A SocioCybernetic Approach to Educational Systems

Dr. Selby Markham
Computing Education Research Group
Monash University
selby.markham@infotech.monash.edu.au

Abstract

The ways in which information and communication technologies are influencing educational systems is the subject of discussion from a number of directions including educational practice, education theory and educational technology. Underlying any discussion is the question of the degree of change that these technologies are creating. It is argued here that the changes constitute qualitative shifts in the nature of education, and that we need to look at them as Kuhnian paradigm shifts. These significant qualitative changes are engendering debate and theory development on a scale that is unprecedented in education. The conventional thinking about education had its beginnings in the traditional classroom and yet there is a tendency for this conventional thinking to form the backbone of explanation within the changing environment. It is argued that an alternative approach is needed that is able to deal with change in a coherent way and such an approach is seen to be derived from sociotechnical systems theory. All of these factors are seen to be important in defining the way in which education and information technology should combine in order to maximise the developmental potential rather than following along behind.

Introduction

Rushby (2005), in an editorial in the British Journal of Educational Technology, asks where you are the new paradigms for technology-based learning environments. He suggests that the complexity of changing learning environments is not being paralleled in the development of appropriate learning paradigms and in methodologies that support appropriate innovations in instructional design.

The integration of Information and Communication Technologies (ICT) systems, into the management and the functioning of educational institutions is changing the teaching and learning environment and leading to questions like those asked by Rushby. The changes in the learner's view range from the capacity of to enroll and obtain results transcripts on-line, through to the ability of the learner to access self-directed and self-managed learning environments. From the teacher's view we can begin with real-time on-line course management systems through to highly flexible delivery platforms that transcend the classroom. Much of the traditional thinking about educational systems was premised on delimited physical environments where a set of traditional roles defined interactions and many of the models used to describe educational environments continue to work from these types of assumptions.

Little of the discussion of the way in which educational systems have changed has moved to the level of questioning the depth of this change. The various positions developed on learning systems in Jonassen and Land (2000) are primarily about various pedagogies and technologies while recognising that there is a need for review, but they do not address fundamentals. When Galbraith (2004), Gunter (2004) and Sullivan (2003) debate chaos theory versus system dynamics theory in education, they are not addressing issues central to the nature of educational organisations, rather they are focusing on models that may or may not be relevant.

Evaluation of functional educational activities add insight but often fail to question the fundamentals such as the work of de Kock, Sleegers & Voeten (2004) where they recognise issues of change but reformulate it within existing thinking.

Where there is discussions of fundamentals it is at the more extreme limits of educational thinking or comes from outside education. For example, the various papers written by Heylighen over the past decade from with the Cybernetics community (eg Heylighen, 1993) generate challenging ideas. Such ideas may not permeate into the general education community but warrant responses. Similarly, the work of Voithofer (2002) on nomadic epistemologies develops a particular view of education that is outside the mainstream but, again, needs to be considered.

An element in the changing structure of education that appears to have generated minimal discussion is the socio-cultural implications of distributed delivery systems based upon western culture. Neither the Anglo-Scottish educational model nor the North American model were
designed to accommodate cultural difference, yet they are both being distributed as default models. The technology is carrying along cultural issues that will have effects and that may or may not be beneficial. There appears to have been limited research (e.g., Chang and Lim, 2002) into ways in which this might effect pedagogical practice.

The idea that information technologies are changing the education system is not without its critics. Robertson (2003) questions the claims about the impact of technology and suggests that constructivism has been hijacked in the name of technology. Her position is partly correct because few of the system developers appear to have a great interest in pedagogy, if their literature is indicative. For example, within the whole of the specification systems for interoperability for e-learning systems, there is no material on educational process and pedagogy (e.g., ADL, 2004). But Robertson’s position lacks scope by not seeing many aspects of technology as components in a changing world.

The position to be argued here is that a paradigm shift is upon us and that this requires a response that produces some integrating approach that accepts the real diversity that distributed, global educational systems imply. We also must understand that the shift is neither complete nor universal and this is quite understandable given the diversity of educational thinking and pedagogical models that support educational practice across the globe. The most likely approach that can help explicate what is happening is seen as being some variation on open systems theory (Emery & Trist, ) and this will lead to a super-ordinate pedagogy that allows for the existence of task-specific pedagogies, such as constructivism. Open systems theory would allow us to develop an overall organisational model but this is outside the scope of the current paper.

It is also argued that the qualitative shifts that are occurring in education impact upon computers in education and upon computing education. These shifts are moving towards the point where the instructional designer and the educational technologist will be working with the ICT educator, with the person who is trained to deal with developing, implementing and evaluating systems that can be distributed, mobile, virtual and student-directed.

Defining the Domain

There are major definitional problems in trying to define the components of the teaching/learning environment. ‘Pedagogical’ is being confused with ‘pedagogy’, ‘learning theory’ is being confused with ‘pedagogical’, ‘epistemology’ is being confused with ‘learning theory’ and all are being used in strange ways (Heylighen, 1993; Ford, Glymour & Hayes, 1995). There is desperate need to clean up the formal denotational framework – considering that we are involved in an educative process.

