understood within schools: the *predispositions* to innovation, the *pressures* towards innovation *and the potentialities* for innovation (Hargreaves 2000, [italics in original]). Predispositions are the inclination of the organisation or its readiness to engage in new ideas: the stronger the controls, the more stifling the culture will be towards innovation. Pressures are the forces that drive innovative educational activity even in the face of antipathy towards innovation. Potentialities are the factors that make it easier for a school to engage in the kind of innovation that it desires e.g. schools that are well-provisioned with ICTs are in a stronger position to use ICTs for organisational change (2000, p.52-53).

Schools in the complex knowledge society need to become learning organisations with innovative structures and processes that encourage the development of professional learning capacity to cope with unpredictable and changing environments (Senge 2006, p.308). A school as a professional learning community (Wenger 1998, p.2) emphasises collaborative opportunities amongst professional teachers. It also focuses on teaching and learning and the collection and use of assessment and other data to evaluate progress over time (Giles & Hargreaves 2006, p.126). Giles & Hargreaves point out that professional learning communities are difficult to establish in secondary schools because of hierarchical administration and the strong subject-based structure that counters collaboration. They also identify the conflict between informal relationships in a professional community and formally established collaborative networks (2006, p.127).

A paradoxical tension exists between change and innovation (Giles & Hargreaves 2006, p.152). Teachers can cope to a certain extent with the change forces that threaten the sustainability of innovations and offset the

"evolutionary attrition of change" by distributing leadership, planning for leadership succession, managing community relationships and renewing their teacher culture, but they cannot withstand the standardised reform agenda that undermines their innovative efforts. Detailed, prescriptive reform also undermines professional learning communities (2006, p.152-153).

For innovations to flourish, it is critical that the *"mechanisms which can sustain and encourage"* innovations are understood (Sharma 2005, p.51). Sharma argues that while individual or pedagogical innovations at the classroom level are important, school level innovations are *"far more complex and challenging"*. Individual innovations need to be encouraged and supported for them to be sustained at school level. Whilst the need to adopt innovations at school level has been repeatedly recognised examples are scarce and research on the organisational perspective in schools is rare (2005, p.52).

For innovations to succeed in schools the following conditions, as identified by Sharma should be present:

- supportive leadership in an atmosphere of trust and collaboration and a tolerance of constructive controversy and risk taking
- networks to encourage lateral thinking rather than strongly hierarchical structures that discourage creativity and innovation
- resources are essential to innovation, but an abundance of resources does not guarantee innovation
- effective group processes: group members need to be part of the processes of decision-making and setting objectives
- organisational goals and objectives need to be outlined clearly
- mutual concern for quality as well as positive support (2005, p.54-56).

In describing his study, Sharma (2005) focuses on schools that have implemented innovative practices in teaching methodology, curriculum design, evaluation, resource mobilisation or administration for more than five years. He points out that while research has provided useful information on innovations in education, there is little that provides insight into how such

innovations are initiated and managed and calls for further studies to enable understanding of the processes that facilitate or inhibit innovation (2005, p.58). In Sharma's study the choice of school is once again based on exemplary features and his is a management-orientated perspective conducted by an outside researcher.

The degree of complexity of an innovation affects the implementation process (Rowan, Camburn & Barnes c.2005, p.17). Whilst simpler designs can be implemented more smoothly and faster, more complex designs produce more fundamental change, but only if it is delivered in small sequential steps. In some designs instructional practices are clearly described, in others they are not specified and teachers are given the aims, such as *"authentic, learner-centered, interactive, continuous and inclusive learning"* but not the tools (Rowan *et al.* c.2005, p.19) and are expected to rely on their own *"discovery learning"*.

The response of a school as an organisation to mandated change is therefore a complex process. However, it is a process that is intertwined with teacher innovation as, without teacher innovation the purpose of organisational innovation cannot be achieved.

2.4.4 Innovation and teachers

Much of the focus of innovation in schools has been from an organisational perspective. However, Fullan and Hargreaves (1992, p.1) focus on the teacher's role in innovation arguing that the successful implementation of innovations is directly related to teacher development. They argue that effective implementation involves alterations in curriculum materials, instructional practices and behaviour, as well as in beliefs and understandings on the part of the teachers involved. Essentially, implementation of an innovation is a learning process. Fullan and Hargreaves point out that schools not only implement one single innovation at a time but are typically required to manage *"multiple innovations simultaneously"* (1992, p.4). Little is

known or understood about the *"teacher's sense of purpose, the teacher as a person, or the context or conditions under which they work"* (1992, p.4). To understand these elements requires a professional development process that allows teachers to act on their sense of purpose, provide them with the opportunity to voice their opinions, assumptions and beliefs and to create a collaborative community together. The process should also take into account individual characteristics such as age, gender, career stage and life experiences that might affect their response to an innovation. Secondary school contexts provide very different challenges to primary schools and socio-economic factors also play a role. According to Fullan and Hargreaves, collaborative work cultures that promote continuous teacher development rather than individualism are essential (1992, p.6).

Later research indicates that the type of professional learning opportunities that teachers require in order to be able to innovate with ICTs is still being called for, almost a decade after Roschelle *et al.* (2000, p.76) called for a focus on the pedagogy rather than the technology. Such opportunities include:

- pedagogical development days and workshops (OECD 2000, p.116; Fogelman, Fishman & Krajcik 2006, p.186)
- a culture that epitomises a learning organisation (OECD 2000, p.116)
- collaborating with colleagues on organisational, pedagogical and pastoral issues (OECD 2000, p.117; Peurach, Glaser & Gates, 2004, p.5-6; Fogelman *et al.* 2006, p.186)
- developing expertise in student-centred learning (OECD 2000, p.117)
- the ability to use and integrate ICTs (OECD 2000, p.118)
- networking (OECD 2000, p.124; Rowan *et al.* 2005, p.38)
- embedding professional learning in the development of instructional materials (Rowan *et al.* c.2005, p.22)
- setting up model classrooms (Rowan *et al.* c.2005, p.22)
- providing on-site instructional leadership and support for learning design (Rowan *et al.* 2005, pp.22, 39)

- ensuring common planning periods to discuss practice (Rowan *et al.* c.2005, p.22)
- leadership attitudes; opportunity to collaborate with colleagues (UNESCO 2004, p.61, 119)
- adapting hierarchical structures to enable collegiality, collaboration and strong relationships (Giles 2006, p.13)
- leadership to provide clear short and long term goals and buffer teachers from distractions (Rowan *et al.* c.2005, p.22)

Whilst the need to improve teaching and learning is an important focus for teachers, individuals manifest an internal need to innovate tied more to their teaching style than to their subject (Lane 2001, p.88). From his research in tertiary institutions Lane concludes that teaching and learning innovations are sustainable when they become part of and are integrated within the individual and that institutionalisation and integration of innovation on a personal level cannot be separated. Interactions with colleagues are crucial to continuous learning about different innovations and helping teachers avoid pitfalls in sustaining the innovations (Lane 2001, p.89-90).

Innovation diffusion theory is also applicable to the study of ICT innovations and has provided insight into ICT integration (Prescott 1995, p.16) as product innovation. According to Prescott, the resulting research has contributed to the development of innovation diffusion theory as well as providing guidance in the introduction of ICTs, particularly in the workplace. The next section will consider this link between innovation and ICT integration.

