Chapter 1

Introduction and orientation

1.1 Introduction

This study investigates influences on the implementation of a computer-integrated education project, with a view to ensuring the sustainability thereof. Furthermore, the study considers influences that originate within the project, as well as influences that originate in the larger system in which the project is embedded. An understanding of the way in which all these influences are interrelated might suggest ways in which the sustainability of similar projects could be addressed during the implementation phase.

1.2 Background

Numerous studies document factors influencing the successful modelling and support of computer-integrated education initiatives at school level (Mooij & Smeets, 2001; Baylor and Ritchie, 2002; McMullan, 2002; Shuldman, 2004; Bebell, Russel and O' Dwyer, 2004; and Plomp and Pelgrum, 2005). In the first place, the emphasis in each of these studies is placed firmly on the pure implementation of computer-related technology rather than on implementation of such technology with a view to ensuring the sustainability of the initiative. In this sense, the studies represent an account of static situations rather than dynamic processes.

Secondly, such implementation initiatives are characteristically embedded in a systemically significant context, such that Mooij and Smeets (2001) identify a multi-level structure of education relevant to the implementation of computer-integrated education in schools. These structural levels range from the international, national, regional and administrative levels to the level of the individual pupil and internalised learning processes. Such multi-layered contexts provide comprehensive momentum and support for successful implementation. What is not clear, however, is the effect of a withdrawal of the momentum and support supplied by such a rich, multi-layered external context on the implementation and sustainability of computer-integrated practice in individual schools. Nor are such processes easily observed since initial contextual investments in terms of time and money usually preclude stable

investors, such as departments of education, from withdrawing support and thus risking the success of the project.

In this respect, the CALIS (Computer – Assisted Learning in Schools) Project, initiated by the Orange Free State Education Department (OFSED) of South Africa, provides a unique opportunity. The Project was originally designed to implement computer-integrated education in selected schools in the region. Deserving schools and deserving teachers were identified and trained to facilitate co-operative learning. Teachers were then supplied with enough computers to ensure that roughly one third of their class could work on computers simultaneously. The Project was officially set in motion with the presentation of the first CALIS conference (or 'expo', as it was known at the time) in 1993. The Project continued during 1994 and 1995. It was, however, officially abandoned by the OFSED in 1996 when the new government identified other priorities, thus paring down contextual support and exposing individual institutions to the prospect of ensuring the sustainability of computer-integrated education in their institutions without further assistance.

Such might be the supposition, on face value. The supposition seems to find support in the fact that many of the schools in which the Project had originally been implemented had been unable to sustain institutional computer-integrated education over time. In the narrative produced by Johan Badenhorst, he mentions, by name, ten schools where the Project had originally been implemented but where computer-integrated education could not be sustained over time. These institutions are situated, in the main, in small rural towns: Clocolan, Koffiefontein, Hertzogville, Bultfontein, Hoopstad and Viljoenskroon. Not one of the 'unsuccessful' institutions identified by Johan Badenhorst is situated in Bloemfontein, the only relatively large city in the region.

In contrast, Johan Badenhorst mentions by name 27 schools (see Appendix A) where the 'fruits of the Project' are still visible today. These schools are situated in all districts in the region. They are also situated in larger towns and cities, as well as relatively small rural towns. Maureen Dale provides supporting evidence with respect to eight schools in Bloemfontein that she knows to be presenting computer-integrated academic offerings at present.

According to all participant narratives, schools tended, over time, to move computers from the classrooms, where they had originally been installed, to dedicated computer laboratories. Such installation, claims Johan Badenhorst was followed in many schools by the appointment

of a dedicated 'computer laboratory teacher'. He is also adamant that the use of such laboratories in schools was aimed, not at computer literacy in the first instance, but rather at the integration of computers into the curriculum during scheduled academic periods. Furthermore, many schools entered into agreements with private partners such as *Future Kids*®. Such partnerships contributed towards the continued financial viability of computer-integrated education in schools.

1.3 Problem statement

Given the situation sketched in participant narratives with relation to the continued use of computer-integrated education at schools involved in the CALIS Project, a number of questions arise:

- why did computer-integrated education die out at some schools;
- why are most of the schools at which it died out situated in smaller rural towns;
- what influences or circumstances enabled some schools to continue offering computer-integrated education in their classes long after official government support of the Project had been withdraw?

Assuming that the withdrawal of government support did influence the continued existence of the Project negatively, answers to the first two questions are readily found. It might be supposed that such withdrawal of support could have had a detrimental effect on the continued existence of computer-integrated education at some schools – particularly schools situated in small rural towns where rich contextual support systems that characterise urban settings are largely absent. This much seems reasonable.

It is, however, the plausibility of such conjecture which makes the third question, mentioned above, even more difficult to answer. If the rich contextual systemic support afforded schools in urban areas plays an important role in ensuring the continued existence of such projects, why is it that so many schools situated in smaller rural towns continued offering computer-integrated education long after official support had been withdrawn? Clearly, there must have been other influences at work in bringing about continued usage. It is this puzzling aspect of the situation that led to the formulation of the research questions presented in the following section.

1.4 Research questions

In an attempt at identifying as many influences on the implementation and sustainability of the Project as possible, the main research question was formulated as widely as possible:

> ***How did influences on the implementation of the CALIS Project affect the sustainability thereof?***

Because of the breadth of this question, five sub-questions, dealing with specific aspects of the main research question, were arrived at:

> *1. How did personal qualities, possessed by people directly or tangentially involved in implementing the Project, influences the implementation and sustainability of the Project?*
>
> *2. How did elements of programmatic design (those elements of programmatic design specifically embodied in the goals of the Project) influence the implementation and sustainability of the Project?*
>
> *3. How did the availability of physical resources during implementation influence the sustainability of the Project?*
>
> *4. How did the larger systemic environment in which the Project was implemented, influence the sustainability thereof?*
>
> *5. How was the further development of the Project affected by the animated, interactional interrelatedness of the complex system infused by all of the influences mentioned above?*

1.5 Purpose of the study

The purpose of this study is to arrive at a description of the way in which various interrelated influences affected the implementation of the CALIS Project, with a view to ensuring the sustainability thereof. This description is then to be followed by an indication of important influences on sustainability to be borne in mind during the planning and implementation of similar projects, situated in similar dynamic, complex educational environments.

1.6 Objectives

Given the purpose of the study, outlined in the previous section, a number of more specific objectives may be identified. In the first place, the study sets out to confirm or contradict the notion (see Mooij and Smeets, 2001) that the educational system is characterised by the existence of a number of vertical structural levels ranging from the international level to the level of the individual learner. In addition, the study seeks to confirm / contradict the notion that the presence of 'active contributors' at each of these levels affects the sustainability of individual projects situated in the larger educational system.

Secondly, the study sets out to ascertain whether the suggested influence of active participants at the various structural levels of the educational system can be viewed as the sole kind of influence on the implementation for sustainability of computer-integrated education projects. Are there not programmatic and systemic influences on these structural levels that also influence the implementation and sustainability of such projects?

Thirdly, the study is aimed at elucidating the general characteristics of the kind of system (educational system) within which computer-integrated education projects are implemented.

Related to this objective, is the aim of establishing the way in which influences on the implementation and sustainability of such projects are dynamically entwined co-determinants of such implementation and sustainability.

1.7 The scope and context of the study

The study examines a specific computer-integrated education project, namely the CALIS Project that was implemented in the Free State Province between 1992 and 1996, with a view to describing the way in which influences on the Project affected implementation and sustainability. The study is conducted against the backdrop of a dearth of inclusive definitions of sustainability in the literature. Also, there is an absence of comprehensive treatments of influences on sustainability of such projects in the literature.

1.8 Exclusions from the study

The study does not seek to examine influences on the further sustainability of the CALIS Project, simply because post-implementation developments in individual institutional environments are likely to have proceeded in unique ways. Such unique, and often unpredictable, development is consonant with what is reported in the literature on the nature

of dynamic complex systems (Senge, 1990; Stacey, 1996; Cavallo, 2004; Fullan, 2005), Rather, the study focuses on a wide variety of influences on the implementation of the Project that enabled the unique, evolutionary development of the Project in specific host environments.

1.9 Limitations of the study

As a result of this exclusion, the study does not make predictions regarding the sustainability of the Project over time. In fact, one of the characteristics of dynamic, complex systems is the fact that long-term developments are essentially unpredictable. Coupled with this proposition is the proposition that dynamism implies evolution over time. Such evolution over time begs the question as to whether the evolved project is still substantively the same project, or whether it has become something completely different. It is therefore inevitable that sources of noise brought about by the passage of time will be discernable in the research report.
The study is thus limited to an exploration of influences on the implementation of the Project and the extent to which such influences might have enabled the evolutionary further development of the Project. The report specifically documents positive influences on the CALIS Project since the focus is placed squarely on sustainability. The reader will, however, be able to deduce from the absences in the text the role played by negative influences on the Project.

1.10 Significance and potential contribution of the study

The opportunity afforded by this Project lies in the possibility of investigating not only the process nature of the implementation, use and sustainable use of computer-integrated education in schools. It also elucidates the multi-directional, mutual causal relations that define an educational programme as complex system. The existence of such complex systems in the no-man's land between chaos and regulation (Stacey, 1996) implies that deterministic predictability at the micro-level is impossible. What is possible, however, is the drawing of multiple inferences which may be identified with in terms of varying degrees of certainty at the macro-level. An investigation into the influences on the implementation and sustainability of the CALIS Project could provide insight into the way in which similar projects, determined by common dynamics, characteristic of complex educational systems, might be implemented with a view to addressing sustainability.

1.11 Research method

. Qualitative research allows for the inferential interpretation of narratively-constructed, plural and interior realities (Patton, 1985; Miles and Huberman, 1994, p.41). In this sense, the choice of a broadly-characterised qualitative approach was the natural choice in terms of examining a complex, educational system. I have consciously avoided the use of the term 'paradigm'. It is impossible to conduct research on an indeterministic and unpredictable complex system under the banner of a particular 'paradigm', the tenets of which the system does not adhere to. Rather, the postmodernist-inspired approach to research values multi-vocality, narrative, culturally-inspired mythology, and the value of minority or previously disempowered voices (Woods, 1999; Schostak, 2002). In this way, the 'master narrative' of the selected 'paradigm', is discarded in favour of a plurality of narratives. My own narrative, in the form of this research report, is inescapably an interpretation of narratives produced by participants (Kvale, 1996). Such narratives, in turn, are an interpretation of an individually constructed reality, shaped partly by cultural mythology and metaphor. For this reason, narrative, religious and cultural mythology, and metaphor play a central role in this research project.

1.12 Research design

The CALIS Project appeared to have many of the characteristics of a case study. It appeared to be 'bounded' (Yin 2003, Merriam, 1998); it appeared to be a 'unique' occurrence (Yin, 2003, p.40; Cronbach, 1975; Merriam, 1998;); it appeared to demand an answer to a 'how' question (Yin, 2003, p6); it appeared to be situated very clearly in the past and thus fall essentially beyond my control or the control of the participants (Yin, 2003, p.7); it appeared to involve a programme or process that was inextricably linked to organisational change (Yin, 2003, p.23). In Yin's view (2003, p.8), the case study research design adds two tools to the researcher's repertoire that are not available to the historical researcher, namely direct observation and the possibility of interviewing participants. I therefore, selected the case study design as the most appropriate way of eliciting the information that I needed.

Furthermore, the situatedness of the CALIS Project within a wider complex systemic context accorded well with views expressed in the literature regarding the possibility that cases could be situated within larger cases (Yin, 2003, p.14). The view is also expressed in the literature that the embeddedness of cases provides the researcher with "an even deeper understanding of processes and outcomes of cases…" (Miles and Huberman, 1994, p.26). It was clear, from the outset, that an examination of sustainability or evolutionary development would demand a process-friendly research design. The selected research design would also have to take

cognisance of the influence of a multiplicity of contextual influences on the evolutionary development of the Project. Yin (2003, p.13) is of the opinion that the case study design does just that: "In other words, you would use the case study method because you deliberately wanted to cover contextual conditions – believing that they might be highly pertinent to your phenomenon of study".

1.12.1 Population and sampling

The broad approach outlined above also informed my approach to sampling. Just as the focus on the functionality of complex systems informs the overarching research design of this study, so also, it informs the sampling procedures followed. Miles and Huberman point out that approaches to sampling are deeply influenced, not so much by whether one conducts quantitative or qualitative research, but rather whether one seeks an understanding of a limited range of controlled variables or whether one seeks an understanding of a wide array of interactional variables that are active in a complex system (1994, p.41).

As indicated above, the intention in this study was to elucidate the interactional nature of a wide array of interrelated variables or influences in an evolving, complex system. This system takes the form of an educational project that was abruptly officially terminated, even as plans for the evolution of the project were being formulated. In this sense it represents a unique case. As Yin points out, the veracity of single case study research is validated by research studies such as Graham Allison's 30-year long study of the 1962 Cuban missile crisis (2003, p.4). Also, and perhaps more importantly, case study research should not be equated with research that demands samples as representations of universes. Such an analogy breaks down because the latter relies on statistical generalization, where samples are generalized to universes, whilst the former relies on analytic generalization, where a particular set of results are generalised to some broader theory (Yin, 2003, p.37). In this particular study, the results obtained from the examination of a single, unique case are generalized to the conceptual framework presented in Chapter 2.