We would, following various external definitions, say that a pedagogy is a ‘model’ of the teaching/learning environment that allows the participants in the environment to interact and achieve outcomes. To define as pedagogy one of the possible sub-models associated with the way people can learn, is a distinct category problem in that a part is being confused with the whole. One process within a complex set of processes is being defined as the set of processes. This applies whether we try to talk about instructivism, constructivism or critical theory as a pedagogy. They are each versions of how people learn, none of them has an a priori precedence over the others and none of them directly define instructional practice, instructional design or social educational outcomes.

Defining the Paradigm Shift

A paradigm shift in the basic Kuhnian sense (Kuhn, 1996) occurs when new components enter the area of study and these then seriously disturb the status quo. These lead to a qualitative transformation or shift in the way materials are handled and theories are formulated. Additionally, these new elements increase the richness and complexity of the area. Kuhn’s interest was in scientific theory but it is reasonable to extend his thinking into more applied areas when it can be shown that what he formulates can have clear explanatory value.

Simply saying that change has occurred and therefore there is a paradigm shift is not sufficient. Changes can be linear where they represent a change in quantity rather than a qualitative change. This can be best seen through catastrophe theory (Arnold, 1992; Zeeman, 1977). Catastrophe theory tells us that change can occur in a given plane of activity where all the changes represent some path in some direction along the plane. The telephone has changed in many ways since the early work of Alexander Graham Bell but the bulk of that change has been paths across the plane ‘telephone’ until the development of the mobile phone. This took personal telephony onto a new plane. There was a catastrophe shift from one technological
plane to another and from one user method plane to another. A cusp occurred in the telephone plane as it moved from the various versions of fixed phone to the the variations on the non-fixed phone. Figure 1 shows the various paths that could have occurred as telephones became more mobile. If the role of the mobile phone as an accoutrement to life had not developed then path A would have been most likely, while path B assumed a sedate acceptance of the fashion statement of the phone. What actually happened was that the mobile phone began moving towards an accoutrement even when it was fairly bulky and when the size became optimal, and more gadgets were added, a catastrophe shift occurred where its fashion function has almost taken over.

The justification for talking about a paradigm shift in education as a consequence of the recent effects of ICT systems derives from specifiable changes that have occurred in the educational environment over at least the last ten years. These changes can be seen in both pedagogy and administration and can be shown to have transformed aspects of education including attempts to develop new theory. A basic example of this is the introduction of the asynchronous chat room as a feedback forum on course activities. This can be seen to be a qualitative shift in that both the staff and student move from the face-to-face communication methods to the computer-to-computer communication methods. Not only is there are catastrophe shift in the mode of communication but that communication process also changes from one-to-one to one-to-many-to-one.
In 1995 Thornburg was suggesting that we had moved from the information age to the communication age. Critical in this was the way in which information had become an infinite resource rather than something under the control of a limited number of people – usually teachers and librarians. This was an early statement about some of the core ingredients in the paradigm shift.

Writers on changes in distance learning tend to accept that a fundamental shift has occurred. Harper, Chen and Yen (2005) give a useful summary of the history of distance education and the importance of the current changes. What is being argued here is that the shift is functional across all educational modes, not just distance education.

Another indicator of the likely extent of the shift is the development of counselling and related services using the Internet (eg. Mallen, Day, Susan and Green, 2003). This will affect the way education is functioning because it allows for student support services to parallel those that exist on campus. The significance of this shift lies in the basic definitions that existed for effective counselling where body language and total listening were seen to need face-to-face interaction. Even the use of telephone counselling was seen as an inadequate approach except in crisis interactions. To accept that counselling can be carried out over the internet requires the creation of a new model of counselling that is qualitatively different from the old. Hence the work by Mallen et.al. (2003) and others on the way in counselling communication processes over electronic media.

**Pedagogy**

The qualitative transformation in pedagogy, defined as the science and art of teaching, is quite complex and covers a number of aspects of what the teacher is doing. The first of these concerns the impact of information technologies on teaching where the teacher can now control and manipulate information at an extremely complex level. The teacher is not constrained by the four walls of the classroom. She is, for example, able to utilise complex simulations to develop student thinking and understanding; to work with the student outside the classroom via the computer. In addition the teacher is able to traverse traditional pedagogies and tailor materials to fit student needs. And all of this can be done “on the fly”. Education can be seen as shifting from a delivery paradigm that is focussed on the classroom to one that is multidimensional and flexible from both the teacher and the student view.

