Computers in schools: implementing for sustainability. Why the truth is rarely pure and never simple

H. Thomas
Head: Division e-Learning
Centre for Higher Education Studies and Development
University of the Free State
Bloemfontein, South Africa
e-mail: ThomasH.RD@ufs.ac.za

J. Cronje
Dean: Faculty of Informatics and Design
Cape Peninsula University of Technology
Cape Town, South Africa
e-mail: cronjej@cput.ac.za

Abstract

This study investigates influences on the sustainability of a computers-in-schools project during the implementation phase thereof. The *Computer Assisted Learning in Schools* (CALIS) *Project* (1992–1996) is the unit of analysis. A qualitative case study research design is used to elicit data, in the form of participant narratives, from people who were involved in the regional management of the Project, as well as teachers who implemented the Project in their classrooms. These narratives are then analysed from a postmodern perspective (Kvale 1996). The analysis reveals personal, programmatic, physical and systemic influences on the Project. These influences can be identified on all structural levels of the education system (Mooij and Smeets 2001). Furthermore, metaphoric patterning across narratives is analyzed in terms of implicatures, postulated by Relevance Theory (Sperber and Wilson 1995). Analysis of the data provides evidence in support of Fullan's (2005) definition of sustainability as a quality of dynamic, complex systems. Personal, programmatic, physical and systemic influences on the Project are found to be interrelated on, and across, structural levels of the system. In addition, influences are dynamically related to the changing Project in particular host environments (Cavallo 2004). The resulting ecological or viral growth is characteristic of complex systems, where further development is indeterminate. Finally, suggestions are made regarding the possible implications of these findings for the development of a framework for the sustainable implementation of ICT- enabled educational projects.

ISSN 1011-3487

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.

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.

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 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.

OBJECTIVES

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 that follow.

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, influence 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?

The purpose of this study was 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 would then 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.

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.

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 dynam-

ics, characteristic of complex educational systems, might be implemented with a view to addressing sustainability.

THEORETICAL FOUNDATION

Numerous studies document factors influencing the successful modelling and support of computer-integrated education initiatives at school level (Mooij and 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.

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.

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, 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, 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, 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, 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, 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, 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?

The reasons for the vast discrepancy between implementation and integration in developed countries as opposed to implementation and integration in developing countries are even more complex. 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. Ex-

pensive, 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, 6).

Conceptual framework

Given the complexity of the situation sketched above, coupled with the inability of the existing literature to define the sustainability of ICT-integrated educational projects meaningfully, the following conceptual framework was arrived at. Concepts used in this framework were drawn from the following theories/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.

Figure 1 provides a visual representation of the way in which concepts from these theories are related.