2.4.5 Innovation and ICT integration

Innovation in the educational context is defined as pedagogical practices that promote active and independent learning; encourage collaborative and project-based learning in real-world contexts; heighten sensitivity to individual needs and diversity; redefine traditional space and time learning configurations; and increase parent and community connections with the

school (Mioduser *et al.* 2003, p.26). Together with Nachmias, Cohen, Tubin and Forkosh-Baruch, Mioduser conducted a series of investigations on pedagogical innovations involving ICTs in Israeli schools. They developed a configuration of factors involved in these innovations (Nachmias *et al.* 2004, p.70). The factors included roles within the school; roles outside the school; learning configuration; organisational climate; staff training; ICT infrastructure and ICT policy. These factor all impact on more central factors such as student role; curriculum; teacher role and learning configuration.

There are many similarities between Tearle's (2004, p.345) model of the implementation process and that of Nachmias *et al.*'s. Both were derived from the literature and tested in practice, although while Tearle's was tested against a single case study, that of Nachmias *et al.* was tested against a range of ten schools. Although Tearle focused on the implementation of the technology, while Nachmias *et al.* focused on successful innovative educational pedagogies (Nachmias *et al.* 2004, p.296), both highlight the inter-relatedness of contextual factors. At the centre of Tearle's diagram is ICTs in practice; at the centre of Nachmias' is the interplay of curriculum, learning, teacher roles and student roles. However, similar to Tearle, the Israeli research series focused on the exemplary, selecting specific innovative practices within the schools and not schools as a whole as described in the report by Tubin *et al.* (2003, p.8). Whilst the Israeli research provides a model for what should be, it does not account for schools in general that may not be considered exemplary.

Numerous factors affect innovation, but do so unevenly (Nachmias *et al.* 2004, p.305). In the light of the findings of Nachmias *et al.* that personal knowledge acquisition by leading staff is more significant than organised staff training, they claim that the contention of teacher training as significant is only partially correct (2004, p.305). Nachmias *et al.* confirm Venezky and Davis's (2002, p.22) view that computers alone do not create innovation, although they found that many schools still interpret the student-computer ratio as an

indicator of the extent of ICT implementation. They acknowledge that their research produced shallow results and suggest that a much wider study involving many more schools would be necessary to validate their results. Nachmias *et al* suggest that further research investigates the relative importance of the factors; their relation to the innovation life-cycle; the correlation between the factors; and the nature and properties of innovation (2004, p.306-307).

A further phenomenon from the Israeli study is identified by Tubin *et al. (*2003). Termed the *"islandness"* phenomenon, Tubin *et al.* found that an innovation was limited by its specific characteristics and demands on resources amongst surrounding traditional practices (2003, p.22). However, this did not apply to all instances and in many cases there were intricate webs of innovation, not limited to ICT-related practices. With regard to the "*islandness"* phenomena, Tubin *et al.* recognise the potential for identifying and examining the whole set of factors e.g. human resources, infrastructure, staff training, policy, outside-school agents affecting the emergence and sustenance of innovative practices within schools.

Further significant studies that have investigated the relationship between ICTs and innovation, reform or change include that of Owston (2006); Venezky and Davis (2002) and Venezky (2004). Owston's model for sustainable classroom innovations (2006, p.8) resulted from his analysis of school and classroom contexts based on data obtained from the SITES M2 data (Quellmalz & Kozma 2003). Venezky and Davis (2002, p.4) describe the impact studies on ICT and organisational change and ICT and information handling skills initiated and conducted by the OECD/CERI in 1998. The focus of the case studies was to understand the relationship between ICT and educational innovation. They identified far-reaching changes taking place in schools within the OECD countries:

> *"… a variety of instructional reforms driven by a perceived need to reorient schooling from rote learning, shallow but wide coverage, and individualistic learning processes to higher level skills, problem solving, in depth study, and collaborative learning"* (Venezky & Davis 2002, p.5).

The central finding of Venezky and Davis's study was that ICT rarely acts as a catalyst by itself for schooling change, yet it can be a powerful lever for realising planned educational innovations (2002, p.13-14). They show how the intended use of the ICTs to realise particular goals lead to their conclusion of ICTs as a lever rather than a catalyst. According to Venezky and Davis a catalyst is an agent that provokes a specific, anticipated change, but can act beyond its immediate goal. A lever, on the other hand, must be applied intentionally to produce a desired change. If ICTs were catalysts then expected changes would result from their introduction, which the OECD studies that they analyse demonstrated did not happen (2002, p.10-14). Venezky and Davis argue that the distinction between a catalyst and a lever is critical for policy:

> *"If the mere application of ICT within a school generally led to more student centred teaching, then countries that desired changes in that direction could focus resources solely on bringing a strong ICT infrastructure into schools and assuring that teachers used it in their teaching. The opposite finding, which is what we are reporting, leads to a different strategy wherein both the ICT infrastructure and the planning and professional development for pedagogical change are required to achieve more student centred teaching. However, ICT can act as a lever for change, providing a strong push toward innovative practices, but the direction of change must be carefully mapped in advance and the staff prepared for it"* (Venezky & Davis 2002, p.14).

In certain cases Venezky and Davis found that where ICTs had been introduced as levers for particular purposes, they had a catalysing effect on other aspects of schooling (2002, p.15).

ICT implementation at a school level should be viewed in the context of school improvement plans and not simply as a technical issue. Problems that schools face should be identified, strategies for overcoming these problems designed, and progress indicators designated. The highest returns on ICT in education appear to come when ICT is seen as part of a strategy for solving an important problem rather than as an end in itself (Venezky & Davis 2002, p.42-43).

There is a complex relationship between ICTs and innovation in schools. Innovation in schools is pedagogical practice supported by ICT, but factors affect innovation unevenly. Certain characteristics of innovations can be limiting and conflicting demands may impact its implementation. ICTs are often assumed to be catalysts for change, but, as argued by Venezky and Davis, they should be used as levers for change. For an innovation to be sustained there need to be mechanisms in place to ensure that their benefits are shared. However, the notion of sustainability also requires clarity.

2.4.6 Sustainability of innovations

The terms 'sustainability' and 'institutionalisation' are often used interchangeably. Institutionalisation occurs when an innovation is assimilated into the culture of an organisation and becomes a part of it, losing its own identity (Miles 1983 cited in Billig, Sherry & Havelock *et al.* 2005, p.987). A sustainable innovation is one that retains its own identity and endures over time as part of the organisational culture (Billig *et al.* 2005, p.987).

Schools that consciously establish themselves as learning organisations and professional learning communities are not always able to sustain their early promise of success in the face of predictable cycles of the attrition of change

(Giles & Hargreaves 2006, p.124). Giles and Hargreaves found that innovative schools possessed some properties of learning organisations and professional learning communities, but were unable to sustain the innovations over time. This ability of schools to sustain innovations over time is addressed by Mioduser *et al.* (2003, p.6) who identify the institutionalisation process as the key element. To be institutionalised requires the innovation to be integrated harmoniously into the *"grammar of schooling"* (Tyack & Tobin 1994, p.453) or the structure of the school as an organisation.