Given the nature of the case, coupled with the fact that the Project had been officially terminated virtually a decade before this study began, it was clear that decisions relating to sampling strategies and sampling design would be constrained by the circumstances surrounding the case. Goodson and Sykes (2001, p.24) enumerate a number of sampling techniques, indicating that one or more of these techniques are often used in qualitative case studies involving the production of narrative accounts. In terms of these types, the sampling

techniques employed in this study might be identified broadly as purposive, snowball, homogeneous and extreme case.

In the first instance, sampling might be seen as purposive in that all participants were selected on the basis of their active involvement in the CALIS Project, either as part of the OFSED management team or as educators who implemented the Project in their classrooms. Secondly, the sampling technique referred to by Goodson and Sykes as 'snowball sampling' (2001, p.24), referred to by Glaser and Strauss (1967) and Merriam (1998) as theoretical sampling, is relevant to this study. Invariably, each of the participants approached provided the contact details of potential participants in the study – and also an indication of what the nature of their involvement of the Project had been. Thirdly, it might be argued that sampling in this study was 'homogeneous' since all the participants were selected on the basis of a common experience, namely participation in the Project. Finally, it might also be argued that the selection of Maureen Dale as participant might be viewed as an 'extreme case' since she is the only participant who is a mother-tongue speaker of English, whilst the rest are all Afrikaans mother tongue speakers.

But this is exactly where the traditional conception of sampling breaks down. Postmodernism and complex systems theory opposes the view that any two accounts of an experience can be the same. In this sense, homogeneity is impossibility. Even if participants were nominally involved in the same Project, their unique circumstances, worldviews, systemic situatedness and cultural/personal mythologies (coupled with the unique 'performances' mentioned above) meant that I would be confronted with individually unique experiences that might or might not correspond in unpredictable ways. Furthermore, extreme case sampling becomes irrelevant when one assumes that experiences and the associated narratives are unique, and thus all participants are extreme cases. Given the philosophical and theoretical difficulties associated with these sampling techniques, I decided to make use of 'snowball' or 'theoretical' sampling. The similarities between the sample constitution and the sampling techniques critiqued above are purely coincidental.

The selection of 'snowball' or theoretical sampling also meant that I could follow the approach to sample size suggested by Taylor and Bogdan (1998, p.93). Their view is that the sample size should not, and cannot, be determined at the outset but that it should be determined towards the end of the data gathering process. Miles and Huberman (1994, p.29) concur by drawing attention to the fact that within-case sampling has an "iterative or 'rolling' quality, working in progressive 'waves' as the study progresses.

1.12.2 Data collection

As indicated above, the decision to elicit narratives from participants was based on the belief that this would provide evidence of a wide array of interrelated influences on the CALIS Project. Each of the narratives was thus recorded on an audio tape recorder and transcribed as accurately as possible by myself.

I also felt that the keeping of a research journal would provide me with the opportunity of documenting insights and decisions made as the research project progressed. In this regard, I undertook to enter into the research journal my own impressions of each interview, directly after the completion of the interview itself. I further undertook to complete the electronic transcription from the audio tape directly after each interview, so that I would be able to follow any leads, produced by such transcription, in subsequent interviews.

1.12.3 Data analysis

The realization, gained at the beginning of the first interview, that participants were likely to present me with narratives rather than answers to questions embodied in a semi-structured interview format, convinced me to adopt the approach outlined below.

Firstly, I decided, on the basis of views expressed in qualitative research texts (Yin, 2003; Miles and Huberman, 1994; Merriam, 1998), that I would transcribe all of the audio-taped interviews myself. If, as is suggested, the researcher is the most important instrument in qualitative research, then it follows that the researcher, having conducted the face-to-face interviews, would be in the best position to transcribe these interviews in a manner consistent with the philosophical and theoretical presuppositions that underlie the research study. Furthermore, transcription and analysis are not to be thought of as discreet, linear processes. As Goodson and Sikes (2001, p.33) point out, researcher transcription of the interview data enables the researcher to become familiar with the data and aids analysis, in that initial ideas and themes emerge with repetitive, intensive interaction with the data.

Secondly, participant production of narratives meant that listening to the audio-taped interviews and transcribing only those expressions that I deemed to be relevant would not be the most effective approach in the case of this study. Not only would I be precluding the emergence of relevant ideas and themes on a second or third examination of the complete set of narratives, but I would also be precluding an examination of those heuristic qualities that characterise both the individual narratives and the multiple narratives as the bulk of the data

set. Such heuristic qualities of narrative embody key characteristics of complex systems, as suggested by Rodriguez (2002). On the basis of this reasoning, I decided to transcribe the audio-taped narrative *in toto*. I also decided to conduct the transcription in such a manner that it would capture my own perception of the narrator's intended meaning (see Atkinson, 1998, p.56). I thus attempted to capture as much of the spoken narrative as faithfully as possible, only adding punctuation marks and separating paragraphs in order to aid the reading of the transcribed material. As mentioned earlier, data collection, data editing and data analysis took place simultaneously.

As I edited the transcriptions, I was also involved in seeking substantive statements (Gillham, 2000, p.71); "identifying themes and developing concepts and propositions" (Taylor and Bogdan, 1998, p.141); and, "noting regularities, patterns, explanations, possible configurations and causal flows" (Miles and Huberman, 1984, p.22). In this way, an initial coding schema (Taylor and Bogdan, 1998; Giorgi, 1985; Moustakas, 1994; Price, 1999) was established in the form of a matrix of perceived categorised influences on the CALIS Project. I then proceeded with the second attempt at coding the data, and adapted the original matrix accordingly. A third round of coding resulted in further adaptations to the original matrix, as well as a set of categories that appeared to satisfy the data obtained from participant narratives.

1.12.4 Authenticity and trustworthiness

Given the approach to data capturing, data editing and data analysis outlined in the sections above, potential questions relating to the validity, reliability and generalizability of findings need to be addressed. As outlined above, the study was approached from a point of view termed "moderate postmodernism" by Kvale whereby the "notion of an objective universal truth" is rejected, while the possibility of "specific, local, personal, and community forms of truth, with a focus on daily life and local narrative" is accepted (1996, p.231). This philosophical position necessitated the use of a broadly qualitative case study design, with a focus on the use of unstructured interviews and researcher observation as the data-gathering instruments of choice. Only then could I elicit narratives that would illuminate a wide array of influences on the sustainability of the CALIS Project.

Kvale argues that modern approaches to "the legitimation question of whether a study is scientific tend[s] to be replaced by the pragmatic question of whether it provides useful knowledge" (1996, p.42). Against this backdrop, the issue of validity in this study is approached from the point of view expressed by Kvale, where validating involves: adopting a

critical outlook on the analysis of data (1996, p.242); clearly establishing the content and purpose of the investigation at the outset (1996, p. 243); and, addressing the theoretical questions raised about the nature of the project investigated (1996, p. 244). Such a general validatory approach is supplemented by an approach to the validity of narrative that emphasises the internal coherence of a person's (narrator) experience (Atkinson, 1998, p.61), and the extent to which the narrator agrees that the transcribed and edited narration conforms to or supports what was said originally (Lincoln and Guba, 1985; Atkinson, 1998, p.61). Both Denzin (1970) and Skeggs (1994) point out that narrators often disagree with, or fail to understand, the interpretation of their narratives. This is not strange since, as pointed out above, the transcribed, edited narrative is my own interpretation of the participants' interpretations of their individual and collective experiences.

After all is said and done, I was still the primary instrument and issues of instrument validity and reliability (Miles and Huberman, 1994, p.38) would have to be addressed by way of the rigour with which I documented not only the presuppositions and world view that I brought to the study, but also the decisions and interpretations made as I gathered and analysed the data. If the reliability of the study refers to the consistency of the research findings, as suggested by Kvale (1996, p. 235), then the study is reliable. If reliability refers to the way in which the research findings strike a resonant chord in terms of my own experience (Atkinson, 1998, p.61), then the research findings are reliable. But, perhaps the best indicator of reliability, in my own view, was the fact that I attempted at all times to allow for findings not specifically envisaged by myself; furthermore, I was determined to remain flexible throughout the data gathering, data editing and data analysis stages of the research study in order to prevent the kind of rigidity that would preclude me from gaining access to a wide array of influences on the CALIS Project. The kind of indeterminacy that characterises complex educational systems had alerted me to the fact that I could not possibly have foreseen all of the potential influences on the CALIS Project at the outset of the research study.

Adherence to theoretical rigour throughout the data gathering, data editing and data analysis stages of the study meant that it was easy to achieve the kind of generalizability referred to by Kvale as analytic generalization (1996, p.232). Analytic generalization is a kind of naturalistic generalization that is informed by theory (in this case the theoretical position adopted in the conceptual framework, presented in Chapter 2, regarding the sustainability of complex educational systems). Such generalization is predicated on "a reasoned judgement about the extent to which findings from one study can be used as a guide to what might occur in another situation" (Kvale, 1996, p.232; see also Kennedy, 1979).

1.12.5 Crystallisation

Literature sources documenting quantitative research methodology are replete with references to 'triangulation' as a technique designed to enhance the validity of research endeavours. This claim is, however, predicated on the implied existence of a unitary, exterior reality which can be subjected to 'measurement'. Furthermore, the term itself is a metaphor implicating the plotting of a course on a two-dimensional map. Tied to such a metaphor is the assumptional world view that comprehends the world as flat and that understands travel as the traversal of two-dimensional space. The map becomes a key to enabling the exact measurement of a universal exterior reality. But if there is no universal exterior reality such triangulation becomes meaningless. Richardson replaces the two-dimensional metaphor of the map with the three-dimensional metaphor of the crystal:

> . The crystal, by contrast, 'combines symmetry and substance with an infinite variety of shapes, substances, transmutations, multidimensionalities, and angles of approach' (Richardson 1994, p. 522).

But, the 'crystal', as stealth metaphor, readily renders up for interpretation multi-faceted surfaces, whilst concealing its compacted and solidified materiality - and these surfaces cannot represent 'the many overlapping truths operating at different levels and constantly subject to change'. These surfaces themselves are precision-patterned in such a way as to provide a mechanistic Lego-like fit. This metaphor, as embodiment of societal complexity, implodes because it seeks to figure forth multiplicity in the form of the solitary and unitary – multi-faceted though it might be.

Where does that leave my approach to post-modernist inspired qualitative research? As mentioned above, with reference to case study design, case studies cannot be expected to provide findings that can be generalised to other cases. Rather, the findings relating to single case studies must be generalised to theory (Kvale, 1996). So, rather than paying lip service to 'scientific' rigour as envisaged above, I concur with Caelli, Ray and Mill, for whom rigour in qualitative research is a deeply theoretical issue, rather than a technical one:

> Our position is that qualitative researchers need to (1) articulate a knowledgeable, theoretically informed choice regarding their approach to rigor [sic], and (2) select an approach that is philosophically and methodologically congruent with their enquiry. Researchers'

> approaches to these two issues must reflect an understanding that rigor [sic] is a deeply theoretical issue, not a technical one (2003, online).

1.13 Literature control

The literature reviewed in Chapter 2 shows evidence of extensive research having been conducted on the implementation and use of computers in schools, although such implementation and use is not always clearly defined in terms of integration with the curriculum. Other studies, whilst foregrounding such integration, address influences on computer-integrated education projects in a discreet manner, suggesting that such influences are essentially unrelated to one another. Similarly, treatments of the sustainability of such projects present influences on such sustainability in terms of a list of influences, the length of which determines the continued existence of the project.

Given the inability of the literature on the topic to address dynamic complexity, a conceptual framework is suggested that considers the sustainability of such computer-integrated education projects within the context of the larger dynamic, complex nature of the educational system within which they are defined.

1.14 Ethical considerations

1.14.1 Informed consent

The consent of the adult participants in this study was sought, both orally and in written form, after the aims, objectives, course of the study, and intended use of obtained data had been explained to them.

1.14.2 Anonymity or recognition

Both Yin (2003) and Kvale (1996) endorse the view that participants deserve recognition for the part they played in the production of research. The participants in this study, having been offered anonimity, unanimously elected to be named in the study. It is very likely that the nature of their positions in Free State society as well as the historical situatedness of the CALIS Project would, in all probability, have rendered attempts at anonimity useless. It is thus with the deepest gratitude that I acknowledge the part played by all of them in the production of this research report.

1.14.3 Withdrawal from the project

Although participants were, at the outset made aware of the fact that they were free to withdraw from the study at any time, their enthusiasm for the study, and their determination that the story of the CALIS Project had to be told, was truly inspiring.

1.15 Role of the researcher

Given the philosophical and theoretical underpinnings of the study, it is fitting that my transcription, analysis and interpretation of participant narratives remains my interpretation, just as participant narratives themselves remain interpretations of perceptions initiated over ten years ago, and worked upon by individual and collective consciousnesses in the interim. My own approach to the study, as primary research 'instrument', has been informed by the literature dealing with qualitative, case study, narrative, life history and post-modern interview research. In an attempt at describing as many influences as possible on the implementation and sustainability of the CALIS Project, I have tried, at all times, to remain flexible in my approach and to counteract the effect of my own preconceived ideas on the topic, knowing all the while that the final research report will remain my own interpretation of participant narratives.

1.16 Outline of the study

Chapter 1: Orientation

This chapter provides a general introduction by sketching the background to the study and situating the objectives of the study in the context of a broader statement of the problem addressed in the study. Subsequent derivation of the main research question and related sub-questions is addressed next, and this discussion is followed by an overview of the research methodology and research design adopted in the study. Decisions made in this regard are then related to ethical considerations, and reflection on my own involvement in the study. A brief overview of the rest of the research report concludes the chapter.