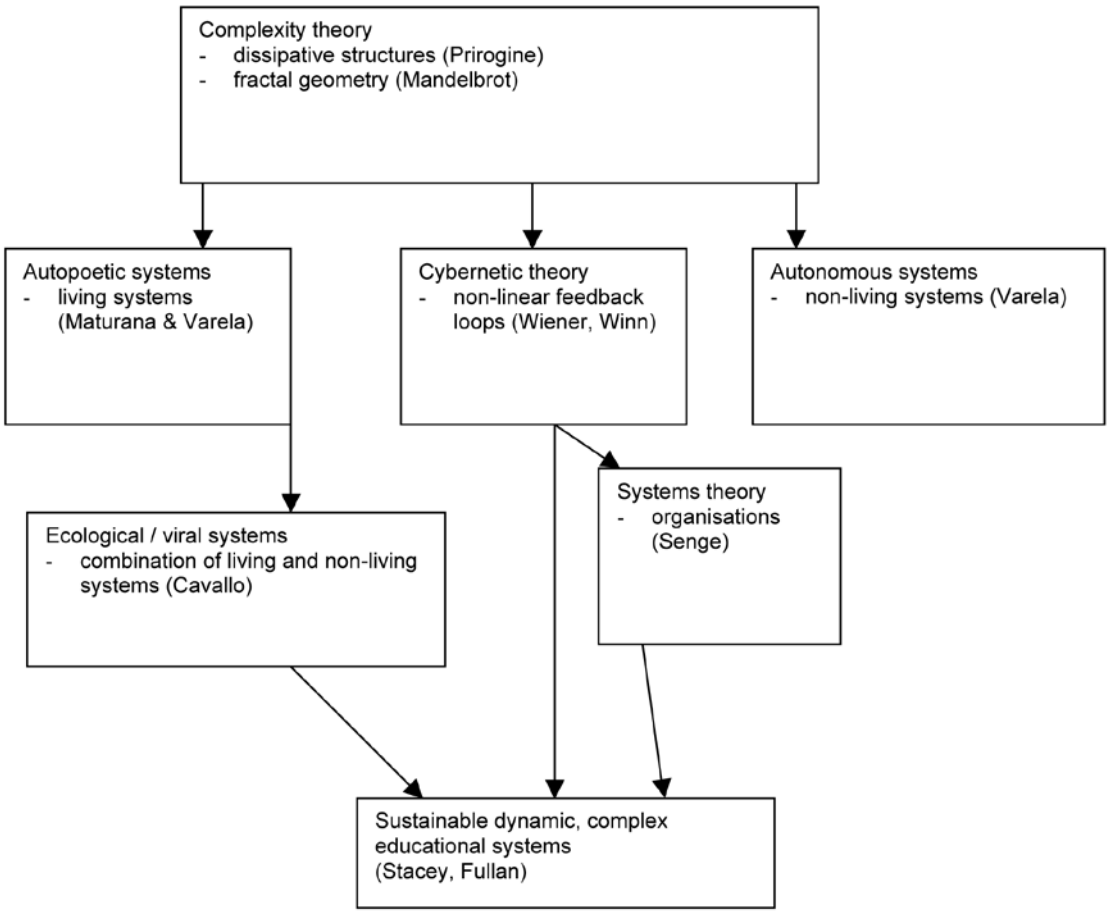

Figure 1: Conceptual Framework

METHODOLOGY

Qualitative research allows for the inferential interpretation of narratively-constructed, plural and interior realities (Patton 1985; Miles and Huberman 1994, 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.

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, 40; Cronbach 1975; Merriam 1998;); it appeared to demand an answer to a 'how' question (Yin 2003, 6); 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, 7); it appeared to involve a programme or process that was inextricably linked to organisational change (Yin 2003, 23). In Yin's view (2003, 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, 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, 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, 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'.

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, 41).

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.

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.

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.

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.

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, 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, 37). In this particular study, the results obtained from the examination of a single, unique case are generalized to a conceptual framework.

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, 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, 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, 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, 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.

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.

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, 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, 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, 71); 'identifying themes and developing concepts and propositions'

(Taylor and Bogdan 1998, 141); and, 'noting regularities, patterns, explanations, possible configurations and causal flows' (Miles and Huberman 1984, 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.

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, 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, 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, 242); clearly establishing the content and purpose of the investigation at the outset (1996, 243); and, addressing the theoretical questions raised about the nature of the project investigated (1996, 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, 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, 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, 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, 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, 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, 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, 232; see also Kennedy 1979).

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, 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).

DISCUSSION OF RESULTS

The narratives produced by participants in this study provide evidence which suggests that influences on the implementation for sustainability on the CALIS Project can, in fact, be identified on various structural levels of the educational system, as suggested by Mooij and Smeets (2001). Furthermore, there is enough evidence in the literature on this topic to support such suggestions. The problem with much of the existing literature on the topic, however, is that, in the final analysis, it proceeds from the implicit assumption that individual influences are discreet entities. As such, the literature proposes a taxonomic approach to investigating the sustainability of computer-integrated education. Paradoxically, the complex systemic nature of educational systems, so well documented and debated in the wider literature involving educational practice generally, is virtually ignored in literature relating to computer-integrated education.

The findings of this study thus endorse a number of propositions expressed in the conceptual framework concerning the implementation of computer-integrated education projects with a view to ensuring sustainability.