Sustainability is also measured not only by time but also by space: by social organisations, human interactions and virtual spaces (Hargreaves 2002, p.194-197). Two further conditions for sustainability are identified by Mioduser *et al.* (2004, p.7). These conditions are transferability (or the extent to which an innovation succeeds in other settings) and scalability (or the ability of the innovation to perform optimally as it develops). However, as Owston points out, it is the benefit that derives to student learning that is the ultimate test of sustainability of any innovation (Owston 2006, p.14). On the other hand, Louis (2006, p.170), in referring to Giles and Hargreaves' research, notes that it is external pressures such as accountability and budgetary decisions that grind away at school innovation and undermined the creative efforts of teachers.

This section has taken the theoretical perspective of innovation and the diffusion of innovations and explored the implications of innovation for ICT integration. However, the concept of innovation is embedded in the notions of 'change', 'reform' and 'transformation'. It is therefore necessary to establish clarity on these terms and their implications for ICT integration and for whole-school contexts.

2.5 Change, Reform and Transformation

This section will attempt to clarify the nature and understanding of the concepts of 'change' and its associated terms, 'transformation' and 'reform'

and their link to the concept 'innovation' and illustrate the relationship between the terms. The section will also touch briefly on the links between teachers and transformation and between student competencies and transformation.

Hargreaves and Fink (2000) use the terms change and reform interchangeably. In their article on educational reform they refer to *"educational change agentry requiring more than strategies to promote change"* (p.2), *"the ultimate goal of educational reform … continents of change"* (p.5), *"deep and sustainable transformations"* and *"deep, sustainable, generalisable reform"* (p.5). On the same page (p.5), they refer to *"three moral and strategic touchstones of reform"* directly under the heading *"Touchstones of three-dimensional change"*. Their example is typical of the assumed interchangeability of the terms. However, they do also refer to reform in the policy context (p.5), to transforming educational systems (p.1), to *"technological, structural and curriculum innovations"* in schools (p.3) and change as "*what actually happens over time"* (p.2) or the capacity for change (p.4), implying that the four terms refer to each of these domains.

Educational reform is understood as *extrinsic* mandated change such as the *No Child Left Behind Act* in the USA or the Ontario reforms (Jordan 2001, p.349). These reforms came about for economic reasons: the former to improve the skills base of American students and the latter, although it included curricular reforms as part of the process, was designed to effect budgetary limitations (Hargreaves 2003, p.74). In South Africa, educational reforms were designed to address the multi-faceted inadequacies and inequalities of the restrictive apartheid era education policy, as part of national democratic reforms. These reforms have evolved over the fourteen years of democracy into an outcomes based, inclusive education policy and curriculum in which human rights are deeply embedded. However, legislated reform does not precipitate transformation or actual change taking place in practice in schools (Venezky & Davis 2002, p.6; Elmore 1996b, p.23; Billig, Sherry & Havelock 2005, p.998). Global and local societal and technological changes

also set an agenda for reform in schools that, although not mandatory, cannot be ignored. Advances in the understanding of cognition and learning processes suggest the need for reforms in teaching and learning approaches that require radical alteration of teachers' paradigms and pedagogy.

Schools throughout the 20th Century were typified by features such as classes, lessons, age grades, subject-based curricula and lesson-based timetabling and testing (Tyack & Tobin 1994; Giles & Hargreaves 2006, p.124). Tyack and Tobin (1994, p.453) refer to these typical features as the *"grammar of schooling"*. As 20th Century schools attempted to reform through introducing interdisciplinary or open-plan innovations, these grammar of schooling features restrained them and the innovations were short-lived. Where innovative schools have emerged, they have failed to sustain innovative momentum for three reasons (Giles & Hargreaves 2006, p.125). Firstly, they are perceived as *"unlike real schools"*. Secondly, their life-spans are predictable and evolutionary, moving through the stages of *"creativity and experimentation, overreaching and entropy and then survival and continuity"*, after which they succumb to cumulative forces such as parental expectations, pressures from surrounding institutions and some teachers proclivity to the conventional grammar of schooling. The third reason is the occurrence of critical incidents such as reduction in resources and changing power relations (Giles & Hargreaves 2006, p.125).

The effect of mandated reforms on teachers is immense (Hargreaves & Goodson 2006, p.34). Mandated reforms often require teachers to spend so much non-classroom time in meetings or administrative duties that little time remains for informal interaction. Other teachers resist reforms to defend both student and teacher rights and learning and teacher needs. Mandated change or the 'top-down' approach often occurs on a large scale and does not necessarily change how teachers and students experience schooling or what is done in classrooms (Assié-Lumumba 2004, p.78; Hargreaves 2000, p.54; Rowan *et al.* c.2005, p.3). Rather, successful improvement depends on the

interplay of external change agents, school leadership and teachers and students working co-operatively. In other words, the actual changes that happen are 'bottom-up' or ultimately dependent on what happens in the classroom (Rowan *et al.* 2005, p.2). Hargreaves suggests that the problem with most large-scale reforms is that they are not trialled beforehand by governments who are therefore loath to admit when the reforms do not work (Hargreaves 2000, p.56). The question arises of the extent to which *any* educational reform or innovation is trialled beforehand.

Transformation, on the other hand refers to the pedagogical and curricular changes that happen *as a result of* educational reforms, despite educational reforms or as a reaction *to* or against educational reform (Fullan 1991, p.4). Transformation is therefore *intrinsic*. Transformation may take place at different levels: in student and teacher thinking, within a subject or grade level, or across an entire school organisation or district. However, as pointed out by Carlson (2005, p.42), a school exists within a "*discursive economy"* that is unique and efforts to transform need to take cognisance of the complex characteristics of that economy. Mehan *et al.* (2005, p.356) concur with this view in cautioning against applying reforms successful in one school in another with a different context or at a different level (e.g. from primary to secondary school). It is also necessary to understand constraints on teachers' change efforts in order to be able to support such efforts (Rousseau & Powell 2005, p.29-30). Change cannot be managed or controlled, but it can possibly be led (Fullan 2001, p.33). According to Fullan, a clear understanding of complexity science is essential to lead change because leading change means *"unlocking the mysteries of living organisations"* (2001, p.46).

Transformation results from a dynamic interplay of change and innovation. Mehan *et al.* (2005, p.353) describe how introducing innovations into complex systems can result in push-back factors which are *"sometimes predictable, sometimes mysterious"*. These factors have technical, cultural and political

dimensions. In the case described by Mehan *et al.*, technical factors related to capacity and cultural factors concerned the meanings teachers attributed to *"new norms, beliefs and standard operating procedures"* which conflicted with their *"long standing and deeply held beliefs about leadership and teaching roles"*. Political factors emerged from district power dynamics. They suggest that reform is *"a messy, dialogic, and convoluted process, not a linear, direct, and rational process … [that must] … actively engage participants from all local contexts in [its] co-construction"* (Mehan *et al.* p.353-355).

The process of transformation, or the cycle of change and innovation, in any secondary school is not linear, but part of an evolutionary process. Each school will manifest patterns of *"emergence and sudden decay"* in innovations that arise, but are not sustained (Clarke *et al.* 2000, p.1-5). Clarke *et al.* apply systems thinking and complexity theory in an attempt to understand complex transformation patterns in their case studies of Vermont schools. Their work complements that of Tearle (2003, 2004) referred to above, but removes the centrality of ICTs as a change agent and locates them comfortably within the wider transformational context as expressed by Fullan:

> *"It is no longer sufficient to study factors associated with the success or failure of the latest innovation or policy. It is no longer acceptable to separate planned change from seemingly spontaneous or naturally occurring change. It is only by raising our consciousness and insights about the totality of educational change that we can do something about it" (*Fullan 1993, p. vii).