Chapter 2: Literature review and conceptual framework

Chapter 2 begins by considering broad treatments of the implementation and use of computers in schools. Subsequently, consideration is given to literature that addresses the topic of the integration of computers into classroom practice. This is followed by a treatment of literature relating to such integration in developing countries. Both topics mentioned above raise the issue of sustainability, which is examined in terms of the literature in the field.

A conceptual framework is then proposed for the treatment of sustainability as a characteristic or quality of dynamic, complex educational systems.

Chapter 3: Research methodology and research design

The conceptual framework presented in Chapter 2 necessitates a specific research methodology and research design. These topics are addressed in this chapter. In pursuing the chosen research methodology and design, sample selection and size, use of research instruments, data collection, data analysis, and issues surrounding reliability, validity and generalizability are addressed.

Chapter 4: Results: presentation and discussion

Chapter 4 presents data obtained from participant narratives in the form of integrated discussions surrounding categories of influences on the CALIS Project. The interrelatedness of categories, and the dynamic functionality of such interrelatedness, is elucidated.

Chapter 5: Conclusions and recommendations

In conclusion, Chapter 5 brings the findings presented in Chapter 4 into dialogue with the literature and conceptual framework presented in Chapter 2. This is followed by a summary of the findings of the research, the identification of anomalies recognised during the course of the dialogue mentioned above, and the subsequent adaptation of the conceptual framework originally presented in Chapter 2. This is followed by a reflection on methodological, substantive, scientific and exploratory aspects of the study. Finally, recommendations for policy and practice, as well as recommendations for further research, are made.

1.17 Summary

This chapter presents an introduction and orientation in terms of the study as a whole. The chapter is intended to be a roadmap which signposts the course of the journey through the research report. Each successive chapter will be recognised as an important landmark signposted in the introduction that is Chapter1. In this way, the journey delivers on the expectations created at the outset. But the journey has to have a point of departure and an indication of what is to be taken along. Chapter 2 addresses these issues by detailing the lay of the land at the outset of the journey – and a consideration of the accumulated knowledge and ideas that will stand the traveller in good stead during the envisaged traversal of the landscape.

Chapter 2

Literature review and conceptual framework

2.1 Introduction

The CALIS (Computer Assisted Learning in Schools) Project was operationalised between 1991 and 1996 in the Free State Region of South Africa. The Project was conceived of, planned and implemented by officials of the OFSED (Orange Free State Education Department). After the first democratic elections in South Africa in 1994, official departmental support in the form of financing, administration and overall management was abruptly withdrawn. In the absence of such support, numerous schools - with markedly different socio-economic, resource and teacher-skill profiles - continued using computers as an integral part of the taught curriculum. The question is thus: how did influences on the implementation of the Project affect the sustainability thereof?

2.2 The search for sources

Before the CALIS Project itself could be addressed, a comprehensive review of the literature would have to be presented. I began by conducting a thorough search for prospective sources. The first step was to search electronic databases, mostly via the EbscoHost service. The following databases were searched: Academic Search Premier; ERIC; SACat; SABINET; MLA International Bibliography; Humanities International Index; Biblioline – Africa-Wide (Incorporating South African Studies). The following input phrases were used: "sustainability computers schools"; "implementation ICT schools"; "integration ICT schools"; "sustainable computers in schools"; and "sustainable ICT in schools". Boolean operators were used in order to make the searches as effective as possible. These searches delivered no results of any consequence for this study. I then adapted my approach by conducting a search for journal titles that held the promise of containing source material that would be useful. A number of journals were identified in this way. Current and archived volumes of the selected journals were scoured for potentially useful source information. The following journals were found to be most useful: *Computers & Education; Educational Technology; British Journal of Educational Technology; Educational Technology, Research and Design; South African Journal of Education*; and the *International Journal of Qualitative Methods*.

2.3 Current and recently completed work in the field

A search was also conducted (NEXUS and SABINET) in order to establish what research has recently been completed, or is still in progress, on the topic of 'the sustainable use of computers / ICT in schools'. No results were found. The search was widened to include the 'implementation' or 'integration' of computers in schools. A number of studies were found that address the implementation / integration of computers into schools or the 'sustainability' of very specific programs in school where computers are not involved. Some of the topics addressed are the following: the use of computers by teachers and learners to enhance aspects of the curriculum in Gauteng schools (Nkumane, 2003); the use of computers in school management decision making (Patel, 1994); and the integration of computers into white and multi-racial school media centres with emphasis on cataloguing and circulation systems (Roberts, 1992).

2.4 Issues raised in the literature

2.4.1 Demarcating the field

It might be supposed that the literature provides clear and cogent answers to the question: how do influences on the implementation of a computer-integrated education project affect the sustainability thereof? This could, however, not be further from the truth. On the one hand, a multitude of different arguments are put forward, and, on the other hand, these arguments themselves are often marked by logicality, over-simplification, and emotively-charged content and hidden agenda. An extreme example of this kind of argumentation is presented by the polemical and virtually antithetical positions adopted by Bennett (1999) and Oppenheimer (1997) on the merits of computer-assisted learning in schools in the United States of America.

In this regard, Bennett points out that the U.S.A faces a crisis in education, evidenced by the fact that 25 million adults are functionally illiterate. He also argues that the burden of providing basic skills that should have been acquired at school now falls on business. The net result of this state of affairs, he claims, is that the present school-going generation will be the first in recent history not to surpass, or even equal, its predecessor in terms of education, literacy and economic attainment. He concludes:

> A century from now civilization will judge if the educational distress in America in the last years of the twentieth century led ultimately to profound improvement of schools, or to more terrible consequences. The latter alternative could include the end of America as a world leader (Bennett, 1999, online).

He then points out that proposed solutions thus far have emphasised increased funding; copying other nations; providing parents with the right to choose their child's school; and the use of the Internet. None of these proposals are seen as providing a solution to the perceived crisis in education (Bennett, 1999). Bennett pointedly defines education as "the transference to others of knowledge and values accumulated by humans, and the development of skills allowing students to integrate this knowledge and these values into their lives" (Bennett, 1999, online). Given this definition, he argues that learning has, in the past, taken place without schools or teachers and that neither schools nor teachers should thus be considered indispensable.

In the light of this argument he then presents his own solution to the perceived crisis in education:

> For computers to accomplish in education what they have done elsewhere, one new element is essential: they must be allowed to teach students without a human in the intermediary position between the child and the computer. This failure to allow computers to teach is the reason technology thus far has been a dismal failure in schools (Bennett, 1999, online).

The solution thus presented is predicated on the understanding that programming is limitless in its capacity to produce software that is as flexible as the human mind and thus an extension thereof. Furthermore, such flexible software will be designed to overcome the variations in intelligence and interests between pupils, as well as the dynamic changeability of one pupil over time (Bennett, 1999).

In terms of Bennett's characterisation of the crisis in education, presented above, the first point with which one might take issue is the flawed cause-effect logic that underlies his perception of the problem. He documents the fact that virtually 25 million American adults

are functionally illiterate and then implies that the direct cause of this situation is the fact that schools are not providing learners with basic literacy skills. The adult illiteracy rate in the U.S.A. is a problem situated within a complex system that lies at the meeting point of political, social, cultural, economic and historical influences, to name but a few. To imply, therefore that this illiteracy is directly caused by the inability of schools to teach pupils basic skills such as literacy is not only false logic but also a gross over-simplification of a complex, multi-faceted problem.

Such reductionist over-simplification similarly characterises his suggestion that the perceived crisis in education may be judged in posterity to have been responsible, amongst other terrible consequences, for the fact that the U.S.A. might have lost its position as 'world leader'. In addition to the fact that the terms of such 'world leadership' are not elucidated, the whole apparatus of global political, cultural and socio-economic dynamism is glibly assumed to play a negligible role in bringing about this state of affairs. Furthermore, the flawed logic, such as it is, is couched in dramatic and emotively charged terms, presumably aimed at arousing patriotic nationalist zeal.

Having pointed out the dire consequences of ignoring the perceived crisis in education, Bennett proceeds to define education as "the transference to others of knowledge and values accumulated by humans, and the development of skills allowing students to integrate this knowledge and these values into their lives" (Bennett, 1999, online). Suffice it to say that generations of cognitive psychologists, constructivists and constructionists are likely to differ from the kind of deterministic, unitary and instructionist approach to education suggested here. This definition of education is, however, the premise upon which he bases his solution to the problem.

In preparation for presenting his own solution, he lists various proposed solutions ranging from increased funding to the introduction of the Internet in all schools. The discussion of these propositions is approached from a very particular point of view: each is addressed in turn as a panacea for the ills besetting the education system. Here, once again, is the essence of the problem. Bennett (1999) never considers the proposed solutions in an integrated and supplementary fashion, and, in so doing, persists in wishing to solve a complex, multi-faceted problem in a simplistic manner.

Such over-simplification similarly characterises his own solution to the perceived crisis in education. He claims that for computers to have the revolutionary effect they have had in other fields, one element is essential, namely the removal of humans from the intermediary

position between child and computer. Let us ignore, for the purposes of this discussion, the dubious implied suggestion that the integration of computers in other fields of human endeavour can be equated with the integration of computers into education. What is striking, in the first instance, about this statement is the gross over-simplification which effectively equates the solving of the perceived crisis in education with the 'addition of one new element'. Equally striking, in the second place, is the linguistic quality of the expression, the meaning of which militates against, and, ultimately, deconstructs Bennett's solution to the perceived problem. Bennett's suggestion that 'humans should be removed from the intermediary position between children and computers' fails to take into account the full import of the term 'intermediary'. Derived from the word 'mediate', which implies the role of the teacher as interpreter in making the adult world intelligible to the pupil, is a host of finely nuanced ways in which the teacher is at once embodiment of, and guide towards, the world of the adult. There is a confusion and conflation of two distinct roles here. The mediating role played by the teacher might, almost incidentally, be that of technological enabler in terms of guiding learners in the use of computers, but that is not the teacher's primary mediatory role. The teacher's most important mediatory role, almost by definition, is that of elucidator and interpreter of the adult world. The presence of computers in the process is at best tangential and, at worst, incidental. So, Bennett's solution, in effect, turns out to be a technicist solution to the inability of learners to interact with computers, rather than an educational solution to an educational problem.

This utopian view of the computer as panacea for the perceived crisis in education is virtually opposed by Oppenheimer's (1997) view of the Clinton administration's spending on computers in schools as 'delusional'. Although these arguments express two extremist positions in the debate concerning the integration of computers into classroom practice, the quality of the argument in each of the two cases is very similar.

Oppenheimer begins by supporting the perception that successive rounds of technology have, in the past, failed to live up to the expectations created by their promoters. So much so, those teachers never really embraced the new tools provided by these technologies. He then concedes that a great number of teachers, however, support the introduction of computers into classroom practice. He adds that the results of a poll conducted during 1996 indicated that teachers in the U.S.A.believed that computer skills and media technology were more 'essential' than the study of biology, chemistry and physics (Oppenheimer, 1997). He then points out that the belief in the ameliorative qualities of technology is so pervasive that New Jersey "cut state aid to a number of school districts [in 1996] and then spent $10 million on classroom computers" (Oppenheimer, 1997, online). A result of this increased spending on

technology, he believes, is that the purchase of school books is stagnating and the fact that shop classes, "with their tradition of teaching children building skills with wood and metal" have been "almost entirely replaced by new technology education programs" (Oppenheimer 1997).

Oppenheimer argues further, quoting Allan Lesgold, that the 'amplificatory' quality of the computer can encourage both enlightened practices and thoughtless ones, but that there was a "real risk that the thoughtless practices will dominate, slowly dumbing down huge numbers of tomorrow's adults" (1997, online). Partly, this 'dumbing down process is seen as being brought about by the replacement of the 'real world' by a 'virtual world':

> This points to the conservative developmentalists' second concern: the danger that even if hours in front of the screen are limited, unabashed enthusiasm for the computer sends the wrong message: that the mediated world is more significant than the real one" (ibid). As proof of the dumbing down process Oppenheimer refers to a research project in which a child is unable to provide the researcher with the reasons for having manipulated a particular software programme in a particular manner: "Anecdotes like this lead some educators to worry that as children concentrate on how to manipulate software instead of the subject at hand, learning can diminish rather than grow" (Oppenheimer, 1997, online).

Given this perceived background, Oppenheimer then presents his solution to the problem. Whereas he does not go so far as to suggest the abolition of computers from classrooms, he does advocate an immediate cessation of the Clinton administration's spending on computers for classrooms:

That could free the billions that Clinton wants to devote to technology and make it available for impoverished fundamentals: teaching skills in reading, thinking, listening and other rich hands-on experiences: and, of course, building up the nation's core of knowledgeable, inspiring teachers (Oppenheimer, 1997).

Besides the fact that the 1996 poll, referred to above, is never referenced in any way which would enable further investigation and debate, the argument presented by Oppenheimer is invalid – simply because he does not compare the computer medium to an alternate medium:

rather he compares the computer medium to the content that the medium is designed to deliver, for example, the academic subjects Chemistry and Biology. In effect, he compares apples to oranges. The error is symptomatic of Oppenheimer's misunderstanding of the role of computers in classrooms as being deterministic rather than enabling. But worse still, the suggested either-or mentality adopted here characterises his approach in presenting simplistic solutions to complex problems.

