CHAPTER 2

Review of related literature

A prologue

It is not usual to start the literature review of a dissertation by referring to the opening scenes of a movie. However, I will borrow this analogy from Hueth (1998) as I find it both relevant and compelling, and thus worthy of reflection. Witness the following two scenes from the film *Modern Times*.

Scene 1 showcases the title – '*Modern Times*, a story of industry, of individual enterprise, of humanity crusading in the pursuit of happiness'.

The camera pans herds of sheep on a runway before zooming in to focus on a factory with lines of men hurrying towards it. We are quickly whisked into the factory where a vista of glistening turbines, shiny gauges, dials and Jules Verne-like technology greet us. Quite clearly, efficiency and productivity are the gods reverently worshipped here.

Then, the star of the movie – the Tramp – appears.

The Tramp is an unassuming and simple man whose job is to tighten the bolts on a conveyor belt. Although his workplace is the epitome of technological sophistication, it is quite apparent by his demeanour and childlike awe that the Tramp is but a common man who has been propelled into the high-tech world only because he happens to be in a particular place at a particular time. He looks lost. Clearly, he has to pull up his socks if he wishes to survive in a work-place where technology and efficiency rule supreme.

Scene 2 takes us forward in time.

The apoplectic face of the company president flashes across the screen. He appears mad at something or someone. He gestures wildly, signalling for the conveyor belt to be speeded up. The foreman complies – he has no choice really – and turns a dial, and soon, the sound of machines speeding up is heard.

Further down the conveyor line, the Tramp tries frantically to increase his pace of work. He grabs at the bolts as they race past him on the conveyor belt, struggling to tighten them before they move on but often failing to do so. His co-workers urge him to hurry up. As the tempo increases, he misses more and more bolts. Then suddenly, he spots an errant bolt and dives after it. No points for guessing what happens next!

The poor Tramp is caught between the meshes of the machine and disappears down the shoot. His co-workers make a grab for him but miss. Then, we see the Tramp INSIDE the machine, entangled with the gears and sprockets. The poor man has been swallowed by the technology he is supposed to work with!

The scenes from the movie described above are certainly reminiscent of what is happening in many schools today. Teachers would have little problem identifying with the Tramp as they too are experiencing what the he was facing – the invasion of technology into the workplace that is gradually transforming education and how its work is accomplished. And like the Tramp, they have to try and survive.

Scene 2 is particularly evocative of the local educational sector. The president makes decisions and the foreman issues directives accordingly. However, it is the Tramp (alias the teacher) who has to actually come to grips with the technology. In the process, interesting questions come to mind. Why does the Tramp try so valiantly to please the powers that be and work with a technology he is clearly not cut out for? And why should the factory, in the first place, wish to implement a technology that its workers find so difficult to handle? More importantly now, will the technology get adopted and, if so, how and why?

These are the very questions that schools are grappling with today. There have been so many changes on the educational technology front in recent years – with familiar gadgets like film projectors, slides and overheads making way for sophisticated computer-based technologies such as the Internet, CD-ROM, digital video, email and on-line conferencing – that it is hardly surprising many teachers feel overwhelmed by the changes. This problem is also compounded by the fact that, just like the Tramp's factory, schools are dynamic systems with structures, processes, controls and cultures which are exceedingly vulnerable to internal and external forces of change. Consequently, they need to respond and to adjust. Herein lies the need for this study.

Introduction to literature review

As this study is concerned with the adoption, diffusion and use of computer technology in instruction, the literature review is divided into two sections. The first part looks at the technology adoption-diffusion process by examining the school system which constitutes the template on which the innovation attempts to take hold, reviewing some of the commonly accepted models of organizational change and exploring the kaleidoscope of factors impacting upon the technology adoption-diffusion process. The second part highlights some of the teachers' patterns of practice with the technology in the school milieu.

The technology adoption-diffusion process

Template for change : The school system

In order to fully understand the intricacies of technology adoption and diffusion, it is necessary to examine the template on which the adoption process is played out, in this case, the school system. Many researchers contend that school systems are best viewed via a systemic perspective as schools essentially comprise interconnected systems and subsystems, with decisions made in one part affecting other parts (Hueth, 1998; Senge, 1990; Washington, 1993). Take the *Modern Times* scene in the prologue as an example. Although the assembly line workers were far removed from the company president, they were nonetheless affected by decisions from his office. Ultimately, it was the president's command to speed up the conveyor belt that caused the plant to be shut down.

In a way, systems thinking facilitates deeper understanding of the school system as it enables us to climb to vantage points from which the entire system may be viewed and alternative methods for restructuring elements and relationships towards greater productivity and efficiency may be explored, just like in business systems (Salisbury, 1996). However, there are fundamental differences between school systems and business organization systems.

Weick (1976) described school systems as "loosely-coupled systems" (LCS) because of the tacit but impermanent link connecting the sub-systems which interact and support eac other while retaining respective identities, as epitomized by different departments within the school which remain separate and independent despite being connected.

Senge (1990) also highlighted the relevance of systemic thinking in understanding educational change when he pointed out that human endeavour is bound by invisible fabrics of inter-related actions which sometimes take years to play out their effects on each other.

Eisner (1991) further supported the relevance of systemic thinking in understanding educational innovation and change when he said that schools were a "mix of interacting factors (where) what teachers do is influenced by their location within the system…" (p. 2).

There is limited literature on loosely-coupled systems and organizational change with regards to the use of computer technology in schools. Telem's (1995-96) study looked at management information systems in a high school. Washington (1993) studied the implementation of a technological innovation in an Indiana public school system and discovered that its failure was due to the fact that the original design and intent had been changed by adopters. Hueth's (1998) study of technology use in a Midwest college emphasized the relevance of LCS theory in understanding technological adoption.