Secondary schools adapt less readily to change than elementary schools and particularly to the changing needs of their students (Hargreaves & Goodson 2006, p.4). Amongst the reasons for this are their size, their complex hierarchical structures, their focus on subject disciplines and their alignment to university entrance (Hargreaves & Goodson 2006, p.4). Given these circumstances, it is very difficult for innovations to become institutionalised.

Change processes need to be studied in context and over a long period of time rather than as detached episodes (Pettigrew, Woodman & Cameron 2001, p.3; Hargreaves & Goodson 2006, p.5; Labaree 2006, p.157) and over a broad cross-section of settings (Hargreaves & Goodson 2006, p.13). Hargreaves and Goodson identified five change forces that had the most significant impact on the structure, culture and identity of schools over time (2006, p.13):

- waves of policy reform
- changes in leadership and leadership succession
- changing teacher demographics and their impact on teachers' generational missions
- shifting student and community demographics and
- changing patterns of relations among schools

To understand change and change forces is therefore to understand context and the effects of context over a period of time. Labaree (2006, p.157) advocates longitudinal studies to understand change as *"an interaction between school and context over decades"*.

Determinants of change include competencies determined by the workplace and that are built into curricula. These competencies are now described.

2.5.1 Student competencies and transformation

Skills required of the 21st Century workplace and therefore of school-leaving students are determinants of change. Determinants include, for instance the SCANS[10] competencies or the similar skill prerequisites embedded as critical outcomes in South Africa in the Revised National Curriculum Statement (DoE 2002, p.4) at school level. The extensive OECD DeSeCo project resulted in a framework of inter-related competencies (2005, p.10-15) that students nearing the end of their schooling careers could be expected to posses to enable them

[10] SCANS = US Departments of Labor and Education Secretary's Commission on Achieving Necessary Skills

to participate fully in society. These SCANS competencies and their indicators are summarised in Table 2.5.

The expectations of competent individuals are therefore that they are able to use a wide range of tools for interacting effectively with the environment including both physical ones such as ICTs and socio-cultural ones such as the use of language. They need to understand such tools and be able to adapt them for their own purposes, to use tools interactively. Secondly, in an increasingly interdependent world, individuals need to be able to engage with others, and interact in heterogeneous groups. Thirdly, individuals need to be able to take responsibility for managing their own lives, situate their lives in the broader social context and act autonomously (OECD 2005, p.5). The implication of these student competencies is therefore that they are prerequisites of teachers responsible for the education of their students.

Table 2.5: Framework of inter-related competencies (Summarised from OECD 2005 pp.10-15)

Category of competency	**Indicator**
Using Tools Interactively	The ability to use language, symbols and text interactively The ability to use knowledge and information interactively The ability to use technology interactively
Interacting in Heterogeneous Groups	The ability to relate well to others The ability to cooperate The ability to manage and resolve conflicts
Acting Autonomously	The ability to act within the big picture The ability to form and conduct life plans and personal projects The ability to assert rights, interests, limits and needs

2.5.2 Teachers and transformation

The traditional classroom is an autonomous zone in which the teacher is free to conduct his or her *"private practice"* (Mehan *et al.* 2005, p.7). However, the traditional classroom can also be an area of enforced isolation (Farmer *et al.* 2005, p.59). Both views need to be countered through effective professional

development (Farmer *et al.* 2005, p.59) to create communities of practice (Hargreaves 2003, p.98; Wenger 1998) and facilitate the development of key competencies in both teachers and students. Effective professional development places the teacher in the role of student, stimulating thinking in new ways of learning. This is essential to encourage *"culturally responsive pedagogy"* in which teachers learn to acknowledge and value the experiences of their students and learn how different a learning experience is from the content of a text book (Farmer *et al.* 2005, p.69). Through culturally responsive pedagogy teachers also learn how to recognise, value and discuss different learning styles and incorporate them in their learning designs. Also, teachers benefit from multiple assessment formats and discover what constitutes authentic assessment. A further aspect of professional development is that *"just as the best teaching empowers students, the best professional development empowers teachers"* (Farmer *et al* p.70). This culturally responsive approach addresses the concerns that culture is the most difficult aspect of a school to transform. Farmer's view aligns with Fullan's suggestions (2001, p.46) of change involving living organisations.

Teachers do not resist change per se, but resist change because they have not been provided with the opportunity to make sense of it (Fullan 1991, p.4). On the other hand, as maintained by Clarke et al. (2000, p.176), where teachers are able to understand the pattern of interactions that support change, it may assist them to shape the process of innovation and change.

In their study of five Vermont high schools Clarke et al. (2000, p.5) identify changes that are self-sustaining within their environments and have become *"permanent features in high schools across the state, with very little policy support from the standards movement"*. In these cases transformation occurred despite mandated reforms. They describe this polarity in terms of, on the one hand, a conservative systemic change that establishes policy structure, common goals, standards and measures of productivity to be applied across the school system. On the other hand, a progressive tendency

"move[s] change incrementally from the bottom of the educational structure, identifying elements of teaching and learning that succeed in one context, then seeking ways to generalize those elements to related situations", favouring responsiveness to individual needs. Clarke *et al.* conclude that both policy and practice need to be aligned for both to be successful (2000, p.6-7).

Clarke *et al.* explored and tracked the complex interaction between policy and practice during a period of dynamic change and developed a *"visible form for the invisible dynamics of change"*. The various stages of development culminated in their visual representation of *"Hypothetical phases of change"* (2000, p.31) and *"Hypothetical patterns of energy flow"* (2000, p.33). These visual representations showed that "*rather than new practices being developed to fit new policies, we discovered existing programs that were continuously adapting to new opportunities"* (2000, p.11). Clarke *et al.* have provided the framework that Tearle calls for in her recommendations as well as locating ICTs within the whole school context (Tearle 2003, p.581).

From their research Clarke *et al.* (2000) were able to draw inferences on student engagement (2000, p.153), the dependence of change on the presence of a *"dogged pioneer"* and support from reliable partners within and beyond the school (2000, p.154). They also found that:

> "*Increased interaction across organizational lines increased the rate and depth of the change process within the schools, … that promoting reform within any high school depends on expanding existing patterns of growth in that school, rather than on a unitary version of how change should occur in all settings*; … *that systemic change depends upon high levels of energy exchange among all levels of school organization, self-organizing to actualize a shared vision of student learning within that school" ...* [and that] *"change in high school teaching proceeds from existing strengths within a school program, gaining momentum*

> *through connections with related ideas that are also forming within a particular school"* (Clarke *et al. 2000,* p.154-155)

The dynamics of high school reform are explained by Clarke *et al.* through the features of complexity theory: "*adaptation, self-organising growth, confluence of energy, convergence of resources, mutual empowerment, organizational reciprocity and leadership density"* (2000, p.157). Change flows from the frequent interaction of individuals up to organisational level at the same time generating sustaining energy as innovations generalise and become part of the change process. Clarke *et al.* conclude that interactions need to be sustained between individuals across organisational levels (2000, p.156).