One such argument is couched in terms relating to the Clinton administration's perceived belief in the ameliorative qualities of classroom computing. Oppenheimer refers to the New Jersey educational authorities who 'cut state aid to a number of school districts and then spent $10 million dollars on classroom computers'. The either-or logic adopted in this instance is clearly false, since the implication contained in the statement is the view that state aid to school districts is diametrically opposed to the acquisition of computers for classrooms. What is at stake here is surely a strategic re-alignment of state budgeting in order to meet the requirements of a changing society and a changing market place, rather than some kind of technicist conspiracy – as suggested by Oppenheimer. Besides the obvious fact that the re-alignment of schooling budgets does not, in fact, affect the amount of money spent on schools, such re-alignment is designed to make schools more effective in preparing learners for adult entry into the societies of which they are an integral part. So, Oppenheimer presents a view of computers in classrooms which is diametrically opposed to that of Bennett, and yet both arguments are similar in presenting a complex educational system in simplistic, deterministic ways.

There is yet another similarity between the two arguments. Just as Bennett uses emotive language in order to arouse patriotic, nationalist zeal, Oppenheimer similarly uses emotive language in order to arouse public indignation at the prospect of the computer 'dumbing down' successive generations of the school-going population. Oppenheimer suggests that 'the amplificatory quality of the computer can encourage enlightened practices as well as thoughtless practices'. He then argues that thoughtless practices are likely to predominate, and that this will lead to the replacement of the real world with a 'virtual world', resulting in the dumbing down of American learners. The first point to be made is the fact that the computer is seen as an agent capable of wilful action. Surely the (glibly) accepted predomination of 'thoughtless practices' is the consequence of an educational system that is incapable of training teachers to integrate computers into classroom practice effectively, rather than a consequence of the presence of computers in classrooms per se. Given this suggestion, it is not the addition of computers that is 'dumbing down' American learners, but

the inability of the system to enable teachers to fulfil their mediatory function as interpreters and elucidators of the adult world that learners are to enter.

The second point to be made is linked to the first. Virtual worlds are nothing new. The mediatory role performed by teachers in leading learners from the simplicity of childhood to the complexity of adulthood necessitates the presentation of a succession of increasingly complex 'virtual worlds' that approximate reality to various degrees. It so happens that the computer's ability to enable both simple and fairly complex simulations of real-world situations makes it a valuable tool in presenting 'virtual worlds'. The characterisation of these 'virtual worlds' as 'unreal', however, represents a gross misunderstanding of the role played by virtual worlds in education. Such worlds are not meant to replace reality – rather, they are meant to highlight a limited number of pertinent characteristics within the seemingly chaotic appearance of a complex, interrelation system. It is thus not a matter of the 'mediated world being more important than the real one'. The mediated world is a simplified approximation of the real world, designed to enable learners to grasp specific, isolated characteristics of the real world.

In this manner, both Bennett and Oppenheimer fall into the trap of presenting the role played by computers in schools as fairly simple, one-dimensional matters that can be addressed in simplistic terms. Both authors assume that computers and educational systems are discrete entities that can be manipulated at will without doing violence to either. At the heart of this view lies ignorance of the educational system as a dynamic complex system characterised by multiple, interwoven feedback loops and unpredictable lines of development.

The arguments employed by both Bennett and Oppenheimer illustrate, perhaps in the extreme, two related dangers: approaching computers in education from a technicist rather than an educational perspective, on the one hand; and the refusal to recognise educational programmes and systems as complex phenomena, demanding complex rather than simple solutions, on the other. Awareness of these dangers has informed the choice of literature to be covered in this review.

I have, in the first instance, excluded literature that debates the merits of integrating computers into classroom practice. The reason for this exclusion is simply the fact that the initiators and managers of the CALIS Project planned and implemented the Project, fully convinced of the educational merits of integrating computers into secondary school education. For the purposes of this study, the value of such integration is taken as given. Furthermore, initiators and managers endorsed the view, expressed above, that the integration, use and

sustainability of computers in secondary school education are to be approached from an educational perspective, rather than a technicist perspective. I have thus consciously excluded readings that promote a technicist perspective on the matter, rather than an educational perspective. Finally, the danger of failing to represent computers in secondary school education as situated within a complex system has necessitated the exclusion of readings that posit simple, linear and hierarchical solutions, and the inclusion of readings that seek to problematise situations in order to grapple with such complexity.

The inclusion of specific readings has also been motivated by the fact that the integration, use and sustainability of computers in secondary schools, over a number of years, has been characterised by a process of increasing insight into the sophistication and interrelatedness that is the hallmark of complex systems. For this reason, the first topic addressed in the chapter is the initial integration of computers into secondary schools. Not only is the exact definition of such integration problematised, but 'integration' and 'use', as discrete concepts, are evaluated. Since much of the literature pertains to European and North American schools, specifically, the second topic evaluates the veracity of suggestions made in such literature, in the face of the particular challenges faced by secondary schools in developing countries. Such integration and use is then situated against the backdrop of processes of change in educational systems. This discussion leads naturally to the role played by educational leadership in managing not only the integration of computers into schools, but also the wider, more complex change process. Such leadership needs to be informed, not only by an awareness of the nature of complex systems, but also by the ability of leaders at all levels of the system to formulate strategies that will enable the sustainability of such complex systems. Finally, a conceptual framework, which includes concepts drawn from complexity theory, systems theory, and the theory relating to dynamic complex educational systems, is suggested as a theoretical model capable of addressing issues of sustainability arising from the implementation of a computer-integrated education project...

2.4.2 The integration and use of computers in schools

It might appear to the uninitiated that the integration of computers into schools is a matter of hardware and software provision, and the training of staff – all of which might be accomplished during the course of a circumscribed 'implementation event'. But such an approach to integration ignores the "intertwining of complex variables" (Baylor and Ritchie, 2002) in a school environment. Furthermore, the integration of computers into schools is situated within the larger context of educational practice as a complex system and the interaction of education with yet larger and more complex systems.

2.4.2.1 Implementation and integration

Ely's research (1990a, 1990b, 1999a, 1999b), focuses on an evaluation of numerous successful implementations of computers in schools. The question posed is the following: "where innovations have been adopted and implemented, what [are] the conditions that appear to facilitate the process?"(Ely, 1999a, p.24). Consequently, Ely identifies eight conditions that are present across multiple sites: "availability of resources, dissatisfaction with the status quo, existence of knowledge and skills, availability of time, rewards or incentives, participation, commitment, and leadership." (Ely, 1999a, p.24). These findings, endorsed by Mooij and Smeets (2001) and Shuldman (2004), give an indication of the situatedness of such integration in a larger and more complex context. But the perception might still be adhered to that the 'implementation event', complex though it might be, is circumscribed and specific, rather than being process-driven.

Armstrong et al. (2004) conducted numerous case studies involving the implementation of computers and e-learning strategies in secondary schools and further education colleges in the United Kingdom. They found that, even in the absence of overall planning methodology, a "phased approach' had proven to be beneficial, particularly in the face of the ability of staff to accommodate change (Armstrong et al., 2004). Shuldman (2004) elaborates on the role played by staff reaction to change, and their adoption of innovation. Rogers' (1995) innovation-decision process is compared to and contrasted with Hall and Hord's (1987) Concerns-Based Adoption Model (specific to the adoption of educational innovation), the Apple Classrooms of Tomorrow's model of instructional evolution (Sandholtz et al., 1997), the model of instructional transformation (Reiber and Welliver, 1989), and Sherry's learning/adoption trajectory (1998). The conclusion is that the integration of computers into schools, across models, is characterised by a process beginning with the use of technology in such a way that it is "compatible with the teacher's established style of teaching" (Shuldman, 2004, p.323), and culminating in the teacher's ability to "combine idea and product technologies to encourage students to engage in deeper cognitive activity" (Hooper and Reiber, 1995, p.9). This research recognises the process nature of integrating computers and teaching-and-learning styles, but fails to situate it within larger systemic processes that drive the integration of computers into schools on the level of the individual institution – and on the level of the education system as a whole.

Thus, existing research suggests that the integration of computers into schools is greatly influenced by the extent to which staff is able to adopt, and adapt to, innovation. But the process does not end there. Such integration by individual staff members is situated within the

larger context of integration within the institution as a whole. In this regard, Mooij and Smeets (2001) identify five successive phases of ICT implementation in secondary schools:

1. incidental and isolated use of ICT by one or more teachers;
2. increasing school awareness of ICT relevance for the school, at all levels;
3. emphasis on ICT co-ordination and hardware within school [sic];
4. emphasis on didactic innovation and ICT support; and
5. Use of ICT-integrated teaching and learning, independent of time and space.

(Mooij and Smeets, 2001, p.272).

Thus, the integration of computers into schools is recognised as a complex process, co-determined by a plethora of variables, the individual influence of which is difficult to ascertain at the outset of the process. This view of the integration of computers into classroom practice, in contrast to the model presented above, suggests that successful integration is dependent on many more variables than the extent to which teachers are able to adapt teaching and learning practices to encompass the affordances of computer technology. Clearly, teacher adaptability is itself situated within complex processes that operate at institutional level. But the individual school, as complex system, is situated within larger and more complex systems, external to the school, such as "the visions and prescriptions that are reflected in (national) curriculum and national policies on (ICT in) education" (Plomp and Pelgrum, 2005). Such national curricula and policy statements are, in turn, interpreted and implemented on regional and district levels, thus complicating school-based implementation even further. Given the nature of such nested, interrelated complex systems, Mooij and Smeets (2001) argue that the implementation of ICT in secondary schools is influenced by "acting institutions or persons, or 'actors" at each of the following 10 organizational levels:

10. international level;
9. national level;
8. 'umbrella / regional / municipal level;
7. administrative / above-school level;
6. school management level;
5. location level;
4. subject-specific department level;
3. subject teacher level / form level;
2. individual pupil level / level of (small) groups of pupils;
1. developmental level / internal learning process of individual pupil.

(Mooij and Smeets, 2001, p.268-269).

In contrast to the models of integration of computers into classroom suggested in the previous paragraphs, the model presented here suggests that such integration practice takes place within a dynamic, complex system characterised by multiple feedback loops that operate upon one another in non-hierarchical, and often unpredictable, ways.

The complex process nature of such integration of computers into schools raises a related question. The studies mentioned thus far refer specifically to the 'integration' of computers into schools or the 'implementation' of ICT in schools. If we ignore, for the purposes of this discussion, the marked differences between 'integration' (generally associated with complexity) and 'implementation' (generally associated with simplicity) on the one hand, and the marked differences between 'computers' and 'ICT' on the other, then the question remains: at what point in the process does integration become 'use'? Or, in the context of the functionality of complex systems, is the question both unanswerable and irrelevant?

2.4.2.2 Use

In contrast to the studies mentioned above, there are as many studies that address the 'use' of computers in schools. Underlying the distinction drawn between 'integration' and 'usage' is the implied existence of a linear, hierarchical process, consisting of discrete, recognisable phases or steps – the completion of one step enabling the activation of the next. Not surprisingly, the literature is silent on the exact point at which 'integration' becomes 'usage'. I will argue, below, that the reason for this silence is the fact that the integration, use and sustainability of computers in schools are parallel, interrelated processes that follow complex, cyclical patterns involving multiple feedback loops and indeterminate lines of development – rather than simple linear, hierarchical processes.

This does not mean that the use of computers, per se, is viewed by all researchers in simplistic terms. As Bebell, Russell and O'Dwyer (2004, p.45) point out, exactly what is meant by teachers' use of computers, and technology in general, varies widely. In some cases such usage is defined in terms of the integration of technology into classroom practice, while, in other cases, usage is deemed to refer to the way in which teachers require of pupils to use technology in the development of products; or, the way in which teachers use technology to prepare lessons; or, the way in which teachers use technology to communicate (Bebell et al., 2004, p.45). These researchers theorised that teacher use of technology could broadly be divided into one of the following categories: "teachers' professional technology use outside of class time, teachers' use of technology during class time (including student-directed uses) teachers' assigning work that required students to use specific technology, and teachers'

communication through e-mail" (2004, p.60). After having analysed the results of a teacher survey on the use of technology by teachers, however, they were forced to differentiate between teachers' use of technology during class time, and teachers requiring of students to use technology during class time, as two distinct categories (2004, p.61). Similarly, the category relating to technology use outside class time had to be substituted by two distinct categories involving teachers' use of technology for grading, on the one hand, and, teachers' use of technology for preparation, on the other.

Whereas Bebell et al. (2004) evaluate the usage of technology in general, and computers in particular, from the point of view of the teacher as agent, Moursund and Bielefeldt (1999), having conducted a national survey on the role of information technology in teacher education in the United Kingdom, evaluate the use of computers in classroom practice from the point of view of the nature of the interaction between human and computer. On the basis of this investigation, three broad categories of computer use in schools were identified. The first category includes three uses of IT to support learning, namely computer-assisted learning, computer-assisted research and distance learning (p.6). The second category involves the use of the computer as tool, and this kind of usage is "designed to help people extend their abilities to do work" (p.6). The third category involves the use of computers by students for the study of computer and information science (p.7). The identification of such uses is driven, essentially, by a desire to understand the ways in which human beings interact with computers in many different contexts If we wish to address the effective use of computers as part of the taught curriculum in schools, the focus of the investigation will have to be considerably narrower.