There are obvious implications for pedagogy in the way the structure of learning materials is shifting from passive, well defined storage systems into dynamic, open-ended access systems (Krishnaswamy et al, 2004). Even the formalism of SCORM (Sharable Content Object Reference Model http://www.adlnet.org/), and related definitions for electronic storage and retrieval, is accepting that there needs to be some dynamic element. With the introduction of SCORM2004 some capacity has been included for establishing associations between search elements and consequent user patterns. Commercial vendors have begun to produce dynamic meta-tagging software (eg Metatagger http://www. ) and these are being incorporated into repository systems. As repositories develop and provide effective educational materials, the teacher and learner will have access to a different level of learning materials.

Within this the role of the teacher is becoming more varied and flexible. A practical example of this shift is outlined by Young (2004) in discussing the functioning of the School for All program in Taiwan.

Technology/software systems can build distributed systems that move outside the concept of the classroom. When this is coupled with electronic access to information that eliminates the basic need for the library (without becoming involved in the issue of the veracity of such information) then the world of the self-managed or self-directed learner becomes a reality.

**Computer Supported Cooperative Learning**

A more recent change has come through increased ‘connectivity’ of the computer. The realisation of McLuhan’s global village (McLuhan & Powers, 1989) is almost upon us and this is changing the way in which learners can cooperate on learning tasks. The growth of models of cooperative learning environments is one of the major transformations in educational thinking over the past ten years. For example, Rovai and Lucking (2003) look at the application of television technology in creating a distributed learning community while Russell, Calvey & Banks (2003) look at the development of learning communities as means of enhancing e-learning. Järvelä and Salovaara (2004) report on the changes in high school student response based upon exposure to computer supported learning. Added to this is the whole of the Computer Supported Cooperative Work movement (CSCW: eg. Karsten, 2003) that is, in effect, premised on the ability to work together via connected computers.
From another perspective, the world of the learning community, unrestrained by physical meeting schedules now takes on a completely different perspective. Lifelong learning in unconstrained learning environments is almost a reality. What has happened here is not simply a quantitative shift along a linear scale defining personal control versus external control. If we restricted ourselves to externally controlled curricula, as is found in some professional programs, we would have to look at a linear scale shift but once we move out into more general education we are looking at a qualitative shift.

Pedagogy has been transformed through the level of accessible information that the Internet provides. The Web user can search for almost any topic and find information that is not restricted to the formalisation of the encyclopaedia or the indexing of the library. In recognising that the veracity of the data from the web can be in doubt, a new element in the teaching and learning environment has also been introduced, namely the development of a search validation expertise. Once this was the perogative of the researcher but now every student has to learn the processes needed to weigh up the content extracted from a search. A component of this qualitative shift is that teaching moves more and more towards teaching students those skills that help them become independent learners.

Epistemology

Epistemology, as the theory of knowledge acquisition, is a less clearly definable component in the changing educational environment. This is not to suggest that epistemology is unimportant in any analysis of the changing structure of learning systems. The difficulty is that the issues around epistemology very difficult to explore without delving into the core philosophical issues underlying it.

Voithofer (2002) made a series of important points when talking about nomadic epistemology, particularly the idea that the learner who is able to study in a distributed mode is displaced from face-to-face learning environment and is not, in the conventional sense, a part of the geographically physical institution. He sees the knowledge acquisition under these conditions has being influenced by multiple knowledge sources being available at a click.

A search through the articles and papers associated with the issues being addressed by here, shows that epistemology qua epistemology is rarely talked by authors who are researching teaching and learning. At times there are some interesting new meanings added to epistemology such as the epistemic keys of Banerjee (2001)

Technical

Technical factors are also contributing to the paradigm shift. For example, what is generally called distributed computing environments produces new ways of delivering materials and new models of teacher-learner and learner-learner interactions. There are those who see a new epistemologies deriving from this technical capacity such as Voithofer's (2002) nomadic epistemology.

The virtual educational environments are based upon implementation technologies as are some of the agent-based developments including intelligent tutorial and mangement systems . There are also efforts aimed at utilising advanced technology thinking in the development of delivery systems (eg. Chhetri et al, 2004).

We must be careful here that we do not fall into the technology error and confuse technology with pedagogy and teaching and learning processes. Research carried out into the way on-line education was being implemented in the Australian Technical and Further Education sector (Hill, Malone, Markham, Sharma, Sheard & Young, 2003 ), showed that the use of technology lead to the belief that the teaching environment was somehow turned into an e-learning environment. Simple translations of paper-and-pencil materials into internet accessible materials was being defined as the developing an e-learning environment.

Instructional design has its own technical issues when we explore our paradigm shift. The way in which computers and software have effected the profession of instructional design would constitute a separate paper. What we are interested in is the way instructional design has come to see its role in this changing world and the relative depth of the changes that have taken place.