Sherry and Gibson built on Clarke and Gibson's model and extracted three principles from their research on adoption of ICTs by teachers that form a *Systemic Sustainability* model (2002, p.9). These principles – convergence, mutuality and extensiveness – categorise the interactions between different layers of a school system. The principles are critical processes that allow interactions between different levels of the system and are thus essential to the sustainability of transformation. Sherry and Gibson explain that convergence refers to the highest level of a school hierarchy – classroom, school, district or virtual learning community – to which an innovation diffuses. For example, an innovative teacher will be able to influence colleagues in different departments if support is offered by the school leadership. Mutuality refers to the need for a common benefit of the innovation to either side of a boundary. Mutuality ensures the flow or confluence of resources and influence across boundaries, particularly through dialogue between individuals, for example, encouraging an innovative teacher to provide peer leadership will encourage further innovation by that teacher as well as assist the diffusion of the innovation into other classrooms. Extensiveness refers to the extent to which an innovation reaches across all levels of a school system and is sustained over time. The important features of the innovation need to be identified and supported in *all parts of the system*. Where resources

converge, sparking mutual benefits across at least two levels, further extending their influence over time, systemic sustainability is possible and transformation occurs (2002, p.7-9).

The terms reform, change, transformation and innovation, whilst often used interchangeably in the literature, are therefore understood in the following way. Transformation is the expected process or processes through which schools within the educational system strive to meet the requirements of mandated or top-down reforms. Change is what actually happens within a school as an organisation as a result of transformational processes, although the resulting change may or may not be what is intended by the actual reforms. Innovations are the changed practices as implemented in the classroom. Innovations may be personalised, that is, emanating from an individual teacher's own pedagogical practice, or institutionalised, resulting from a top-down developmental process. The interrelationship of these terms is illustrated in Figure 2.3 below.

Figure 2.3: The interrelationship of reform, transformation, change and innovation in the school context

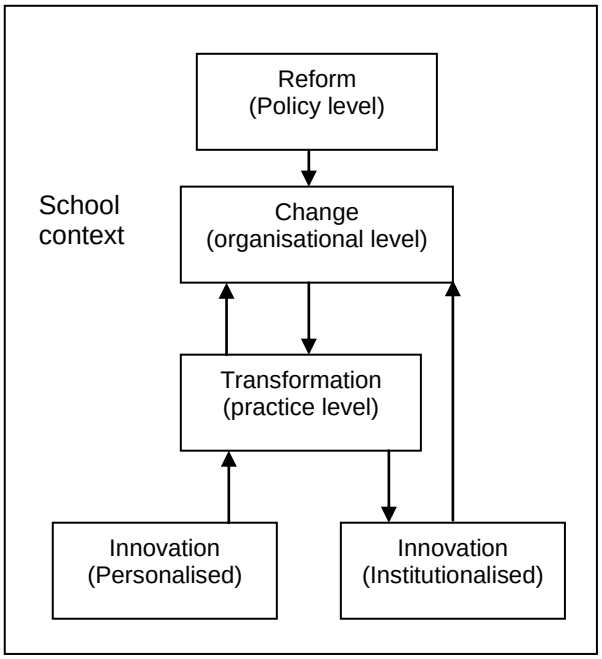


Figure 2.3 illustrates how reforms are generated at policy level for implementation at the organisational level. As implementation proceeds, change happens within the organisation as a whole. Transformation happens in teacher practice when changes are internalised at the personal level. As transformation in practice spreads, innovations become institutionalised and change is accomplished.

The relationship between ICTs and transformation will now be explained.

2.5.3 ICTs and transformation

Early expectations of ICTs were that they would revolutionise schools. However, if ICTs had only to be provided in order to effect such a revolution then that revolution should have occurred. Whilst ICTs can contribute to the transformation of learning environments, they cannot do it by their mere presence alone. Brackett explains the issue of ICTs and transformation in this way:

> *"Technologies do not change schools in any sense worth talking about. Thoughtful, caring, capable people change schools, sometimes with the help of technology, sometimes not and sometimes even despite it. Too often, we focus on the technology rather than the reform. … Admittedly, some reforms might seem impossible without new technologies. But the essential reform here … is the engagement of these students in doing real science, in collaboration with real scientists, instead of reading and talking about science and repeating memorized science factoids. … It's the pedagogy, not the technology that's the key. … It's a mistake to put technology centre-stage as we plan and execute educational reforms"* (Brackett 2000, p.29-30).

In contrast to Brackett's view, there is a tendency to perceive ICTs as the salvation of education such as espoused by Blasik *et al.* (2003, p.44). On the strength of one successful project she states that "*districts across the nation*

can replicate a program that ensures high school completion while readying students for college education, post-secondary technical study and mid- and high-level employment". Tearle (2003, p.579) also refers to *"the more exciting and challenging vision of ICT to revolutionise the way we teach, or facilitate others to learn"*. Beastall (2006, p.97) is more circumspect of the potential of "*technology transforming [the] British education system"* echoing in response to this adage Windschitl's earlier call to concentrate on pedagogy, not ICTs.

Without comprehensive reforms involving contextual variables the benefits of ICT integration to student learning cannot be achieved and ICT integration cannot be understood. These variables include instructional leadership, extensive professional development, a whole-language approach to learning, establishment of libraries, de-emphasis on remediation and emphasis on fostering student creativity (Carrigg & Honey 2003, p.6). Similarly, Scrimshaw (2003, p.93) locates ICT integration within curriculum innovation, recognising that new developments can originate at school, community, national or regional level and be disseminated in a variety of ways. Scrimshaw echoes the competencies (Ch.2 Table 2.5, p.81) suggesting that schools should be able to provide universally high levels of achievement in core skills, achieve greater levels of competence in *"workplace attitudes and skills and develop school leavers with the attitudes, motivation and skills needed to equip them for a life of self-managed learning"* (p.89). Scrimshaw offers (2003, pp.93-97) various complex curriculum scenarios at global national, local and school levels, supported by network connectivity, which all depend on the level of ICT integration in individual schools.

Accordingly, the integration of ICTs in secondary schools is interwoven in complex ways with the whole school context. To understand ICT integration therefore requires an understanding of the complexities of context. To understand context it is necessary to understand the interactions within the context. Such interactions are defined within complexity theory. The pathway to complexity as the theoretical underpinning of this study was influenced

particularly by the work of Clarke *et al.* (2000) and of Sherry and Gibson (2002) on innovation and interactions within complex contexts. The next section will therefore explore complexity theory and its application to school contexts and to ICT integration and show the derivation of the conceptual framework for this study.

2.6 Complexity theory

This section will consider literature relating to complexity as a theoretical underpinning to the integration of ICTs in schools. Complexity theory is defined and described and then related to knowledge and learning, to schools and to the integration of ICTs in schools in terms of organisational behaviour.