1. It is not only the generic personal characteristics possessed by teachers involved in the project that are important; rather there are very specific characteristics associated with participants at all structural levels of the system that need to be taken cognisance of. This is to be expected in complex systems where functional specialisation in integral smaller components of the system enables system-wide functionality.
2. Programmatic planning and implementation of such projects needs to be informed by a systems approach. Such an approach is informed by the recognition that computer-integrated education projects are implemented in a dynamic, complex educational system characterised by unique local host environments and ecological growth patterns. This implies that implementation will be context-specific and that unique, complex feedback systems will stimulate ecological growth of the

project along unanticipated trajectories. Far from implying chaos, the implementation of the project needs to guarantee the maintenance of the resulting system on the boundary between over-regulation and implosion. In the case of dynamic, complex educational systems, this can be achieved by growing large numbers of leaders who are systems-thinkers-in-action. Such leaders must actively pursue Fullan's eight essential elements of sustainability at all levels of the system. Only then, can context at all levels of the system be changed. Such context includes institutional and system-wide cultures, defined by Fullan (2005) as that which we (as participants, institutions, systems) agree on as being true.

3. The availability of physical resources, most notably funding, remains a crucial aspect of implementation and sustainability, but it cannot be seen in isolation. The availability of resources is inextricably tied up with: the personal characteristics possessed by participants in the project; the programmatic involvement of communities in which such projects are implemented; the establishment of public-private partnerships; and the vagaries of historical, economic, technological and political processes that characterise the larger systems within which the educational system functions.
4. It is also evident from participant narratives that computer-integrated education projects are implemented in an educational system which is, in turn, embedded in larger systems. The dynamism of these larger systems thus also influences the educational system, and, by extension, the projects implemented in that system. Such influences, drawn from nested systems cannot be viewed as discreet, individual forces, but rather as interrelated, co-determinants of sustainability.

Thus, the findings of this study suggest that the implementation and sustainability of computer-integrated education projects need to be informed by a systems approach. Such an approach includes conceptions of unique host environments, ecological growth patterns and a systems definition of sustainability. This approach is adequately captured in the conceptual framework of the study.

But participant narratives produce evidence of further influences on the implementation and sustainability of computer-integrated projects not fully accounted for in the conceptual framework, as indicated below.

The conceptual framework presented above incorporates concepts drawn from theories relating to complexity, systems, autopoetic and autonomous systems, and complex educational systems. As indicated above, findings produced from participant narratives provide support for these concepts. But findings also provide evidence for a number of metaphoric patterning across narratives. The traditional approach to metaphor interpretation (Lakoff and Johnson 1980) is precluded in favour of the interpretation of metaphor proposed by Relevance Theory (Sperber and Wilson 1995; Pilkington 2000). The reason for this decision is simply the fact that the latter theory proposes an interpretation of metaphor consonant with the plurality and complexity of educational systems, as encapsulated in the existing conceptual framework. Rel-

evance Theory provides a tool with which metaphoric patterning in the narratives can be unlocked, in order to provide access to a socially, religiously and culturally defined 'meta-narrative' that situates systems influences, previously identified, within a wider anthropomorphic context.

There are essentially four broad metaphoric patterns to be found across participant narratives, namely those relating to: personhood, journeying, ecology and energy. Taken together, such patterning produces a socio-cultural meta-narrative which emphasises the progress of the Project as journey. At the heart of the journey lies an absence, namely the absence of closure – in the form of the arrival at a destination. The journey is undertaken in the name of a socially, culturally and religiously perceived duty to conserve the metaphoric ecosystem by actively assuming the role of the sower in the Biblical parable of the same name. The inability to reach the destination is brought about by the metaphorical loss of energy occasioned by the withdrawal of government support from the Project. The only energy source capable of revitalising the Project is the metaphorical power of nuclear fusion that lies dormant within each and every person involved in the Project. When nuclear fusion takes place, it releases vast amounts of energy in a reaction which becomes self-sustaining and which enables the Project to reach its destination and closure is achieved.

The meta-narrative produced in this way thus reflects and comments upon the overt narratives produced by participants and provides clear evidence of the importance of social, cultural and religious influences on the sustainability of ICT projects in complex educational systems.

CONCLUSION

The 10th Anniversary NADEOSA Conference of 2006 contemplates two extremes: ICT as panacea for educational needs in developing countries, versus ICT as essentially ineffective in such circumstances. Until educational thinkers and practitioners in primary, secondary and tertiary education recognise ICT projects as complex systems integrally entwined in larger and yet larger complex systems, we will continue to suggest simplistic answers to complex problems – and, in the process, we will not escape the dialogic paralysis that characterises current debate.