There is always the issue of whether technology is being used for the sake of technology or whether it has a pedagogical purpose. Few papers on the application of an educational technologies establish a meaningful educational position to justify the introduction of that
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technology (eg. Lid & Suthers, 2003; Blum & Baumann, 2003). Against this trend, Segrave and Holt (2003) discuss the issues of developing courses in the e-learning environment, recognising the changing world:

This broader contemporary view challenges education designers to begin with current conceptions of not only the rationales and practices of e-learning, but more fundamentally the meaning of desired forms of teaching and learning, enacted increasingly through more complex and diverse technology-enhanced environments and aimed at a more diverse range of learner cohorts. (p.22)

Administration

Over and above the teaching-learning component, educational administration is a part of this paradigm shift. Educational institutions are utilising ICT-based administrative tools that allow the student to have direct access to the administrative structure ranging from enrollment (including paying fees) to assessment results and transcripts. No longer does the administration system function *deus ex machina*, rather it is a real-time component in the student's and the teacher's educational life.

This particular change has occurred gradually and varies in its level of implementation. There appears to be no research into its influence upon the teaching practices and upon the relationship between teaching and administrative staff although Segrave and Holt (2003) include in their discussion of effective design of e-learning environments. Even though the shift has been gradual its meaning in terms of the work requirements of academic staff is quite clear, in particular its effect upon the teacher now becoming a quasi-administrator. The teachers then takes on a role that moves beyond the normal pedagogical structures. Now the teacher must deal with problems such as the content of institutions filing systems, a process that has been legendary in education institutions.

Where the student is able to control his/her entry into, and progression through the institution, there is a distinct change in the student's relationship with institution. When a student was required to utilise admissions staff for the enrolment process the student was in a particular power relationship. Once the student is the position to enrol online he/she is taking responsibility for the process that has no particular power relationship to “admissions”. Similarly, a student access his/her transcript without making formal requests also means that the student is being forced to take responsibility for his/her educational progression. All these things constitute a clear qualitative shift in the role the student has in the educational institution.

Added to this is the fact that the administrative staff are also changing their role through these processes.

A Caveat

All of the above discussion must be seen as being a part of a continuing process that is influencing specifiable parts of education systems rather than as being change that has permeated the global education system. Even in the hard sciences, from where Kuhn developed his concept of paradigm shift, change is never universal because theory is theory. Within education, the change we are pointing to is a complex interaction between technology, educational thinking and educational practice. In essence, it is a conceptually noisy place.

A part of this caveat is also that we should not assume that it is all happening in the western developed world. Countries like India are utilising wireless technology at the village level to reduce the need for technology infrastructure, so that local wireless networks can provide low-cost connections to the internet and to the distributed learning systems. The organisational intranet becomes the village communication system.1 It is well understood that a very small percentage of the world’s population has access personal to a telephone, but to focus upon personal rather than communal access is a good example of Western thinking colouring the way we look at this paradigm shift. This is well developed in a note by Mitra (2003) where she

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1 This was reinforced in March 2005 when cyclone Ingrid was pounding the North Queensland coast. A reporter from the Australian Broadcasting Corporation spoke to a member of a small, isolated community of indigenous Australians who were in Ingrid’s path and asked what news they had of the cyclone. The response was that they had not been on the internet that morning because they had not fired up the generator.
reports on work looking at how children learn to use the village computer under different models of availability.

A shift or not a shift

The data presented above indicates that something is occurring in education, it does not tell us definitively that there has been a paradigm shift. We could simply say that there is change and that a change is influential and that would partly meet with the requirement of Occam's razor. That is, the simplest explanation for the phenomenon we have observed. Unfortunately, such a simple explanation belies the depth and breadth of the change that is happening in education. We have tried to suggest that many of the changes constitute clear qualitative shifts within the educational system and that they might also be defined as catastrophe shifts.

The key places where there has been a qualitative change in the way education is happening include:

- The availability of information and the opening up of information sources. This could be seen within post-modern thinking as being a part of the development of critical thinking and de-institutionalisation of education. More generally, information is far less likely to be in the hands of gatekeepers.

- The development of agent managed educational environments such as TILE (Honget al, 2000; Kinshuk, et al, 2002) and PIAVEE (Krishnaswamy et al, 2004). This has required new thinking on educational practice and the relationships between of ICT educational systems and potential users.

- Building various intelligent systems to support educational activities such as the conceptual awareness tools of Morch, Jondhal and Dolonen (2005) that move into user support. The possibilities of various forms of interactive support tools is opening up the question of what constitutes pedagogical agent systems.

- Synchronous interaction via ICT tools is changing thinking in various areas of education including the Computer Supported Cooperative Learning movement and those working in student support areas. It is in the latter that major reviews are taking place on how to train on-line counsellors and how to monitor the effectiveness of these activities.

- Students taking responsibility for their education through on-line administrative processes constitutes a significant change in the way the administration of an educational system functions. The changes that have staff directly interacting with the administration systems is also significant although it may not be quite a dramatic.

- Wireless distributed synchronous educational delivery in remote areas. The School of the Air began some 50 years ago in Alice Springs and that was a true paradigm shift. What is happening now is an extension of that shift into the greater informational complexity of the Internet.