Perhaps even more constraining is the fact that the use of computers in schools does not necessarily constitute effective use. Pelgrum (2001) reports on a SITES survey conducted in 26 different countries (both developed and developing), the aim of which was to establish what the most critical obstacles to the effective use of ICT in schools were perceived to be. Principals and technology experts in the schools that took part in the survey identified the following as the most critical obstacles:

1. insufficient number of computers;
2. teachers lack knowledge / skills;
3. difficult to integrate in instruction;
4. scheduling computer time;
5. insufficient peripherals;
6. not enough copies of software;

7. insufficient teacher time;
8. WWW: not enough simultaneous access;
9. not enough supervision staff; and
10. lack of technical assistance.

(Pelgrum 2001, p.163-178)

The obstacles thus identified focus very heavily on institutional and teacher characteristics as determinants of the effective use of computers in schools. Such teacher characteristics are never brought into dialogue with pedagogical practices at the schools mentioned in the survey (SITES 2006 will, specifically, address pedagogical practices – see Plomp and Pelgrum, 2005). Also, larger institutional and systemic influences on the integration of computers into classroom practice are mentioned only in a discreet, disjointed manner. Methodologically, the survey format is designed to produce exactly what has been produced in the case of this study: a list of perceived obstacles to the integration of computers into classroom practice. The survey format is not designed to elicit dialogue between disparate influences, where the dynamic interrelatedness of influences enjoys precedence over the arrival at a list of obstacles. In this way, the complexity associated with dynamic processes is not addressed and the result is that fairly simple static solutions are posited for dynamic, complex challenges.

Research on institutional characteristics influencing the effective use of computers in schools highlights the increasingly sophisticated nature of our understanding of this complex process. Pelgrum and Plomp (1993), evaluating the effective use of computers in European schools at the beginning of the 1990's, claim that the "newness' of the situation in the previous decade had precluded schools from setting clear goals (p.324). This state of affairs meant that schools often started using computers for unspecified reasons, even though there was an implicit expectation that such usage would improve the quality of education (Pelgrum and Plomp, 1993). As a result of the fact that clearly defined goals could not be set, computers were used most frequently as add-ons to the existing curriculum (Pelgrum and Plomp, 1993).

As institutional approaches to computer use became more sophisticated, however, distinctive exemplary institutions emerged. In the process, researchers became aware of the importance of pedagogical processes within which computers were to be used. Becker (1994, 2000a, 2000b) examined the differences in teaching environment between exemplary computer-using teachers and that of other computer-using teachers. He concludes that exemplary computer-using teachers are to be found in schools that have "both technology and pedagogic support, a full-time technology coordinator, teachers with an above-average level of

technology expertise, as well as staff development, access to computer resources, time, and authentic or consequential use of technology" (Shuldman, 2004, pp.326-327). In addition, Mooij and Smeets (2001) point out the vital role played by the policy and budgetary decisions made by the school board and management, as well as the importance of an ICT policy (see also Armstrong et al., 2004) that co-ordinates the purchasing of hardware and software and matches training opportunities.

2.4.2.3 Leadership

The influences on the effective use of computers in schools, as outlined above, imply strong leadership. Baylor and Ritchie (2002) believe that, even though grass-roots movements in schools can be successful, the effective use of technology-enhanced environments is, more often than not, accompanied by the presence of leaders who "have the leadership ability and vision to direct changes". The school inspectors interviewed by Shuldman (2004) feel that such leadership is more accurately characterised as leadership at three crucial levels: leadership at the level of the school inspector; leadership at the level of the school principal and administrative leadership; and, technology leadership. But leadership influences on effective institutional use of computers does not end there. Armstrong et al. (2004) claim that curriculum managers who take ownership of purchasing decisions in their own fields of expertise influence effective computer use positively. Support for virtually all of the institutional influences mentioned above is found in Pelgrum's (2001) evaluation of an international survey on the use of computers in schools.

2.4.2.4 Teacher characteristics

But, important as these institutional influences are, the literature is adamant that the teacher plays a pivotal role in the effective use of computers in the classroom. Moursund and Bielefeldt (1999) emphasize the fact that the technology proficiency of teachers begins before they actually start teaching. They point out that, in order to increase proficiency in this regard, it is essential that teacher training institutions should increase the level of technological integration in their own academic offerings.

Once teachers enter their institutions of choice, it is equally important that they buy into the institutional "vision for learning and the associated strategies for the use of ICT" (Armstrong et al., 2004). The institution, besides providing the global ICT policy within which the effective use of computers in the classroom takes place, needs to create opportunities for teachers to have regular contact with technology and technology experts. The district superintendents interviewed by Shuldman (2004) believe that the 'lack of time' obstacle in this regard stems from the fact that teachers need more 'contractual' or formal school time

(as opposed to own time) during which to gain proficiency in the integration of technology into classroom practice.

But institutional support can only go so far. Veen (1994, 1995; see also Mooij and Smeets, 2001) argues, that teacher characteristics outweigh school characteristics in explaining teachers' use of computers. Are there inherent qualities possessed by individual teachers who integrate technology successfully into their classrooms? The literature differentiates between attitudinal characteristics, on the one hand, and, acquired skills on the other.

Predictably, in terms of the situatedness of teacher use of computers within a changeable, non-linear complex system, attitudinal characteristics revolve around the ability of teachers to cope with change and innovation. Ten Brummelhuis (1995) identified 'perceived relevance of the innovation' as the most important determinant of teachers' use of computers in secondary schools. These findings are confirmed by a study conducted by ten Brummelhuis and Tuijnman (1992). Baylor and Ritchie (2002) argue that teacher openness to change is the most critical predictor of effective computer use amongst teachers. These suggestions relate to the use of computers as a lever for bringing about change. In the first place, the suggestion is that teachers need to be made aware, and convinced, of the relevance of innovation to their own practice before they are likely to adopt the innovation. But, what is not clearly implied here is the fact that the change process itself needs to incorporate changes to pedagogical practice. It is thus crucial that larger changes in the education system be linked to changes in pedagogical practice, if the 'no significant difference' situation is to be avoided.

Whereas there seems to be agreement on the attitudinal predictors of successful computer use, there is great disparity when it comes to the specific skills that teachers should acquire. In fact, the effectiveness of staff development sessions aimed at promoting the integration of technology into instruction is called into question by Mann (School Boards Association, 2000), who claims that most teachers freely acknowledge that training is virtually useless. His argument is, however, flawed by false appeals to authority and generalization – not to mention the fact that there are numerous reasons for teachers' negative experiences of such staff development sessions, not least of which might be the failure of such sessions to transfer, effectively, applicable integratory skills. In contrast, Pelgrum (2001) emphasises the need for effective staff development programmes by elucidating the complexity of such integratory skills. Teachers from 26 countries were asked to rate (in the form of a percentage) how well prepared they thought they were in each of the following areas:

- application of software to track student progress;
- didactical and organizational integration of computers in subjects;
- the use of specific programs for subjects;
- evaluation and selection of instructional software;
- use of computers for individualised learning programs;
- the use of multimedia applications; and
- adaptation of software to fit school purposes.

(Pelgrum. 2001, p.171)

Such preparedness was seen against the backdrop of planned acquisition of integratory skills ('goal') as opposed to actual acquisition of such skills ('realised'). The effectiveness of staff development programmes could then be determined by comparing averaged percentages of each of these skill sets. The discrepancy between the 'goal' and the 'realised' in the case of all of the countries involved in the survey is significant. In Canada, for instance, acquisition of skills was planned by 80% of participant institutions (lower secondary schools) but the actual acquisition of skills took place in only 17% of institutions; in South Africa the percentages were 64% and 6%, respectively. The large discrepancy between the planned and actual acquisition of integratory skills can be ascribed to numerous factors. It is quite conceivable, for instance, that the presenters of such staff development sessions did not possess the necessary technological or presentations skills to ensure the uptake of skills amongst staff. It is also possible, that such staff development sessions were predicated on the assumption that the integration of computers into classroom practice was dependent on the acquisition of a limited number of hierarchical skills that could be acquired in a very limited period of time; rather than numerous, incompletely defined skills that interacted in complex ways.

But, whether or not this is the case, it is clear that the absence of teacher integratory skills constitutes a serious obstacle to the integration of ICT into schools (see Mooij and Smeets, 2001). Moreover, the failure of staff development programmes in enabling the acquisition of integratory skills impacts negatively on teacher confidence (McMullan, 2002; Shuldman, 2004). The superintendents interviewed by Shuldman (2004), in fact, claim that "no learning outcomes of any consequence will be seen as a result of teachers' use of technology until teachers have more experience and attain a greater personal level of comfort, confidence , and skill" (Shuldman, 2004, online). McMullan's (2002) findings suggest that teacher lack of confidence is most effectively addressed by the provision of personal access to computers on the part of teachers. But personal access, important though it might be in promoting teacher

confidence, is not the most important influence on the effective use of computers in classroom practice. The most important influence, claims McMullan, is the ability of teachers to "adapt their practice to embrace the new technologies" (McMullan, 2002, p.16). The crux of the matter is thus not technological skills per se, but the way in which these technological skills can be harnessed in the service of pedagogical effectiveness.

2.4.2.5 Pedagogical practices

The relatively late focus on the importance of adapting pedagogical practices to the affordances offered by computer technology is ascribed to the fact that the development of computer-based technology infrastructure in education outpaced the integration of computer resources into pedagogical practice (Moursund and Bielefeldt, 1999). This was brought about by a situation where governments over-emphasised the importance of computer hardware provision, rather than the ways in which computers could be used to support teaching and learning effectively (McMullan, 2002). Such a pedagogically undesirable situation was further worsened by the acquisition of stand-alone computer-based coursework, which did not bring about the expected gains in student learning (Moursund and Bieleveldt, 1999). The approach by governments in the early 1990s, seen from the vantage point of complex systems, appears simplistic in the extreme. Not only was the implementation of the physical technological infrastructure seen as a sufficient condition for improved student learning, but the implementation of stand-alone computer-based courses (artefacts of the underlying hierarchical and linear approach to teaching and learning) denies the complex interrelatedness of numerous influences that co-determine the effectiveness of learning, in particular, and the nature of a complex educational systems, in general.

Towards the end of the 1990s, however, influential policy documents in numerous countries reflect a shift from viewing the learner as a consumer of knowledge to a view of the learner as active constructor of knowledge – a change that speaks of the realisation that the computer and ICT more generally, can act as a catalyst for educational reform (Pelgrum, 2001). This point of view is endorsed by Kozma (2003), who notes that such educational reform went hand-in-hand with the widespread adoption of constructivist approaches to teaching and learning. One of the possible reasons for this state of affairs is to be gleaned from the findings of a national study in the United States of America (1998) that found a negative relationship between the frequency of the use of school computers and school achievement, but, also, a positive relationship between certain uses of technology and school achievement (Wenglisnksi, 1998; Kozma, 1993).

The key to the dilemma appears to be the fact that the majority of teachers use computers and ICT to teach the standard curriculum (Law et al., 2000; Scofield and Davidson, 2002), while others use computers and ICT "within the context of complex tasks, conducted within a multidisciplinary context and extended blocks of time, and with performance-based assessment (Kozma, 2003, p.4). The actual activities in classrooms of teachers who employ this approach to teaching and learning are characterised by collaboration in pairs or larger groups, constructivist activities, research and product development (Kozma, 2003, p.5).

The centrality of active student involvement as a predictor of the adoption of new pedagogical approaches is envisaged in Pelgrum (2001) and further explored in the aims of the proposed SITES2006 international survey, which has as its main aim the extent to which ICT is used in education and how the use of ICT is associated with changing pedagogical practices (Plomp and Pelgrum, 2005). But perceptions of student influences on the effectiveness of learning have come a long way since the *tabula rasa* of previous eras. Students bring a wide variety of abilities, skills, interests, experiences and preferences to the learning situation.

There is a large body of research on differences in gender-based learning styles, for instance. The results are inconclusive, as evidenced by the contradictory findings presented by Biggs (1987) on the one hand, and Shaw and Marlow (1999), on the other. Furthermore, it would seem that differences in learning style between individual learners may well be a predictor of positive or negative ICT learning experiences (Shaw and Marlow, 1999, p.233). But innate capabilities and preferences are not the only predictors of effective computer-based learning. Holt and Crocker (2000) argue that prior negative experiences of ICT-integrated learning actually motivate learners to do better in subsequent ICT-integrated learning sessions.

The way in which the traditional pedagogic triangle, involving the teacher, the learner and the material contributes to effective computer-based learning is thus not as unproblematic as one might suppose. The matter is, however, further complicated by the fact that such interaction is situated within a wider context which forms an integral part of the education system. In the first instance, effective learning is impacted upon positively by the extent to which the institutional ICT coordinator possesses effective technological and educational skills (Pelgrum, 2001; Mooij and Smeets, 2001; Baylor and Ritchie, 2002). One might well ask whether the possession of technological and educational skills, in tandem, is not a requirement for teachers as well. It is, after all teachers who must align technological affordances with curriculum requirements and learning-and-teaching practices on a daily basis. Beyond human intervention, support influences such as the student / computer ratio

(McMullan 2002); the quality of connectivity to the Internet (McMullan, 2002); the presence of 'embedded systems' in the form of comprehensive service agreements, support and replacement costing and budgeting (McMullan, 2002) may all contribute to effective learning.