References

Atkinson, R. 1998. *The life story interview*. Thousand Oaks CA: Sage.

Armstrong, D., J. Atkins, M. Kane, A. Mackenzie, M. McBurney and T. McMullan. 2004. *Moving towards e-learning in schools and FE colleges: Models of resource planning at the institutional level* (No. RR601). London: Pricewaterhouse Coopers LLP.

Baylor, A. L. and D. Ritchie. 2002. What factors facilitate teacher skill, teacher morale, and perceived student learning in technology-using classrooms? *Computers and Education* (39):395–414. Available at: http://www.sciencedirect.com/. Accessed on

10 June 2005.
Bebell, D., M. Russel and L. O'Dwyer. 2004. Measuring teachers' technology uses: Why multiple measures are more revealing. *Journal of Research on Technology in Education* 37 (1): 45–64.
Caelli, K., L. Ray and J. Mill. 2003. 'Clear as mud': Toward greater clarity in generic qualitative research. *International Journal of Qualitative Methods* 2(2). Available at: http://www.ualberta.ca/~ijqm/backissues/2_2/html/caellietal.htm. Accessed on 17 January 2005.
Cavallo, D. 2004. Models of growth – towards fundamental change in learning environments. *BT Technology Journal* 22 (4): 96–112. Available at: http://learning.media.mit.edu/publications.html. Accessed on 28 June 2005.
Cawthera, A. *Computers in secondary schools in developing countries: Costs and other issues*. The Department for International Development; World Links for Development. Available at: http://www.dfid.gov.uk/pubs/files/computersinsecschoolsedpaper43.pdf. Accessed on 18 June 2005.
Denzin, N. 1970. *The research act in sociology*. London: Butterworth
Ely, D. P. 1990a. Conditions that facilitate the implementation of educational technology innovations. *Journal of Research on Computing in Education* 23 (2): 298–305.
——. 1990b. *The diffusion and implementation of education technology in developing nations: Cross-cultural comparisons of Indonesia, Chile, and Peru*. (ERIC Document Reproduction Service No. ED 331 469).
——. 1999a. Conditions that facilitate the implementation of educational technology innovations. *Educational Technology* 39 (6): 23–27.
——. 1999b. *New perspectives on the implementation of educational technology innovations*. (ERIC Document Reproductive Service No. ED 427 775).
Fullan, M. 2005. *Leadership and sustainability*. Thousand Oaks, California: Corwin Press.
Giorgi, A. (Ed.). 1985. *Phenomenology and psychological research*. Pittsburgh, PA: Duquesne University Press.
Glaser, B. G., and Strauss, A. 1967. *The discovery of grounded theory: Strategies for qualitative research*. Chicago: Aldine.
Hall, G. E. and S. M. Hord. 1987. *Change in schools: Facilitating the process*. Albany, NY: State University of New York Press.
Hawkins, R. J. 2002. *Ten lessons for ICTs and education in the developing world.* World Links for Development Program, The World Bank Institute. Available at: http://www.cid.harvard.edu/cr/pdf/gitff2002 ch04.pdf. Accessed 1 September 2004.
Hooper, S. and L. P. Rieber. 1995. Teaching with technology. In: *Teaching: Theory into practice,* ed, A.C. Ornstein, 154–170. Needham Heights, MA: Allyn and Bacon. Available at: http://www.nowhereroad.com/twt/index.html. Accessed on 15 November 2004.
Kennedy, A. 1979. *Meanings and signs in fiction*. London: Macmillan.
Kvale, S. 1996. *InterViews. An introduction to qualitative research interviewing*. London;