2.6.1 Complexity theory and organisational behaviour

Complexity theory falls within the ambit of systems thinking (Boulding 1956, p.197; Senge 2006, p.69; McElroy 2000, p.200) as applied to organisations as well as to the physical sciences (Davis & Sumara 2005, p.443). *"Complexity theory, or the science of complexity, is the study of emergent order among disorderly systems. Complexity theory offers an explanation of how cognition happens in human social systems … systems thinking applied to the behavior of natural systems"* (McElroy 2000, p.196). With origins in 19th Century evolutionary and social science thinking, complexity theory emerged in the 1950s in response to a need for a way of explaining the complex relationships between disparate phenomena within the empirical world (Boulding 1956, p.197). Complexity theory does not assume a single theory as the explanation of everything; rather, it aims to *"highlight similarities in the theoretical constructions of different disciplines"* (Boulding 1956, p.197). Complexity theory does not try to understand the whole by understanding its parts; but rather aims to understand the interaction of its parts (Phelps & Hase 2002, p.510). It is the interaction of such parts within a complex context that is of interest in this study.

Change in a complex system is dynamic and to understand the parts, it is necessary to understand the whole for it is small changes that force larger systems to adapt and changes in larger systems that force new innovations to emerge (Morris 1997, p.24; Clarke *et al.* 2000, p.17). At the same time, as each innovation affects its intended environment, the innovation itself must adapt in response to the change in the environment (Morris 1997, p.24). Change and adaptation are therefore mutually inclusive and contribute the dynamic element of complexity. Lissack (1999, p.120-121) notes that, whilst organisations had previously focused on *controlling* the uncertainty that arises from dynamic interactions, since the 1990s complexity science has focused instead on *understanding* and *channelling* that uncertainty.

Complex systems display certain characteristics. They are unpredictable (Davis & Sumara 2005, p.455), self-steering (Lissack 1999, p.112), non-linear (Wheatley 1994, p.119), structure-determined and emergent (Lissack 1999, p.112; Davis & Sumara 2005, p.455). Complex systems operate in identifiable complex patterns of interactions between change and innovation. Complexity theory describes the entities that generate innovation as agents. Multiple agents exist within a system. An agent could be anything from a neuron to an experience or an individual person, depending on the point from which the learning or change process is viewed (Doolittle 2001, p.2). Agents interact with each other producing energy. The greater the interactions, the higher the energy levels generated. The higher the energy levels, the less likely the predictability of the outcomes (Clarke *et al.* 2000, p.18). As innovations become embedded within a system, the more complex the interactions between agents become and the sustainability factor of the innovation rises. Sustainability emerges from within and cannot be applied externally therefore complex entities are largely self-steering. Multiple interactions form a non-linear web of systemic change (Wheatley 1994, p.118). Controlling uncertainty implies imposing a level of order within this web, whereas unbridled stimulation of creative energy can lead to chaos or weakening of its tensile strength (Lissack 1999, p.120-121).

Table 2.6: Six principles of Complexity Science (adapted from Webb & Lettice c.2005 p.2)

Principle	Associated organisational behaviours
Self-organisation & emergence:	*Organisations show self-organising behaviour is supported by an enabling environment. Self-organisation means that the system organizes itself, i.e. that the single agents of the system find a structure bottom-up on their own, without having a master-plan or an observational guider telling them how to organise.*
Edge-of-Chaos:	*The edge of chaos can be interpreted as the balance between structure and flexibility that a company needs to become robust. In complexity science, the edge of chaos, i.e. the zone between complete stability and complete chaos, is the area, where the system is most productive;*
Diversity:	*Organisations need a diverse set of agents to be successful and to enable an effective structure to emerge. In companies, this means that the right mix of people is indispensable for innovation and creativity. Self-organising teams cannot work if all team members have the same strengths and weaknesses; it is the combination of different abilities that makes such a system creative, but also robust;*
History and Time:	*Organisations have a sense of historicity. This means that, although the future behaviour of an organisation cannot be extrapolated from the past, the past of this system is still important for its present and future position;*
Unpredictability:	*The notion of unpredictability implies that the development of an organisation cannot be foreseen, i.e. not extrapolated from past behaviour) and not calculated on the basis of linear cause-effect relationships.*
Pattern Recognition:	*Organisational and employee behaviour show patterns. In the natural sciences these patterns can, for example, be observed in a flock of birds or the complex structures of bee hives. Human beings, however, have a natural urge to identify patterns in the evolution of complex systems, which can be helpful but also dangerous in the corporate context (because the human brain tries to identify patterns even if there are no patterns).*

Complexity theory differs from traditional analytic scientific theory in that it studies phenomena at the point at which they emerge or self-organise (Davis & Sumara 2005, p.455). In contrast, scientific theory relies on a conscious and deliberate process of prediction, experimentation, observation, pattern-recognition, hypothesising and generalisation (Cohen *et al.* 2000, p.16). The dynamic nature of complexity dictates the necessity for its phenomena to be

studied at this point of emergence. Phenomena may also display coherent collective behaviours which cannot be understood by reductionist analytical methods (Klein 2004, p.4). The notion of unpredictability is linked to the characteristic of structure determinism in which phenomena are inexplicably able to "*adapt themselves to maintain their coherence in the face of changing circumstances"* (Davis & Sumara 2005, p.455). As a consequence, the replicability requirement of traditional experimental methods cannot apply to the study of complex phenomena.

Webb and Lettice (c.2005, p.2) describe the characteristics of complexity theory as six principles associated with certain organisational behaviours (Table 2.6). These principles of complexity science were derived from research conducted in a Europe-wide corporate partnership (Webb & Lettice c.2005, p.2) and are intended to be used to help organisations deal with uncertainty. The principles may be applied equally to schools.

It is not only organisational behaviour to which complexity theory applies. Knowledge construction and the process of learning also manifest principles of complexity theory.

2.6.2 Complexity theory, knowledge and learning

Complexity theory applies to the body of knowledge and to the process of learning. Knowledge itself is no longer divided and compartmentalised in a linear structure but in a network, web or rhizome structure (Klein 2004, p.3) with infinite complex possibilities of interconnection and interaction. Knowledge generation is no longer the domain of venerated experts but of *"affiliations, coalitions and alliances"* through "*dialogue, interaction and negotiation"* (Klein 2004, p.3) at all levels. Knowledge sharing and knowledge construction underlie individual and social construction of knowledge and collaboration is necessary to such construction in schools (Reynolds 2005, p.67).

Complexity theory applies also to learning and thinking as an emergent process in which ideas and concepts are formed within a unique context and outcomes cannot therefore be predicted (Bloom 2001, p.23). Davis and Sumara (2005, p.458) extend Bloom's notion, referring to the *"nested organisation"* of individual and community. They suggest that all complex phenomena are cognitive agents or learners explaining that the brain is continuously evolving as it learns (2005, p.456). However, 'the learner' may refer to not only the physical entity of an individual, but also to the abstract concepts of organisation or community. Davis and Sumara's concept of this nested organisation of knowledge is illustrated in Table 2.7 below.

Table 2.7: The nested organisation of knowledge (after Davis & Sumara 2005 p.458)

Cognitive agent or body	Theory	Evidenced in
individual biological body	constructivism	individual knowing
social corpus	socio-constructionism	collective knowledge
society (body politic)	critical theories	cultural identity

Davis and Sumara suggest (2005, p.458) that each cognitive agent is concerned with a particular body. Each body learns in a different way: the individual through constructing knowledge, a defined group (e.g. a group of teachers) through socially constructed knowledge and a cultural group through power-related critical theory. Davis and Sumara describe these different bodies as nested: the individual within a social corpus, the social corpus within society.