We doubt that the significance of these changes can be simply put down to linear shifts. They have engendered debate and have, if nothing else, created a range of sources for reporting that debate, particularly online journals. The development of online journals is, perhaps, one of the clearest indications of the paradigm shift from the current influence of ICT systems on education.

Possible responses to the shift

The history of change in the development of all the educational systems has not been terribly responsive to social change going on around it. For example, the development of constructivism as a response to the changing post-war social world was hardly a major theoretical shift in our view of education. Constructivism took, basically, some interesting ideas in educational psychology and generalised into a broader model of educational behaviour. When we look at the criticisms that have been made of constructivism (Fox, 2004) we find that there are substantial problems its generalisability and its capacity to deal with the real-world. Later developments such as Activity Theory can be seen as relatively esoteric and lacking real-world focus. The position of Critical Theory is even more tenuous in the real world.

Any response to the current paradigm shift must be able to deal with the various components that have been pointed to. In particular, a response must be able to cope with the changing complexity of interaction between the teacher, the student and the administration, not to mention the issues raised by distributed learning.


**Current pedagogies and the shift**

Current pedagogies must be able to deal with:

- The merging of teacher roles with that of the administrator role.
- The merging of the student role with that of the administrator role.
- The socio-cultural expansion of the educational world.
- The diversity of learner needs in terms of what they expect to get. Including the intellectual needs of the learner.
- The technological changes within the teaching-learning environment as it affects both student and teacher.

**Instructivism**

Instructivism is what most people would see as conventional teaching. The instructivist model says that the learner requires a structured environment in which to learn materials that are stored in “repositories”. These materials are derived from an objective reality.

The instructivist position has few answers to the issues listed above. Interestingly enough it is the instructivists who would best be able to design global materials that would minimise cross-cultural problems.

**Progressive**

Progressive education probably derives as clearly from Dewey. The primary feature of the progressive movement was that it placed emphasis upon the learner as someone who had to be nurtured in an intellectually challenging environment. Progressive education can be seen as the precursor to Constructivism, although most progressive educators would except that knowledge was derived from objective fact and that a part of good teaching was to help students understand fact from fiction as well as error.

The progressive pedagogies have little to do with the changing roles of the teacher but can deal with technology in education.

**Constructivism**

Constructivism has a great advantage that is essentially simple in what is defining. The basic statement that we construct our view of the world based on our experiences is, to most people, patently obvious. We all experience the phenomena associated with personal perceptions and the failure to communicate on seemingly simple issues. If our world was hard wired to objective reality then there would be no difference in what we saw and how we communicate it. Unfortunately, constructivism is basically an application of learning theory to educational practice. It requires extensive development well beyond either Bruner or Vygostsky to add the necessary dimensions to create a pedagogy in the sense that we are talking about the science and art of teaching. Notably some of the exponents of constructivism have began to incorporate other models such as Activity Theory in order that their approach might be more comprehensive and applicable (eg. Jonassen and Roher-Murphy, 1999).

All of this is exacerbated by the basic criticisms that have been levelled at constructivism by practitioners. For example, when Simpson (2002) titles his article “Dare I oppose constructivist theory?” doubts are raised about the rationality of the way constructivism is presented. Fox (2000) also questions that the fervour of some of constructivist writing. Matthews (2003) evaluated constructivism in the K12 system and pointed to the research that raises serious questions about the performance of constructivist classrooms. He is particularly concerned that research sophistication of teachers is well below the level needed to appreciate what research has shown about classroom performance and teaching methods.

The capacity of Constructivism to handle the new world is limited because it has little to say about the educational environment. Even when attempts are made to broaden constructivism explanatory role, such as Ludeke's (1999) relating constructivism to an organisational model for innovation, constructivism as added on rather than being conceptually integrated into the model/theory. Its other great problem within the wider need to distribute educational systems is its lack of obvious cross-cultural relevance. It is very North American even though it has been picked up by educators in Singapore and Taiwan.
Distributed cognition

Distributed cognition is based upon the idea that information does not live in isolated human minds and that information that is generated in a distributed social environment is different from that generated by an individual (e.g. Salomon, Perkins & Globerson, 1992; Halverson, 2002). This position suggests that cognition itself need not be defined in terms of individual brains; that cognition can be interaction between brains. This implies some sort of entity that constitutes a cognition and does appear to be similar to Meme theory (e.g. Dawkins, 1982), with all the problems that have been experienced in trying to clearly delineated what constitutes an actual Meme (e.g. Sperber, 2000).

Distributed cognition has the advantage that it was derived from sociotechnical systems theory (Emery & Trist, ) through work that was carried out in various settings including the aviation industry. In the sense that is about the way in which humans interact and solve problems through those interactions, it could be one of the models that would help explain a number of the points listed at the beginning of this section. The problem faced with distributed cognition is that it does not provide any clear model of learner behavior because it is more concerned with the consequence of an activity rather than the process within the activity; it is more concerned with the outcomes of learning that with learning itself. To this extent it provides some information about educational delivery but not about the form of the delivery relative to the learner.