2.4.2.6 Funding

Of all of these 'support influences' on effective computer-based learning, the issue of funding is perhaps the most hotly debated. Seen in the light of suggestions that support costs are over 10 times the initial cost of the hardware and software (National School Boards Association, 2000), it is understandable that funding needs to be attracted, retained and expanded over the life of a computer-based educational initiative. Whereas schools have been supplied with ICT equipment by governments in the past, suggestions are that such strategies need to be replaced by strategies that provide incentives to the private sector to provide managed services to schools, and, the involvement of local parents, teachers and community groups in providing financial support to computer-based learning efforts (McMullan, 2002). Linked to this suggestion is the suggestion that schools lease ICT equipment, thus cutting down on major capital outlay at the time of delivery (Armstrong et al., 2004, p.4). This would alleviate pressure on financial resources in ensuring a sustained outlay over a number of years in terms of support, training and upkeep/ replacement.

It is sufficiently clear that the exact nature of what constitutes computer 'use' in schools is not only contested, but also affected by a host of influences that spring from the situatedness of such an endeavour in a complex educational system. Furthermore, if 'use' is taken to refer to the integration of computers into the teaching and learning process, the present state of affairs is far from satisfactory. Levin (2004) reports that in 2002 there were 4.8 students to an instructional computer with Internet access in public schools in the United States of America. Furthermore, 99% of all public schools had access to the Internet in 2002 and $5.8 billion was spent on technology-related matters in public schools in the 2002/2003 school year. And yet, 50% of students with computer access at school use school computers one hour or less a week (Levin, 2004). In fact, so glaring is the failure to integrate computers into classroom practice, that Armstrong et al. (2004), based on the results of a national survey in the United Kingdom, estimate that only 11% of secondary schools and further education colleges integrate computers effectively into the curriculum. Based on these findings, Armstrong et al. (2004) suggest that future national policy should encourage institutions to develop appropriate and effective e-learning strategies – both independently and collectively (p.8) They also suggest that institutions should be encouraged to move towards a "more embedded delivery model which locates computers in the classroom, or in clusters and not, as is

predominantly the case, in computer suites" (Armstrong et al., 2004, p.9). In the case of the CALIS Project, investigated in this study, this was the presupposition accepted when the Project was originally planned.

Future policy decisions will, however, be based on research conducted today. Levin (2004) argues that, although there is a growing body of literature on the use of technologies in schools, there is very little accumulated knowledge about the effectiveness of educational technology. Such 'effectiveness' is a critical determinant of the sustainability of a project over time. Furthermore, he argues that there is little information on variations in implementation of interventions or the nature of control conditions. There is thus a need for research relating to influences on the implementation of such projects, which affect the sustainability thereof. Also, there is no sensitivity in the literature to variations within and across grades and academic content areas (Levin, 2004). What Levin does not explicitly state is that all of this is true of the United States of America, in particular, and developed countries, in general. The situation is more complex yet in the case of developing countries.

2.4.3 The integration and use of school-based computers in developing countries

Commentators on the integration and use of computers in developing countries at the end of the 1980s and the beginning of the 1990s stress the inability of the process to address the educational needs of a wide variety of learners (De Villar and Faltis, 1987, 1991; Maddux and Cummings, 1987; Arias, 1990). The wide variety of learners envisaged here include: 'mildly handicapped' learners (Maddux and Cummings, 1987); language minority learners (Arias, 1990); learners from socio-economically disenfranchised backgrounds (De Villar and Faltis, 1987); and learners from different racial and cultural backgrounds (De Villar and Faltis, 1991). What is striking is that the inability envisaged above is true of the situation in American schools, at the time.

In a report on the use of computers in 'Third-World' schools, Hawkridge, Jaworski and McMahon (1990) conclude that, both in Zimbabwe and Botswana, the primary reasons for introducing computers in schools are to be found in pressures brought to bear on schools by parents, principals and teachers wishing "to be up to date, professionally" (1990, p.224). They further stress that this situation was only true of the most affluent schools in these countries.

Whilst schools in the United States were thus involved in addressing issues surrounding equitable access for all learners, selected, affluent schools in some African countries were

attempting to convince school governing bodies to introduce computers in schools, even if such introduction (in the case of Botswana) involved the use of computers for administrative purposes only (Hawkridge, Jakowski and McMahon, 1990, p.230). The reasons for the vast discrepancy between implementation and integration in developed countries as opposed to implementation and integration in developing countries are far more complex than the inability of computers to address the educational needs of a widely diverse learner body, as suggested by the abovementioned studies. Virtually a decade after the comments contemplated above, Hawkins (2002) produced a report, funded by the World Links for Development Program and the World Bank Institute, on the state of ICT and education in the developing world. Drawing on information gathered from across the globe, Hawkins postulates 'ten lessons for ICT and education in developing countries:

1. computer labs in developing countries take time and money but they work;
2. technical support cannot be overlooked;
3. non-competitive telecommunications infrastructure, policies, and regulations impede connectivity and sustainability;
4. lose the wires;
5. get the community involved;
6. private-public sector partnerships are essential;
7. link ICT and education efforts to broader educational reforms;
8. training, training, training;
9. technology empowers girls; and
10. technology motivates students and energises classrooms

(Hawkins, 2002, online).

Although a number of these lessons might seem to be applicable to educational institutions in developed countries, there are clearly influences that are developing-country specific. The monopolies that characterise telecommunication infrastructures are characteristic of smaller, developing economies. Such monopolies imply that educational computer usage is subject to higher connectivity costs. Similarly, the empowerment of girls is a particularly relevant issue in many developing countries since many traditional, indigenous cultures negate the equality of women, and thus, by extension, the access of girls to education. These influences do not stem from the characteristics of individual schools, or even national education structures; rather, they come into existence at the confluence of complex systems, such as the situatedness of educational systems within the wider context of interrelated geographical, social, political and economic systems.

Understandably, one of the most important obstacles in the path of universal computer access to learners in developing countries is the dearth of resources. In an investigation into the costs associated with computer use in secondary schools in developing countries (focusing on Zimbabwe and South Africa), Cawthera (2002) underlines the vast differences in provisioning between schools serving different socio-economic communities. But, even in the face of such differences, he is able to formulate broad recommendations applicable to schools in developing countries, in general.

- The usage of existing computer facilities is often only a fraction (average around 20-30%) of what it could be.
- Probably the best way to both reduce unit costs and increase provision is to extend usage …
- For planning effective computer provision it should be realised that the costs of equipment tend only to be a fraction of the total cost of provision over five years…
- The training of teachers in the use of ICT in schools is an important aspect of provision which may often be overlooked and under-budgeted…
- Policy makers need to be aware of the range of computer provision available. Expensive, state of the art equipment is not essential to achieving good educational outcomes.
- Careful consideration should be given to the processes involved in the provision of computers in schools so as to ensure high levels of usage…
- Where there is sufficient usage, computer labs should have a minimum of 20 computers. This will reduce unit costs by spreading the high fixed costs of training over a larger number of users.
- Benchmarks and ratios for usage and costs need to be developed against which to monitor the efficiency of computer provision …
- Schools are likely to need assistance with planning and managing income generating activities if these are seen as a way of meeting running costs…
- The cost of computer provision in rural areas need not be prohibitively expensive. Data from *Myeka High School* suggests that this could be achieved in schools without mains electricity or landline connectivity for under $20 per student per year provided there are high levels of usage

(Cawthera, 2002, p.6).

This does not mean that national governments are turning a blind eye to the dearth of resources in developing countries. On the contrary, governments, such as the South African

government, are making concerted efforts to ensure that the limited resources available for the integration of computers into schools are employed as effectively as possible. The South African *White Paper on e-Education* (2004), in fact, stresses the formulation of an approach that takes cognisance of cost-effectiveness, integration with educational and developmental demands, sustainability and the effective and efficient utilisation of computers in classrooms (Government Gazette, 2004, pp.10-11).

Laudable though such national initiatives might be, however, the expertise and political and educational will at national level is not always reflected at regional level, where national policies are interpreted, and find expression, in regional initiatives such as the E-Lapa Project in the Free State region (Thomas, 2005). In this particular case interpretation and implementation of national policy is taking place without due consideration to larger systemic complexity in the region, and sustainability of the Project over time (Thomas, 2005).

The golden thread uniting the implementation and integration of computers in schools, both in developed and developing countries, is the concept of complexity. Schools, districts, regions and national departments of education are more successful or less successful in achieving such integration, depending on the extent to which they are able to plan for, and account for, the complexity of the systems that they wish to harmonise. All of the influences mentioned thus far, however, represent only half of the complexity of educational systems, since such influences exist essentially on a horizontal, synchronic plane of interrelatedness. Already complex synchronic educational systems are also affected by processes of change that exist diachronically and that provide extra dimensionalities of complexity to the system. The following sections of this chapter deal specifically with the nature of complexity, in general, and the nature of dynamic complexity in educational systems, in particular.

2.5 Summary of issues raised in the literature

There are numerous studies that address the implementation and use of computers in schools. In the first instance, many research projects view the implementation of computers in schools as a discreet event, rather than a dynamic process. Secondly, such implementation often lacks definition and needs to be distinguished from the integration of computers into classroom practice, specifically. Furthermore, although there are many studies that address the use of computers in schools, it is not completely clear what constitutes effective use, on the one hand, and it is also not clear at which point of the process ‘implementation’ becomes ‘use’, on the other.

Both the effectiveness of implementation and the effectiveness of use are seen as subject to a number of influences. Firstly, institutional leadership in the form of the school principal and the school management team are seen as having a significant influence on the integration of computers into classroom practice. Leadership at other levels of the education system, namely district (with the exception of the superintendent level – see Shuldman, 2004), regional, national and international levels are largely ignored. Secondly, teacher characteristics (particularly attitudinal characteristics) are foregrounded. Thirdly, pedagogical practices are seen as a significant influence on the successful integration of computers into classroom practice. The literature does not address the dynamic interrelatedness between teacher characteristics and pedagogical practices. Neither does it consider ways in which these influences might be inextricably linked to larger systemic processes. The emerging picture is thus one which suggests the existence of numerous, discreet influences on the successful implementation and further sustainability of such projects. Integrated, dynamic processes affecting such implementation and sustainability at larger systemic levels are not considered, other than in a very superficial way. Fourthly, the way in which identified 'support' influences, most notably funding, are inextricably woven into the fabric of systemic functionality is denigrated by the presentation of such influences as discreet influences. Lastly, the literature draws attention to additional influences on such projects, stemming from the fact that they are implemented in developing countries rather than developed countries. In this way, monopolies on telecommunications infrastructures and the socially constructed roles assigned to girls in some societies might influence such projects significantly.

The fact that the dynamic interrelatedness of all of the identified influences might affect the implementation and sustainability of such projects, in the form of integrated systemic processes, is not considered in the literature at all. On the basis of such silence, research questions addressing this interrelatedness of influences, on both horizontal and vertical structural levels of the system, have been formulated.

2.6 Research questions

The main research question addressed by this study is the following:

> ***How did influences on the implementation of the CALIS Project affect the sustainability thereof?***

Because of the breadth of this question, five sub-questions, dealing with specific aspects of the main research question, were arrived at:

1. How did personal qualities, possessed by people directly or tangentially involved in implementing the Project, influences the implementation and sustainability of the Project?
2. How did elements of programmatic design (those elements of programmatic design specifically embodied in the goals of the Project) influence the implementation and sustainability of the Project?

3. How did the availability of physical resources during implementation influence the sustainability of the Project?

4. How did the larger systemic environment in which the Project was implemented, influence the sustainability thereof?

5. How was the further development of the Project affected by the animated, interactional interrelatedness of the complex system infused by all of the influences mentioned above?

These questions will be addressed against the theoretical backdrop provided by the following conceptual framework.

2.7 Conceptual framework

This conceptual framework encapsulates related concepts drawn from the following theoretical approaches.

Complexity theory: This approach is not so much characterised by a coherent theory – rather it is characterised by theoretical work in many different fields on the nature of complexity. Such work was made possible by an understanding of complexity significantly influenced by Prigogine's (1967) work on dissipative structures and Mandelbrot's (1983) work on fractal geometry.

Cybernetic theory: This theory, proposed by Wiener (1950) and adapted by Winn (1975) proposes a complex view of computer-based functionality, based originally on the non-linear feedback loops that are an integral feature of complex systems.

Autopoetic systems theory: This theory addresses the complex functionality that is the hallmark of complex living systems. The formulation of the theory, by Maturana and Varela (1980, 1987), was influenced, partly, by cybernetic theory.

Autonomous systems theory: This theory was developed as a direct consequence of autopoetic theory. Maturana and Varela (1979, 1992) propose that many of the functional characteristics of living systems may also be found in non-living systems.

Systems theory: Senge (1990, 2000) proposes that the functionality observed in living and non-living systems also characterises larger systems that are created by human beings. In these respect large organisations, both created by human beings and within which human beings are active, functions in ways that are characteristic of complex systems.

Dynamic, complex educational systems: Stacey (1992, 1996) recognises the education system as one such organisational system that is characterised by complex functionality. Furthermore, Fullan (2005) proposes an approach to the sustainability of such dynamic, complex educational systems. Cavallo (2004) combines the functionality of autopoetic systems with the functionality of dynamic, complex educational systems in order to arrive at a theoretical model of ecological or viral growth patterns in educational systems.

The ensuing diagram provides a visual representation of the way in which concepts from these theories are related.