New Delhi: Sage Publications.
Lakoff, G. and M. Johnson. 1980. *Metaphors we live by*. Chicago: Chicago University Press.
Lincoln, Y. S. and E. G. Guba. 1985. *Naturalistic inquiry*. Beverly Hills, CA: Sage.
Maturana, H. 1970. Biology of cognition. In: *Autopoiesis and cognition,* eds. H. Maturana and F. Varela. Dordrecht, Holland: D. Reidel.
Maturana, H. and F. J. Varela. 1980. *Autopoiesis and cognition*. Dordrecht, Holland: D. Reidel.
——. 1987. *The tree of knowledge.* Translated by R. Paolucci. Boston: Shambhala.
McMullan, T. 2002. *Wired to learn. What's holding up the school of the future?* London: Adam Smith Research Trust.
Merriam, S. B. 1998. *Qualitative research and case study applications in education. Revised and expanded from case study research in education*. San Francisco: Jossey-Bass.
Miles, M. B. and M. A. Huberman. 1994. *Qualitative data analysis. An expanded sourcebook.* 2nd Edition. London; New Delhi: Sage Publications.
Mooij, T. and Smeets, E. 2001. Modelling and supporting ICT implementation in secondary schools. *Computers and Education* 36:265–281.
Pelgrum, W. J. 2001. Obstacles to the integration of ICT in education: Results from a worldwide educational assessment. *Computers and Education* 37:163–178.
Pelgrum, W. J. and T. Plomp. 1993. The worldwide use of computers: A description of main trends. *Computers and Education* 20 (4): 323–332.
Plomp, T. and W. J. Pelgrum. 2005. Sites 2006 – international comparative survey of pedagogical practices and ICT in education, *World Conference on Computers in Education*. Cape Town.
Prigogine, I. 1967. Dissipative structures in chemical systems. In: *Fast reactions and primary processes in chemical kinetics,* ed. S. Claessons. New York: Interscience.
Reiber, L. P. and P. W. Welliver. 1989. Infusing educational technology into mainstream educational computing. *International Journal of Instructional Media* 16 (1): 21–32.
Richardson, L. 1994. Writing: A method of inquiry. In: *Handbook of qualitative research,* eds. N. Denzin and Y. Lincoln. London and New York: Sage.
Rodriguez, A. 2002. Redefining our understanding of narrative. *The Qualitative Report* 7(1). Available at: http://www.nova.edu/ssss/QR/QR7-1/rodriguez.html. Accessed on 24 January 2005.
Rogers, E. M. 1995. *Diffusion of innovations.* 4th Edition. New York: Free Press.
Sandholtz, J. H., C. Ringstaff and D. Dwyer. 1997. *Teaching with technology: Creating student-centered classrooms*. New York: Teachers College Press.
Schostak, J. 2002. *Understanding, designing and conducting qualitative research in education*. Buckingham: Open University Press.
Senge, P. 1990. *The fifth discipline*. New York: Doubleday.
Senge, P., N. Cambron McCabe, T. Lucas, B. Smith, J. Dutton and A. Kleiner. 2000. *Schools that learn*. New York: Doubleday.

Shuldman, M. 2004. Superintendent conceptions of institutional conditions that impact on teacher technology integration. *Journal of Research on Technology in Education* 36 (4): 319–343.

Sikes, P., B. Troyna and I. Goodson. 1996. Talking lives: A conversation about life history. *Taboo: The Journal of Culture and Education* 1 (Spring): 35–54.

Sperber, D. and D. Wilson. 1995. *Relevance. Communication and cognition.* 2nd Edition. Oxford: Basil Blackwell.

Stacey, R. D. 1992. *Managing the unknowable*. San Francisco: Jossey-Bass.

——. 1996. *Complexity and creativity in organisations*. San Francisco: Berrett-Koehler.

Taylor, S. J. and R. Bogdan. 1998. *Introduction to qualitative research methods.* 3rd Edition. New York: John Wiley and Sons Inc.

Varela, F. J. 1979. *Principles of biological autonomy*. New York: North Holland.

——. 1992. Whence perceptual meaning? A cartography of current ideas. In: *Understanding origins,* eds. F. J. Varela and J. Dupuy, 235–271. Dordrecht: Kluwer.

Wiener, N. 1950. *The human use of human beings*. New York: Houghton Mifflin.

Winn, W. 1975. The open-system model of learning. *AV Communication Review* 23 (1): 189–212.

Woods, P. 1996. *Researching the art of teaching: Ethnography for educational use*. London: Routledge.

——. 1999. *Successful writing for qualitative researchers*. London and New York: Routledge.

Yin, R. K. 2003. *Case study research. Design and methods.* 3rd Edition. Thousand Oaks, London, New Delhi: Sage.