Activity theory

Activity theory is strongly associated with the computer supported cooperative work (CSCW) movement (e.g. Halverson, 2002) as well as computer support cooperative learning (CSCL).

The key to activity theory lies in a triangular interactions between the individual, the community, the rules of engagement, cultural factors and the object of the activity. The complex interactions between these factors leads us to the outcome of the activity. Within activity theory we must be able to account for many of these components if we are to understand how we can effectively achieve an outcome.

Much of the published work in the Journal of Computer Supported Cooperative Work is about practice and associated reports from workplace activities. There is little material that shows a roll for activity theory with a pedagogical system although Jonassen and Roher-Murphy (1999) have suggested that it can provide a framework for designing constructivist learning environments.

An example of an attempt to apply activity theory to the higher education environment by Issroff and Scanlon (2002) is not terribly convincing in that the examples they use can be quite easily described in conventional social psychological thinking. Their claim that the analysis that they carried out provide the language for better describing the way students deal with information technology in a learning environment potentially leads to obsfucration. It could be argued that much of what they are talking about is simply good teaching, as defined by conventional pedagogies, rather than anything new or different.

Critical Theory

Gorsky and Caspi (2005) generate the idea that an effective theoretical framework for DE would be dialog vis-a-vis the Socratic method. They generate a set of five assumptions but fail to support those assumptions through either contrasting them with current thinking or empirical work. That asside, they do not appear to be clear on where dialog fits in the educational domain. Part of sounds like epistemology and learning issues while part of sounds like a basic pedagogy. There theoretical framework adds little to the debate through its inherent confusion.

A complex model is generated by Alonso et al(2005) using learning theory, cognitive psychology and social constructivism. This is clearly an instructional model that does not create an integrated whole that allows us to clearly differentiate between the components. This is compounded by the fact that it does not challenge any of its starting points. Good theory development has to look at economies of explanation and to look to the criticism that have been made of basic tenents. Alonso et al simply take, for example, social constructivism without

Given the difficulties of finding a model from within current thinking, it will be argued here that the most appropriate path to go down is one which can take seriously the interaction involved in the changing structures in educational environments and the most likely candidate is system theory. The advantage systems theory lies in the fact that it is a definition about the interaction between subsystems within some overall system. It has the great advantage that is highly scalable; that operate at the level of classroom all the state education system, using exactly the same parameters at any of these levels.

System theory has not always have good press because it has been used to refer to over defined systems related to poor industrial practice. For example, Taylorism has been associated with systems thinking not because it is related systems thinking in the because people think that anything but becomes highly systematised has to do with systems thinking. In reality, the best of systems thinking looks highly unsystematic because it often includes activities such as consultation and cooperation.

**Towards a systems orientation in education**

A systems orientation in education starts from the complexity of the educational environment and attempts to build the well structured model of this complexity. To begin this process all possible components have to be taken seriously. Were not simply talking about the teacher and his/her delivery but also talking about the learner, the administrator and parents, and all this takes place within the formal and informal systems within which educational system is embedded.

One of the keys to understanding the power of systems orientation in education is the idea that any system is embedded in other systems; that systems do not operate insolation and interfaces between system components have to be understood. Current pedagogical thinking, from constructivism to critical theory, we would say that there is nothing new in this, in that they have been talking about the social context of learning. The difference between what will be developed below as the systems orientation and what has been developed in current pedagogy is that the systems orientation is explicit on both the definition of the various elements, or components, and the ways in which these elements interact.

In developing a systems orientation for education will focus upon what is called general systems theory and its specific variation sociotechnical systems. From this we will develop basic structures that help define structural components and their interactions.

**General systems theory**

Systems theory differs from the general description of 'system' or 'information system' in that it is a theory of how things can be defined. The 'things' can be almost anything. Systems theory has been applied from micro-biological systems through to trans-national organisations.

A system is based upon a set of objects that have a definable relationship with each other. A part of this relationship is to achieve goals which are common to all the objects and, consequently, they interact with each other and effect the behaviour of each other. In this sense a system can be seen as a set of interdependent components that work together to achieve outcomes and the role of the systems theorist is to define the way in which these components actually interact.

Important to the understanding of systems is the concept of a system being open or closed. An open system establishes transactions with other systems and exchanges things with those other systems. Against this, a closed system has impervious boundaries that do not allow for such exchange.

From this comes the concept of exchange of 'materials' and the way in which systems establish protocols for exchange. Even within an open system it will have components or subsystem that must, themselves, be open systems that have transactions with other subsystems.

Katz and Kahn(1966) wrote one of the key texts on the application of open system theory to organisational issues. They point to the following processes that are needed to formally understand open systems:

**Sociotechnical Systems**
A variation on open systems theory developed by Emery and Trist is the sociotechnical system. The core of this is the fact that at least one component of the system is a social subsystem and that social subsystem interacts with a technical subsystem. The task is to define the transactions between the subsystems and to facilitate such transactions.