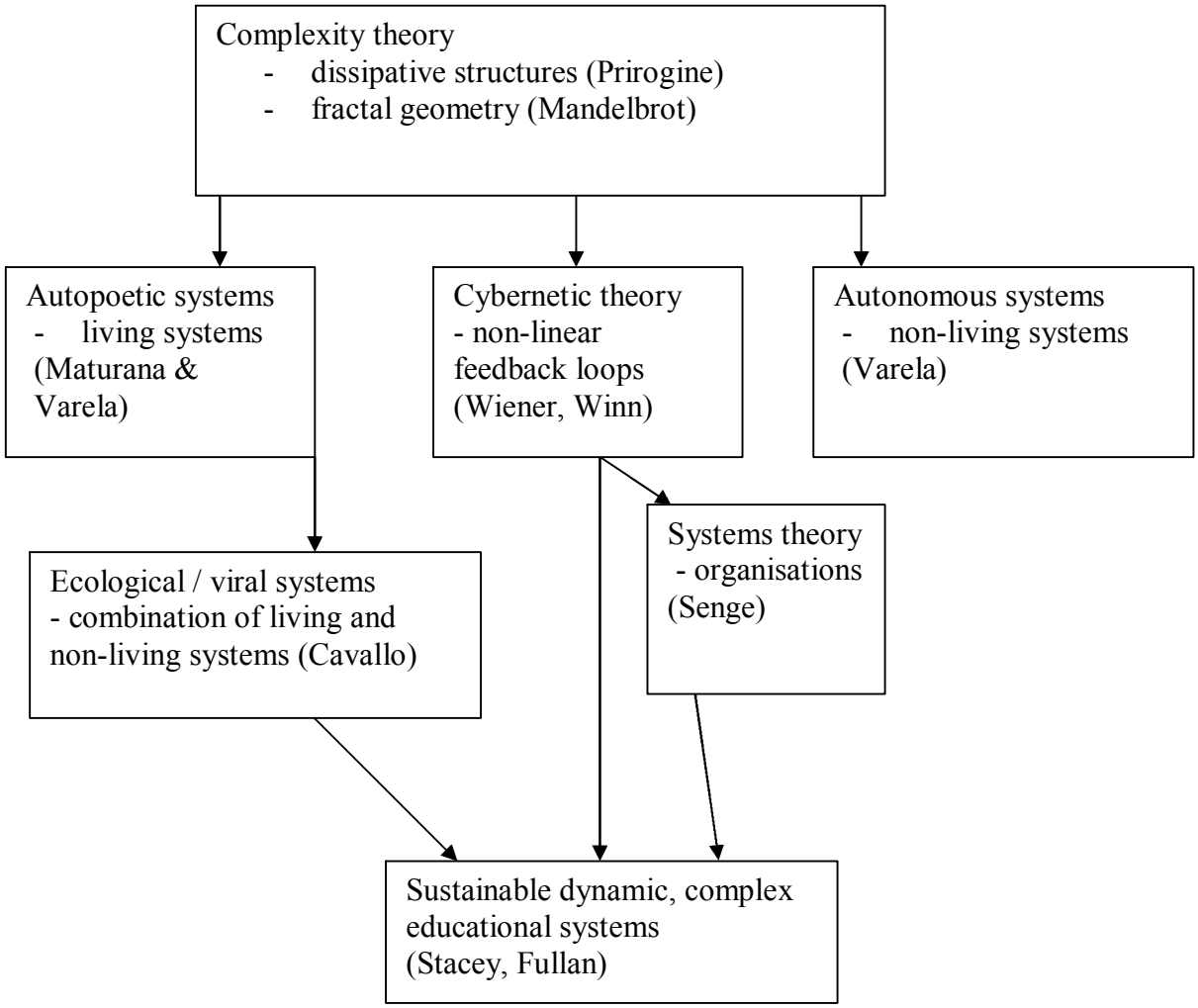

Figure 1: Conceptual Framework

In the ensuing sub-sections I will expand upon the philosophical and theoretical interrelations between these theoretical approaches.

2.7.1 Postmodernism, chaos, autonomous systems and complexity

It might be argued that, within Western philosophical tradition, a worldview begins and ends with one's conception of reality and the kind of knowledge that makes such a reality manifest to one. The very concept encapsulated in the Ancient Greek formulation of an alpha and an omega implies linear progression in the (metaphorical) form of either a passage of time or the traversal of physical space, or both. As discussed below, the metaphor of travel or journeying is particularly relevant in the context of this study.

There is about such linear progression the beginning of a positivistic determinism that finds its most eloquent expression in the Newtonian characterisation of the universe as machine. Nor is it coincidental that Newtonian physics, and later the hard sciences in general, should be the touchstone by which Enlightenment conceptions of reality and the nature of knowledge were to be evaluated. Such hard sciences provided the assurance that direct experience of an external, monolithic reality could be achieved through a replicable 'scientific method' that provided predictable evidence (in the form of 'measurement') of such a reality. The ontological and epistemological character of positivist thought is thus deterministic and predictable.

Philosophical conceptions of reality and the nature of knowledge, thus engendered and persuasively advocated by the hard sciences, found expression in other branches of human knowledge. In this way, the study of the humanities, for instance, was deeply influenced by structural linguistics (De Saussure, 1966), structuralism (Bush, 1995), and semiotics (De Saussure, 1966; Morris, 1946; Solomon, 2000). Besides the central thesis involving the existence of " a systemic 'centre' that organised and sustained the entire structure (Bush, 1995, p.2), the commonality in each of these instances was a view of reality as fixed and 'knowable' – and capable of being represented and reflected in human knowledge structures.

Ironically, physics was also the branch of human knowledge that witnessed some of the first challenges to the positivist position. The success of positivistic scientific enquiry resulted in an exponential growth in technological innovation. One of the results of such technological innovation, during the first half of the twentieth century was the ability to observe, for the first time, sub-atomic matter. Almost shockingly, the sub-atomic world, governed by quantum principles, as it was found to be, reflected a reality which was uncertain, partly unpredictable and characterised by indeterminism, generally. Furthermore, knowledge of such a reality was not unmediated and positivistic, as had been the case with Newtonian physics – rather, knowledge of such a reality was inextricably intertwined with the gaze of the observer / researcher. The birth of quantum physics signalled the birth of a philosophy of uncertainty and pluralism; the death of master narratives (Lyotard, 1984) and the beginnings of subjectively constructed, internalised realities that were 'knowable' only in terms of experience and interaction. Such ontological and epistemological indeterminism finds its most vehement twentieth century expression in the tenets of postmodernism (Lyotard, 1984; Foucault, 1980; Baudrillard, 1990; Anderson, 1995a; Jencks, 1992a; Solomon, 2000).

Solomon (2000, pp.13-15) argues that post-modernism rests on eight assumptions. The first assumption is that of pluralism, which is succinctly captured in Hlynka and Yeaman's

proclamation that "if there are multiple ways of knowing then there must be multiple truths" (1992, p.3). The second assumption is that of eclecticism, which finds its quintessential expression in Derrida's insistence on artistic collage/montage as the most important form of discourse (Harvey, 1990, p.51). The third assumption, and also a fundamental tenet of post-modernism, is the belief that knowledge is constructed, rather than acquired (Bruner 1991; Papert and Harel, 1991; Wilson et al., 1995). The fourth assumption underlying post-modern practice is the belief that truth is grounded in subjective experience. In this regard, the Baudrillardian conception of the simulacrum signals the breakdown between representation and reality, thus heralding the absence of a monolithic, exterior reality (Braudrillard, 1990). The fifth assumption relates to the way in which language is centrally involved in the social construction of knowledge, such that participants are actually "shaped by particular discourse communities" (Anderson and Damarin, 1996, p.270). Related to the centrality of language, is the assumption that communication is not determined by sender and message alone, but also, importantly, by the receiver and interpreter of such a message (Levinson, 1983; Sperber and Wilson, 1986, 1995). A central assumption underlying postmodernist practice is the shift of scientific interest from the study of inanimate systems to self-organising, dynamic, living systems that "consist of non-linear processes and a high degree of feedback" (Jencks, 1992a). It is thus not surprising that the eighth assumption should suggest a view of self as pluralistic and multiple, "struggling to maker internal peace among the multiple components of their selves and the claims of the different communities to which they are connected (Anderson, 1995b, and p.128).

Just as other branches of human knowledge had embraced empiricist positivism, espoused by the hard sciences in previous centuries, other branches of human knowledge embraced the relativism of postmodernity, once again espoused by the hard sciences, in the twentieth century? Postmodernity found expression in the humanities as a worldview that superseded predecessors such as post-structuralism and deconstruction (Gottdiener, 1994).

Subsequent developments in physics have included the conception of chaos as inherent in naturally-occurring and man-made systems, from the action of waves to the performance of the stock market (Sheldrake, 1990, pp.70-71; Solomon, 2000, p.14). With the advent of computers, chaos theory evolved in a number of ways, notably cybernetic theory (iterative non-deterministic feedback loops) (Wiener, 1950; Winn, 1975; Capra, 1996, p.52); autonomous systems theory (systems as self-regulating entities based on feedback and response) (Varela, 1979, 1992; Maturana and Varela, 1980, 1987); autopoeitc theory (autonomous biological systems) (Maturana, 1970; Maturana and Varela, 1980, 1987); the emergence of fractal geometry (Mandelbrot, 1993); and, finally, complex systems theory

(Senge, 1990, 2000; Trilling and Hood, 1999). Complex systems exist on the boundary between regulation and chaos (Stacey, 1996). They are not fully deterministic, tend to be characterised by uncertainty, and develop in non-linear and unforeseen ways. Because they do not develop in a linear fashion, they are also subject to multidirectional, often mutual, causality. Systems devised by human beings, involving human action and interaction, are typically complex systems. One such system, embedded in larger and yet larger systems, is education (Fullan, 1999, 2001, 2005). In short, educational systems are indeterministic, subject to multi-causal networks of interaction and interrelatedness, and often develop in unpredictable and unforeseen ways. The study of such systems militates against the ontological and epistemological characterisation of unitary exteriority and certainty that was the bedrock of positivist thought. Rather, scrutiny of such systems demands a postmodernist approach that allows for relativism, plurality, interiority and paradoxicality.

2.7.2 Education, change and complexity

The puzzling aspect of attitudes towards the way in which computers are meant to change education is accurately captured by Papert (1997a). He argues that "the idea of school in many of its features is so deeply ingrained in people's thinking that when they look at technology to discuss it in relation to computers, they see it in a particular and very narrow way dominated by the nature of school as they've known it" (Papert, 1997a, online). Herein lies the contradiction, says Papert: people think that "the role of the computer should be to get in there [existing educational system] and improve a system which exists as a result of the technological limitations of a previous epoch" (Papert, 1997a, online). It is exactly this contradiction that leads Papert (1997b) to claim that school reform is impossible, if reform is defined as "attempts to impose a specific new form on education" (Papert, 1997b, online). Change, with relation to educational systems, he argues, is evolutionary. Given this perception of change, he argues further that the computers that will act as the levers of change will be those that are outside the control of schools and outside the "schools' tendency to force new ideas into old ways" (Papert, 1996, online). What is needed are "bold, coherent, inspiring yet realistic visions of what education could be like 10 to 20 years from now" (Papert, 1991, online). Papert's impassioned plea in favour of allowing evolutionary change rather than enforcing centrally-controlled reform is, however, only the tip of the iceberg. Evolutionary change has to be viewed in concert with issues such as the exact character of the system that is to evolve, the principles underlying such evolution, and the propensity of the human actors involved in such change processes to produce implementation and management models that are consonant with such change.

Educational change has to be understood against the backdrop of change in complex systems. Senge draws a distinction between 'detailed complexity' (characterised above as 'synchronic' complexity) and 'dynamic complexity' (characterised above as 'diachronic' complexity) (1990, p.365). He further argues that dynamic complexity (the home of change in complex systems) is characterised by a situation where "cause and effect are not close in time and space and obvious interventions do not produce expected outcomes" (Senge, 1990, p.365). Stacey, commenting on Senge's characterisation of dynamic complexity, claims that the linkages between cause and effect in dynamically complex systems, rather than being distant in time and space, in fact, disappear altogether and are "impossible to trace" (1992, p.78). Furthermore, if there is no conclusive proof that specific intended actions were not affected by chance in bringing about specific intended material changes, then success in such systems is characterised by "the discovery of patterns that emerge through actions we take in response to the changing agendas of issues we identify" (Stacey, 1992, p.124). It is this 'perpetual suspension of intentionality' that results in the paradoxical nature of organizational dynamics, whereby organizations are "powerfully pulled towards stability by the forces of integration, maintenance controls, human desires for security and certainty", on the one hand, and "powerfully pulled to the opposite extreme of unstable equilibrium by the forces of division and decentralisation, human desires for excitement and innovation, and isolation from the environment", on the other (Stacey, 1996a, p.349).

Productive educational change, powerfully influenced by the underlying forces that shape complex enterprises, similarly "roams somewhere between overcontrol and chaos" (Fullan, 1993, p.19). So, the question that now arises is the following: is it possible to develop an implementation and management model that can usefully be employed in dealing with dynamic, complex educational systems, and, if so, what would such a model look like?
As a footnote to this enterprise, Fullan cautions that educational change will always fail until we are able to produce infrastructures and processes that enable teachers to develop new understandings (2001, p.37).