Learning is a dynamic process of accommodation and self-organising adaptation (Doolittle 2001, p.5). Knowledge results from the interaction between the learner and the environment and learning or knowledge acquisition results from the construction of representative models filtered through and influenced by "*one's beliefs, culture, prior experiences, and language, based on interactions with others, direct instruction, and modelling"* (Doolittle 2001, p.5). Knowledge is therefore constructed through interactions

with multiple facets of the complex environment. Complexity increases as learning levels increase (Goodison 2003, p.10). Whereas "*complexity provides a metaphor for myriad phenomena … constructivism provides a metaphor for learning"*. From these metaphors Doolittle derives the concept of complex constructivism, which embraces the *"non-linear, adaptive, and constructive nature of learning"* (Doolittle 2001, p.16). The learning process is dynamic and complex in that at the point when new knowledge is understood it immediately changes the body of knowledge within the brain and forms a changed entity or frame of reference for the acquisition of further understanding. Any new idea that is introduced at any stage may lead to outcomes other than those predicted (Phelps & Hase 2002, p.515). Therefore, introducing innovations into a complex entity such as a school may often result in a differing effect to what is intended because of technical, cultural or political constraints (Mehan 2005, p.353).

The construction of knowledge and the process of learning are the business of schools. It is therefore logical that complexity theory will apply to the acquisition of knowledge through the processes of learning in schools. Schools are also complex entities in themselves.

2.6.3 Complexity and schools

Viewed from a complexity perspective a school or its components cannot be evaluated at a specific point before and after an intervention. Nor can an aspect of that school be fully understood in terms of either teachers as agents, students as agents or the organisation as agent. Instead, it is only possible to understand a school in terms of the *interactions* between agents.

Schools, and secondary schools in particular (Clarke *et al.* 2000, p.160), are recognised as complex systems (Bloom 2000, 2001 unpaged; Clarke *et al.* 2000, p.12; Davis & Sumara 2005, p.453; Doolittle 2001, p.9; Eadie 2003, p.2; Hennessy, Ruthven & Brindley 2005, p.6; Phelps, Hase & Ellis 2005, p.73) in which teachers, as agents of innovation, each contribute new understandings

from their unique perspectives (Clarke *et al.* 2000, p.160). The culture of a school is a "*complex web[s] of traditions and rituals that ha[ve] been built up over time"* (Deal & Peterson 2000, p.182).

The process of understanding how schools as organisations transform is "*both a complex and a messy business"* (Schmidt & White 2004, p.207). Structures and systems for formal learning in secondary schools are so well designed for stability that their systems limit adaptive growth, making transformation difficult (Clarke *et al.* 2000, p.5). The challenge to secondary schools therefore is to simultaneously maintain a balance between stability and change, between a predictable order and the unpredictability that produces new energy (Clarke *et al.* 2000, p.17).

When ICTs are introduced into the stable systems of schools they offer radically different opportunities that challenge these traditional systems in complex ways.

2.6.4 Complexity and ICTs in schools

The integration of rapidly evolving ICTs into school curricula, described by Scrimshaw as *"one of the largest and most complex curriculum innovations ever undertaken in schools"* (2003, p.85) adds a further degree of complexity to an already complex environment (La Grange, Artigue, Laborde & Trouche 2001, p.22) and can increase the rate of interactions with potential instability. Staples, Pugach and Hines (2005, p.307) concluded that the analysis of their study elucidated the complexity of the interactions between curriculum, technology and professional development, while Tearle (2003, p.567) refers to the underestimation of the "*complexity of the processes and culture shift"* required to achieve the potential of ICTs. Tearle refers also (2003, p.267) to the moving goal posts, suggesting that developments in ICTs are moving as fast as adaptation takes place, thereby maintaining the gap between actual and potential use. However, Tearle notes that some individual schools have managed to succeed in integrating ICTs into the curriculum, whilst others

have failed, despite the presence of enabling factors. Tearle argues that "*whole school contexts, goals and interpretations of the need and value of deploying ICT create a much more complex picture"* (Tearle 2003, p.568).

ICTs also provide students with the connectivity to explore an increasingly interconnected and complex world (Hargreaves 2003, p.xi), while paradoxically adding to the complexity of their world (Harada 2001, p.42). Skills that students need, including managing complexity (Dede 2000, p.301) are defined by the workplace; skills that students want are determined by their facility with technology, particularly mobile technology and video games. There is a need therefore to understand the difference between educators' and students' perceptions of what students need as well as to understand the paradox (Harada 2001, p.42) that ICTs present.

According to the literature, complexity theory therefore applies to schools as organisations, to the learning process and to the concept of knowledge itself. In the same way complexity applies to the integration of ICTs and to transformation within and of school environments. Finally, complexity applies to the convergent world in which all schools operate.

Davis and Sumara sum up complexity with eloquence:

> *"... even the most profound knowledge of the subsystems that come together to form a complex system will not help us to predict or to control the behaviors of such systems. The most thorough understandings of hearts, livers, brain stems and skin does not help us much in accounting for the emergence of such complex phenomena as consciousness and identity. Although these 'components' all contribute to such phenomena, their interrelation is too complex to understand through a process of fragmented study. It is the relations among them, not the things themselves, that are productive and, as such, of interest"* (Davis & Sumara 1997, p.114).

To understand complexity is to understand the dynamic interactions that constitute the temporal relationships of school contexts.

2.7 Summary of the literature review

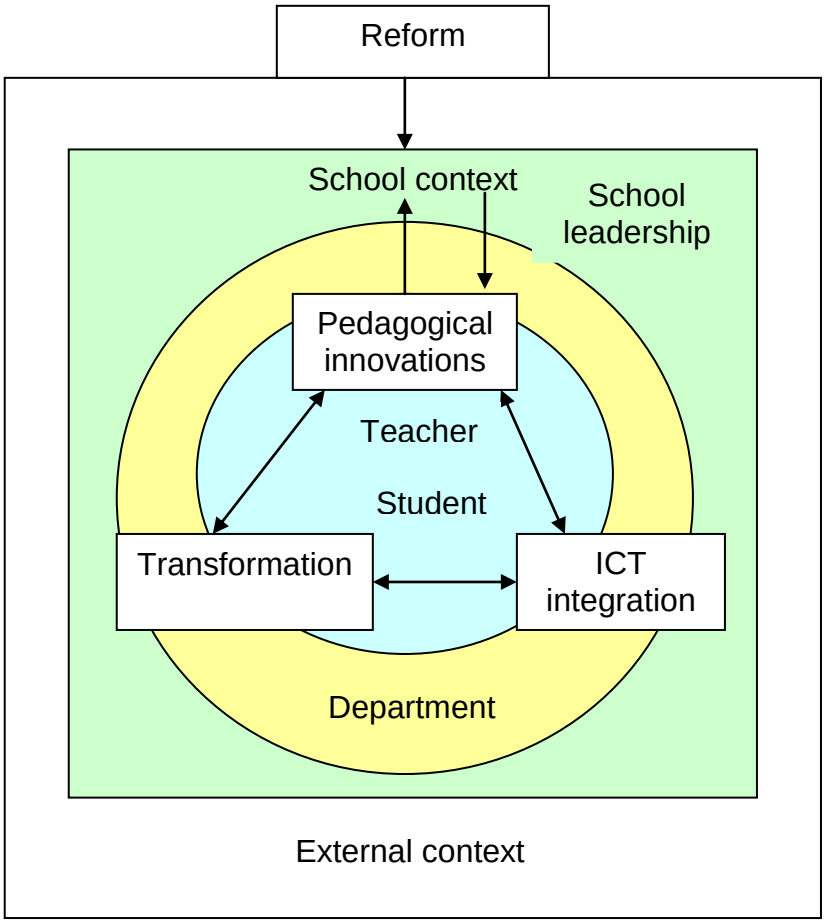
This literature review has described the extent and complexity of the issues of ICT integration. ICT integration needs to be understood in terms of the pedagogical innovations that teachers need to introduce into their practice and such innovations are context-dependent. The review has therefore considered the multiple perspectives that accommodate the complexity of such adjustments that schools and teachers need to make. These perspectives are those of ICT integration; the relationship between innovation reform, transformation and change; and that of complexity theory as well as the relationships between these perspectives. The next section will describe the derivation of the conceptual framework for the study based on these multiple perspectives.