The most important applications of sociotechnical systems theory was in the analysis of work environments. For example, the management structure developed at the Volvo car plant was based on the definition of the functioning of workers and management in relationship to the production line. Work units were created where a car was produced by a given unit creating a situation where the work unit owned and took responsibility for the quality of each car it produced. The social system of the work group had, then, a set of important transactions with the technical system, the production line, designed to maximise worker satisfaction and plant productivity. In another application, mining practices in the UK were revolutionised again focusing on the importance of the work group in take responsibility for work practices.

The applicability of sociotechnical approach to education comes, in part, from the paradigm shift we have been explicating. There has always been a complex interaction between technology and the teaching environment. For example, the blackboard created its own complexities given the need for the teacher to turn his or her back on the students: this then meant that teachers needed to be trained to handle as social-technical interaction. The probable current electronic parallel to this is the capacity of students to “talk which other” via their computers and to send messages embedded in graphics. The teacher now has to learn a new set of classroom management skills.

In order to distinguish the discussion here from the more general area, the model being developed has been called a SocioCybernetic model. Cybernetics is defined as the process of communication and control but it has already been hijacked and taken on the more general meaning of pertaining to ICT systems. We justify the use of it here by the fact that ICT systems are no longer about computers but have become integral to the communication processes and that they function as intelligent control systems. The ‘Socio’ component is simply to emphasise that the ICT component must be always seen in terms of the social system in which it is operating.

It is not possible within the scope of this paper to look at the application of systems theory to the complete educational environment, although we will provide a broad statement in the following section. Rice (1957) wrote a comprehensive systems structure for the Higher Education system but its impact has been limited because dealing with the complexity of the task appears to have been placed in the ‘too hard basket’ by educationists.

**Building the SocioCybernetic Learning System**

The first component in understanding the SocioCybernetic Learning System is the generalised model of the educational system. Diagram x1 shows that the educational system is a component in set of systems that include the general social system and the government system. This is a trivial statement but it provides the general background. Within any particular country this will be expressed in different ways but the interacting systems are those that determine the socio-cultural milieu within which education operates.

Diagram x1
It is important to note that the educational system has many different transactions with other systems and that these will range from the formal necessities of government through to the normal local interactions as shown in Diagram X2.

Diagram x2 Interfaces between the educational and community systems

Our primary concern is to look at the teaching and learning environment, or the basic educational environment. The traditional structure is shown in Diagram 3x where it has the three obvious component sub-systems: Teaching, Administrative and Learner. If we move into the type of structure that the changing educational environment has we need Diagram 4x.
The extended model has structural links between the teacher and learner and the Administrative Subsystem. These structural links are not simple transaction points but reflect a structural continuity. The addition of the Delivery Subsystem indicates that delivery no longer has some general function that need not be defined, rather it is integral to our thinking about the system. What also changes is that the interaction between the teacher and learner is being mediated in various ways. The hatched circle in the top right hand corner represents the range of possible interactions between the teacher and the learner including direct communication and computer mediated communication.

The CyberSocial Pedagogy

The CyberSocial pedagogy is premised on the fact that the teacher operates in a complicated setting where the science and art of teaching includes the technical, social and organisational structures that make up the educational system. That is, this pedagogy takes seriously the total environment in which the teacher operates. Furthermore, the learner is seen as being a part of that environment but not the determinant of the environment.

If we look at the position of the learner, we can see that to focus on the learner we would have to accept that there is a one-to-one relationship between the teaching process and the learning process. This, patently, cannot be the case because the activity of the teacher is qualitatively different from the activity of the learner. It also cannot be the case because there is no one theory of learning that gives us an unequivocal view of the process of learning and without such certainty we have to accept that the process of teaching needs to accommodate a range of possible learners.

The first component of the CyberSocial pedagogy is the role of the teacher as teacher. What we have to accept is that this role is multi-faceted; that the teacher can teach in a classroom, in a virtual classroom, in an asynchronous structure, as a non-contact teacher and in many combinations of these. The teacher will produce teaching materials that can be used in a variety of modes, using various technologies at various levels of complexity. Within this, the role of the instructional designer may or may not change but clearly the teacher must be trained in multi-mode pedagogical skills because he/she has to be in charge of content and structure if coherent delivery is to take place.

The second component of this pedagogy is the interface between the teacher and delivery systems. Critical to the art of teaching has always been the way the teacher uses the primary interface with the learner. A good classroom teacher has been partly defined in terms of blackboard/whiteboard skills and more recently, electronic presentation skills. As the role of the teacher changes then the teacher must develop the ability to deal with a number of different interfaces with the learner.