2.7.3 Ecological or viral change in educational systems

In contemplating the nature of such a model, Cavallo (2004) endorses and extends Fullan's view. Cavallo claims that "real change is inherently a kind of learning" (Cavallo, 2004, p.97). The processes associated with this kind of change are not only evolutionary, as Papert suggests, but more accurately characterised, suggests Cavallo, as 'ecological', 'viral' or 'genetic'. Such characterisation endorses the view that the 'reform' approach to educational change is powerless in the face of essentially unpredictable systemic patterns of change. The

emergence of such patterns is 'ecological' (partly) in the sense that they are beyond the control of hierarchical, linear reform initiatives. It is for this reason that Cavallo urges a management approach to evolutionary, ecological change, based on pattern recognition and the flexible, ongoing development of strategies that will actively contribute to such processes (Cavallo, 2004, p.97). Such an approach to implementing and managing ecological processes of change in complex educational systems is predicated on a design methodology characterised by Cavallo as 'emergent design':

> It supposes an evolutionary model, where we are not passive observers: we design and introduce new variants along certain principles and see how well they grow. We study the fitness functions, the social niches, and the local ecologies of culture and thought. We study change itself as a process of learning. Our role as the exogenous element in conducting the learning projects is to show the existence of a new way of instantiating dynamic learning environments. We bring in powerful ideas about learning and through our practice illustrate how to put them to work. The possibility for spread and growth is not through the exact replication since the context will be different and the culture is dynamic. Rather, the goal is for the appropriation of the principles and the development of models of thinking so that the agents can adapt and apply with the ability to continually develop through reflection on the feedback and changing environmental conditions.
>
> (Cavallo, 2004, pp97-98).

Underlying such an approach to change in educational environments is the recognition that not all host environments are the same and thus " the design of learning projects evolves and changes in dialogue with personal, collective and local interests, conceptions, and needs" (Cavallo, 2004, p.98). But this approach to emergent design, consonant with dynamic change in complex educational systems, has not been recognised by educational administrators in the past – and, is likely to have a profound effect on the design, implementation and management of future educational enterprises (Beare, 2000; Venezky and Davis, 2002; McMullan, 2002; Kinelev, Kommers and Kotsik, 2004). If the emergent design of dynamically complex educational environments in the future has profound implications for school administrators, it implies a complete paradigm shift for school principals. Fullan claims that the principal of the

future "has to be much more attuned to the big picture, and much more sophisticated at conceptual thinking , and transforming the organization through people and teams" (2002, p.3). Also, since complex societies "inherently generate overload, fragmentation and non-linearity -…- effective leaders must always work on connectedness or coherence –making" (Fullan, 2002, p.8). Such school leaders, or principals, are characterised elsewhere (Fullan, 2005) as system-thinkers-in-action.

Cavallo (2004), as indicated above, postulates an ecological, viral model of change within learning environments. Such an approach values the concept of 'evolution', rather than the concept of 'sustainability'. Change in complex, living systems is characterised by growth and development, often in initially unanticipated ways. Such evolution represents the development of a unique system in response to the unique set of environmental influences that affect such a system. Sustainability, associated with concepts such as the 'maintenance' of a synchronic system
over time, is antithetical to evolutionary development which, by its very nature, equates synchronic maintenance of a system over time with stagnation and, eventually, death.

In terms of the nature of learning environments as evolutionary ecological systems, Cavallo identifies certain characteristics inherent to fertile growth environments:

- volition – people must want to do things;
- appropriation and experimentation – people need to try out their own conceptions of the ideas in their own settings based upon their own priorities;
- concrete exemplars – there is a need to experience real examples of the ideas;
- community and communication – peer-to-peer interchange of ideas, explanations from practitioners at a variety of levels of expertise and experience;
- feedback – when one experiments one must not only see the results, but also get feedback from others;
- debugging – one must get the chance to 'make mistakes' and then use those to design and implement further work;
- materials – one needs things to work with that facilitate the new paradigm, and not merely work with the tools of prior instantiations;
- language – new paradigms re-appropriate old terms for new connotations, and even invent new terms to describe things in new ways;
- bottom-up and emergent – large-scale growth comes from the basis of many little contributions;

- time and continuity – major changes do not happen overnight, as there needs to be enough continuous time to experience and develop the ideas in their full complexity;
- hope and expectations – people must come to believe that improvement is desirable and possible.

(Cavallo, 2004, online)

The crucial question arising from a contemplation of the dynamically complex change processes that characterise educational systems is the following: how is sustainability to be understood? How do we know which implementation and usage patterns of computers in schools are likely to lead to sustainability - or is the very concept of sustainability, in this context, under siege?

2.7.4 Sustainability in dynamic, complex educational systems

The sustainability of ICT in education is characterised in a number of different ways in the literature – sometimes within the space of a single article. In one such article, Batchelor and Norrish (2002, online) begin by characterising sustainability as financial cost recovery. This definition is supplemented in the same article by the view that sustainability is a complex concept, but that it must needs involve persistence over time (2002, online). The definition is further elucidated and expanded in the article by the postulation of three different kinds of sustainability: economic sustainability, involving the maintenance of a certain level of expenditure over time; social sustainability. involving the minimization of social exclusion and the maximization of social equity; and, institutional sustainability, involving the ability of existing structures and processes to perform their functions over a long period of time (2002, online).

Batchelor and Norrish reflect upon the sustainability of ICT in educational development projects one year later, and come to the conclusion that there are a number of factors that "would have to be in balance for a project to be in some form sustainable" (2003, online). The factors thus identified are:

- clear objectives held by the majority of stakeholders;
- target groups need to be clearly identified;
- ICT activities cannot be in isolation from the policy environment;
- prevailing structures and processes can continue to perform their functions over the long term;
- linkages with relevant authorities and other authorities working in connected areas;

- planning the process of an activity;
- the human capital available;
- the technology used; and
- replacement costs and cost recovery

(Batchelor and Norris, 2003, online).

In a similar vein, Cisler (online) identifies the four pillars of sustainability as social, political, technological and economic sustainability. What these shifts in definition demonstrate very clearly is the growing realization that sustainability itself is a complex concept. But, instead of elucidating the nature of such complexity, these shifts in definition simply muddy the issue in presenting a number of contributory influences on complexity in an essentially disjointed fashion. There seems to be no pattern that links these influences together in a meaningful way. Employing the metaphor of the net (or web) to characterise the myriad of nodes and links that connect integral aspects of a complex system, we may say that this approach identifies the nodes of the net as repositories of value, and thus also determiners of the sustainability of the system. But such an approach ignores the fact that the value of the net lies in the number and quality of the nodes and dynamic links that define the whole as an integrated system. In this sense, sustainability is a characteristic of the dynamic system, as a whole.

Mioduser, Nachmias, Forkosh-Baruch and Tubin (2004) suggest that the sustainability of ICT interventions in schools revolves around the integration of the innovation into school practice, so that it becomes institutionalized in the form of "rules, regulations and intensive implementation" (Mioduser et al., 2004, p.6). But the suggestion that the innovation must harmonise with the structure of the school organization, runs the risk of appropriating technological innovations in the service of existing organizational structures that are the artefacts of a bygone technological era, as Papert (1997a) points out. Also, with reference to the metaphor of the net, employed in the previous paragraph, innovation is forced to operate within liner, hierarchical structures. It would seem that the very notion of sustainability in complex dynamic systems needs to be revisited and redefined.

The title of a Becta/DfES Report (Hennessy and Deaney, 2004) on ICT-supported classroom practice captures the schizophrenic dilemma faced by educationalists wishing to address the theoretical underpinnings of ICT-integrated classroom practice: "Sustainability and Evolution of ICT-Supported Classroom Practice". On the one hand, such an approach is informed by the need to account for the upkeep and maintenance of physical hardware and infrastructure, and, on the other, the need to account for dynamic, evolutionary people-based changes in practice,

over time. Returning to the metaphor of the net employed above, such schizophrenia is the result of viewing the nodes of the net as repositories of value whilst, at the same time, coming to the realization that the ways in which these nodes are linked is evolutionary in nature. The theoretical underpinnings of ICT-integrated classroom practice, in terms of evolutionary potential, are not to be found underlying the narrow confines of either physical infrastructure, or changing human practices – or both. Rather, the theoretical underpinnings of ICT-integrated classroom practice are to be sought in the evolutionary capacity of a larger, dynamic, complex system within which these processes find expression.

Fullan (2005), in examining the relationship between school leadership and sustainability in complex educational systems, recognises the inherent inability of the term 'sustainability' to capture the complex process of evolution at work in such systems. He points out that the term is derived from the Latin 'sustineo', which means "to keep up", but this suggestion is not applicable to complex educational systems because 'sustainability 'in such systems is cyclical rather than linear (Fullan, 2005, p.25). Retaining the term, even in the face of his own criticism of it, he then defines 'sustainability' in complex systems as the "capacity of a system to engage in the complexities of continuous improvement consistent with deep values of human purpose" (Fullan, 2005, p.ix). This definition of 'sustainability' has much in common with the evolutionary ecological model postulated by Cavallo (2004), above.

In fleshing out the skeletal definition offered above, Fullan argues that sustainability in complex systems is an adaptive challenge (as envisaged by Heifetz, 2004), where 'adaptive challenge' is defined as follows;

1. the challenge consists of a gap between aspiration and reality, demanding a response outside our current repertoire;
2. adaptive work to cover the gap requires difficult learning;
3. the people with the problem are the problem, and are the solution;
4. adaptive work generates disequilibrium and avoidance

(Fullan, 2005, p.45).

In short, adaptive challenges are problems, the solutions to which are unknown. The sustainability of a complex educational system, as adaptive challenge, is considered by Fullan to consist of at least eight elements;

1. public service with a moral purpose;
2. commitment to changing context at all levels;
3. lateral capacity building through networks;

4. intelligent accountability and vertical relationships (encompassing both capacity building and accountability);
5. deep learning;
6. dual commitment to short-term and long-term results;
7. cyclical energising;
8. the long lever of leadership

(Fullan, 2005, p.14).

Given the necessary elements of sustainability outlined above, Fullan argues further:

> "the set of strategies that brought initial success [in a learning organization] are not the ones – not powerful enough – to take us to higher levels. In these cases we would expect the best learning organizations to investigate, learn, experiment, and develop better solutions… If a system is to be mobilized in the direction of sustainability, leadership at all levels must the primary engine. The main work of these leaders is to help put into place the eight elements of sustainability; all eight simultaneously feeding on each other. To do this, we need a system laced with leaders who are trained to think in bigger terms and to act in ways that affect larger parts of the system as a whole: the new theoreticians "
> (Fullan, 2005, p.27).

Such leaders, at all levels of the system, are able to alter school culture and systemic context at all levels, exactly because they are systems thinkers who "gravitate towards strategies that alter people's system-related experiences; that is, they will alter people's mental awareness of the system as a whole, thereby contributing to altering the system itself (Fullan, 2005, p.40).

Fullan's (2005) characterization of the 'sustainability' of complex, dynamic educational systems has much in common with Cavallo's (2004) characterization of change in evolutionary ecological systems. What makes Fullan's treatment attractive, in the context of this study, is the fact that he contemplates the 'sustainability' of, specifically, school-based educational systems. Also, his unique definition of 'sustainability' encompasses many of the evolutionary change processes in complex educational systems envisaged by Cavallo (2004). For the purposes of this study, Fullan's (2005) definition and characterization of

'sustainability' will be taken to encompass Cavallo's (2004) characterization of evolutionary ecological or viral change processes in complex educational systems.

2.8 Summary

Overall, much has been written in the literature about the implementation of computers and ICT into classroom practice at school level. Similarly, much has been written about the effective use of computers as integral parts of school-based curricula. A number of influences on the successful implementation and use of computers in schools have been identified. Yet other influences have been identified as playing a crucial role in the successful implementation and use of computers in schools in developing countries, specifically. Many of these influences originate in the multi-dimensional contexts surrounding such implementation and use.

The literature is silent on the difference between 'implementation' and 'use'. Furthermore, the literature does not present a conclusive theoretical model that adequately describes the relationship between the implementation, use and sustainability of such initiatives.

The failure to produce such a theoretical model is, in the first place, brought about by adherence to a definition of sustainability that negates the dynamic complex nature of educational systems and initiatives. Such a definition treats influences in a disintegrated way and is incapable of integrating static, loose-standing synchronic influences into an integrated dynamic pattern which evolves over time.

Secondly, the failure to produce a satisfactory theoretical model of computer integration into classroom practice is a result of the failure to recognise 'sustainability' as a characteristic of the larger systemic processes within which such integration takes place, rather than a characteristic of the integration process itself.

'Sustainability' as a characteristic of dynamic, complex educational systems is adequately addressed by Fullan (2005), and the diachronic, organic evolutionary nature of such 'sustainability' is adequately accounted for by Cavallo (2004).

For this reason, key concepts derived from the theoretical approaches outlined above are encapsulated in the conceptual framework presented above. This conceptual framework informs the approach to research methodology and research design explained in Chapter 3. It is clear that such an approach will have to be characterised by:

- providing participants with the opportunity of presenting evidence on influences on the CALIS Project from as wide an array of quarters as possible;
- an openness (on my part) to influences on the CALIS Project not envisaged by me;
- a flexible approach to data gathering that would avoid narrow, consensually-constructed evidence;
- an approach to data analysis that would consciously avoid a priori preconceptions regarding findings; and
- extreme sensitivity towards ways in which specific influences on the Project might be integral parts of larger, influential systemic processes.

These are the principles that underlie the choice of research methodology and research design elucidated upon in Chapter 3.