2.8 Towards a conceptual framework

Multiple perspectives of school contexts emerge from the literature. Figure 2.4 is a graphic representation of the inter-relationships between the multiple perspectives that emerge from the literature. The teacher functions within a department within the school context. Reform, conveyed through policy is external and applies to the whole school context. The intention of the reform is transformation within the whole school context. The teacher is central to the context and the transformation process and responds to the reform with innovation in practice. In order to innovate, the teacher may or may not make use of ICTs which are provided in the context for curricular and professional use. Interactions occur between each level of the environment i.e. the external context, the school context and the professional and personal context of the teacher. Interactions also occur between individuals on any level of the environment. For a teacher to innovate in response to either intrinsic or extrinsic motivation involves complex interactions.

These interactions occur between the teacher and the physical entities of the immediate environment or department, of the whole school environment and of the external environment. Similarly, interactions occur within the social environment between teachers and students, between teachers and colleagues within and across departments, and with school leadership as well as external agencies. Interactions also occur with abstract entities such as information and creative ideas or beliefs, attitudes and disposition, personal history or opportunities. These entities form the context that affects each teacher as an individual in a unique way and have a bearing on their ability to innovate.

Figure 2.4: Relationship between perspectives

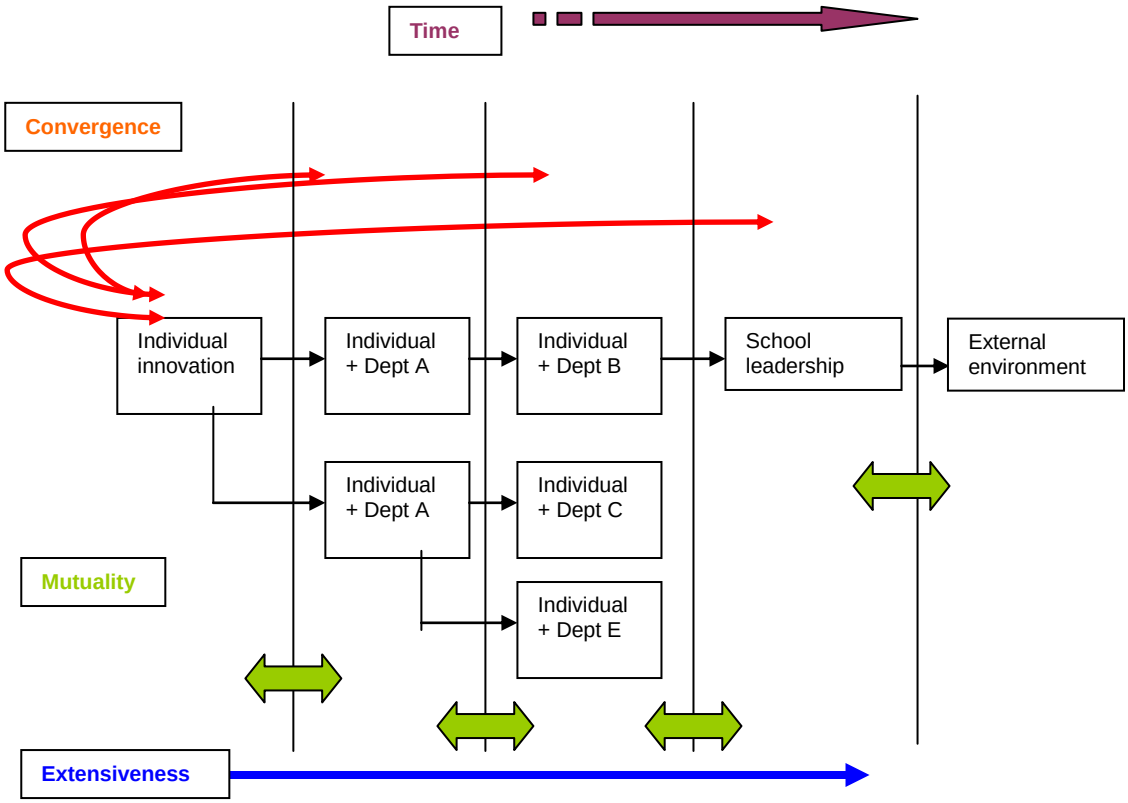


A diagram cannot show the complexity of interactions between each element. To illustrate such interactions would imply the control that complexity repels.

The study draws on the three critical processes of convergence, mutuality and extensiveness which underlie the sustainability of innovations (Sherry & Gibson 2005, p.6; 2002, p.7). These processes are explained in Section 2.5.2 p.86 above and are illustrated in Figure 2.5 (below). The figure shows the three processes which underlie the diffusion of a teacher-generated innovation and how it might become sustainable over time.

In the example in Figure 2.5 convergence occurs enabling an individual innovation in teacher practice. If the benefit of the innovation extends to a further individual with benefit to both parties, then mutuality is recognised. The further the benefit extends over distance and time, the greater the chances of an innovation becoming institutionalised and achieving transformation at whatever levels it targeted.

Figure 2.5: Conceptual framework: Diffusion of innovations within a school system



2.8.1 Applying the conceptual framework

This conceptual framework constitutes my theory about the world that I am researching. It derives from my own experience as a practitioner-researcher and from the literature web that has been described along the pathway of this review. The conceptual framework therefore guided the development of the research instrument and the description and explanation of the phenomena but not the analysis of the data (Rossman & Rallis 2003, p.120). However, the analysis is grounded in the data provided through interviews and observation.

2.9 Summary of Chapter 2

This chapter has reviewed the literature relating to the effect of context on teachers' ability to innovate with ICTs in secondary schools. In order to understand the effect of context it has explored the literature on ICT integration and on innovation and change. Complexity theory was described as the underpinning theory of innovation and change which are integral to ICT integration. The review explained how the construct of ICT integration developed over time and the need to understand it within the context of innovation and transformation. The work of Clarke and Gibson (2000) and the terminology developed by Sherry and Gibson (2002) in response to the findings of Clarke and Gibson were used to develop the conceptual framework which guides the research process. The next chapter will describe and discuss the research methodology, design and process of the study.