Associated with the above points is the changing role of communication. The shift from face-to-face communication to include machine mediated communication, including asynchronous methods, means a different set of skills are brought into the science and art of teaching. Within the pedagogy there has to be the definition of skills and abilities that reflect this change.
Next, the CyberSocial pedagogy has to take into account the electronic administrative role that is becoming a part of the general teaching role. When administration was controlled in "the office", the teacher was distanced from many issues but as the teacher takes on more administrative tasks, he/she has to be more aware of the structure in which he/she organisational works. It might be said that many teachers have been relatively naïve on the way their organisation works, not taking an interest in the basics of enrollment, formal recording and associated activities. The on-line administrative systems are changing this.

As was noted in the general definition of the system, the societal structure surrounding the educational institution is an integral part of the educational system at all levels. A consequence of ICT interfaces is that the teacher is less able to insulate him/herself from the societal pressures. An email message from a parent or employer is less easy to disregard than is a telephone message. We need to look at the impact of this on teaching practice.

This extends into the cross-cultural arena because the CyberSocial pedagogy is not contained within a cultural premise. Systems thinking has been used across a number of cultures – India, Jugoslavia, Sweden and Brazil to name a few. In developing a systems orientation there is no fundamental conflict with existing views on the nature of education.

A superordinate pedagogy

The CyberSocial pedagogy is a super-ordinate pedagogy in the sense that it provides a basis from which other specific teaching models can be implemented. This is based upon it being about the teaching process and not about learning theory. Most current pedagogies have their origin in learning theories and are coloured by a definition of the learner. This, then, extends into the socio-cultural domain so that some pedagogical positions are not appropriate when an attempt is made to apply them to other cultures. In fact, some of the criticism of Constructivism and its variants is that does not provide an appropriate model for some areas of education within its culture of origin (eg. Simpson, 2002).

The ICT Educator

A consequence of ICT driving the paradigm shift in education is that computer science, software engineering and information system need to look at their involvement in producing the professional who can drive innovation and change at the technology level. Education can no longer have a generic instructional design function. The needs for education are based upon an ill-defined mix of skills that cover both Education and ICT because the future of the education/computing mix needs the complex set of skills that can develop for the future rather than simply working in the current technology. This need is emphasised from the review of the Australian technical education sector where it was clear that most of the software being used was just current thinking but was certainly not tapping into developments. Similarly, a review carried out on repositories for re-usable learning objects showed that SCORM etc standards industry was not keeping up with software developments such as the use of agents for real-time management tasks.

Computers in education need staff with a strong pedagogical and educational psychological base that is then supported by strong ICT training. Such training would not necessarily make the person an ICT professional but would produce someone who is able to work with ICT and who is able to comprehend the computing future.

Those who do educational computing can no longer be simply ICT professionals: they will need some understanding of educational needs and educational systems. As educational delivery systems adopt technology, the technologists cannot leave it up to the educationalist to sort things out. If the old consulting model continues to be used there will be the problem of system design over-shooting the educational structure.
Case Study

In a project currently being undertaken, the TELDA system (Schuhmacher & Markham, 2004), the software was being developed as a data base application from a prior spreadsheet version. The programmer implemented the data base as was progressively defined by the educationists but the educational component became progressively more difficult. Near the point of producing a pilot version, it was realised that there had been a miscommunication which meant that a basic procedure could no longer have been implemented.

This was not the programmer's fault but if he had have had the level of educational training being suggested here, he may have better understood what was being said. From the other direction, if the programmer's immediate supervisor had understood databases, he might have seen the issue arising.

A SocioCybernetic Teaching and Learning System (STLS) cannot be sustained without appropriately trained professionals. Computing education needs to include more education while educational computing needs for ICT.

Conclusion and Directions

Rushby (2005), with his focus upon educational technology, saw activities such as the development of more responsiveness metadata systems (eg Mwanza & Engeström, 2005) and more sophisticated portals within a constructivist framework (eg Muthukumar & Hedberg, 2005), as the future for better paradigms in on-line learning systems. Unfortunately, this simply accepts the status quo in the definition of teaching and learning systems in that none of this work challenges the fundamental that we see as being influenced by the change role of ICT systems in education.

Electronic, distributed teaching and learning systems may not be universally accessible given their reliance upon distribution systems such as telephones. This is clearly an influence of what happens in distributed education in the short-term but this area needs to think in the longer term to the right of change in technologies and software engineering. I noted what had happened in the Australian TAFE system where online learning was dependent upon old technology (Hill et al, 2003). Without the appropriately trained professionals electronic, distributed teaching and learning systems cannot meet the challenge that this changing environment is setting.

The new professional in the SocioCybernetic learning world must have a mix of skills and knowledge that reflects the interface between technology, teaching, learning the global cultural systems. That professional cannot be locked into simplistic models of teaching and learning that derived from narrow cultural perspectives.

The research that is needed in electronic, distributed teaching and learning environments must challenge the fundamentals, such as simplistic models like Constructivism.

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Colloquium

A model for integrating instructional technology into higher education

Daniel W. Surry, David C. Ensminger and Melissa Haab