However, despite the limited number of studies using LCS as a theoretical framework to examine computer technological innovations, the systemic perspective is deemed relevant to this particular research study because the schools observed were independent systems nestled within the larger MOE system.

Consequently, all decisions made had to consider the needs of the immediate school system as well as satisfy the requirements of the larger, all-encompassing MOE system. Similarly, measures to promote technology adoption had to bear in mind that schools comprised structures, processes, controls and cultural subsystems which were separate, yet connected in various ways, to varying degrees.

The innovation

Based on Rogers' (1995) definition of an innovation as "an idea, practice or object that is perceived as new… whether or not (the) idea is objectively new as measured by the lapse of time since its first use or discovery" (p. 11), technology-integrated instruction is definitely an innovation in Malaysia despite its having been adopted for some time in schools in the developed world. In fact, such is the impact of the use of technology in schools that it has been touted as the learning revolution "unparalleled since the invention of the printing press" (Bork, 1980) and "the most important change in learning since the 16th Century" (White, 1987). There is little doubt that this innovation is set to usher in large scale changes and a look at global developments in education will only confirm this.

In the United States, ever since the 1983 publication of *A Nation At Risk* by the National Commission on Excellence in the United States sounded the call for the restructuring of education, there have been efforts to increase computer-based resources in schools. A survey which polled 1000 school teachers and other K-12 educators found that in the 1994-95 academic year alone, at least 85% of educators used computers, laser discs or CD-Rom, 16% used the Internet and 12% used other online computer services (Chiew, 1999). Technology-integrated instruction was given an added boost when in 1996, President Clinton announced four goals for American schools in the 21st Century – to make computers accessible to every student, to get classrooms connected, to provide educational software as an integral part of the curriculum, and to train teachers to teach with technology (Executive Office of the President, 1996).

In Singapore, the 'Thinking Schools, Learning Nation' vision and the 'Master Plan for IT in Education' launched in April 1997 aim to provide every Singaporean child with access to an IT-rich school environment. A total of S$2 billion has been committed to this objective and the target is to have all schools fully networked by 2002, with students devoting 30% of their curriculum time accessing electronic resources and computers (Singapore Ministry of Education, 1998).

In Malaysia, the Smart School Project aims to prepare Malaysians for the IT age by teaching them IT skills via the tools of IT (Smart School Project Team, 1997a). While the Seventh Malaysia Plan saw the government allocating RM2.994 billion to primary and secondary education, including the building of nine prototype smart schools, the 1999-2000 period also saw 81 Government-initiated Smart Schools launched, albeit on a smaller scale than originally envisioned due to the economic downturn. This was complemented by the Malaysian Chinese Association's (MCA) pledge of RM2.28 million to eventually upgrade all Chinese schools in its constituencies to smart schools (Indramalar, 1999).

Thus, it can be said that the call to embrace computer technology in schools is a global response to the need to pick up new skills to meet the challenges of the Information Age. However, this call will only yield results if people are prepared to accept change. For innovation is synonymous with change and the innovation of technology-integrated instruction is an instance of planned, organizational change. Consequently, it is necessary, in this literature review, to look at not only the innovation but also models of planned change in order to better understand the change process.

Models of organizational change

Five models of organizational change are reviewed here – the power-coercive model, the research, development and diffusion (R, D &D) model, Rogers' diffusion-of-innovation or social interaction model, the organizational development (OD) model and the concerns-based adoption model (CBAM). All five models have been used to explain the adoption of innovations and the implementation of change strategies in various settings.

The power-coercive model

Traditionally, change in education is regarded as a process of natural diffusion with the innovation spreading slowly but surely, if in an unplanned way, from teacher to teacher, school to school and district to district (Owens, 1992). However, contemporary management approaches prefer systemic models which aggressively plan for change. One such model which still enjoys widespread acceptance is the power-coercive model which advocates change through the direct exercise of power (Owens, 1992).

The best illustration of this model in action is when students are 'persuaded' to master a subject which has been made compulsory to pass in major examinations. Other instances of power-coercive change strategies include the red carrot incentives that school principals sometimes dangle in front of teachers to get them to accept change.

However, although this change strategy model has been found to be effective in business organizations (Kanter, 1988), it is less applicable to schools which are largely peopled by a non-voluntary clientele (Owens, 1992). Fullan, Miles and Taylor (1978) highlighted several attributes of schools which undermine the tenets of the power-coercive model – the diffused goals which make measurement difficult, the loosely-coupled systems which render stringent control impractical, the low technical capabilities and weak scientific base, the generally non-competitive environment and the nominal autonomy bounded by national constraints. These attributes often blur the lines of control and communication between the change advocates (policy makers) and end-users (teachers) who work in self-contained classrooms with little fear of repercussions even if they reject an innovation.

Consequently, persuasion is probably a more potent factor than coercion for instigating change in schools. For instance, Brunner (1992) found that administrators who encouraged teachers to experiment with technology without fear of reprisals were far more successful in promoting technology adoption than administrators resorting to strong-arm tactics. Similarly, Ely (1990) discovered that teachers included in decision-making processes in schools were also more likely to adopt technology than those who were coerced.

To sum up, the power-coercive model enjoys only limited success in schools – and that only on a superficial 'quick fix' basis – because schools are composed of "loosely coupled components through which it is difficult to transmit precise orders and from which it is difficult to extract compliance" (Owens, 1992).

The research, development and diffusion (R, D & D) model

The R, D & D model regards the production of empirically tested and validated knowledge as the key to planned change in education. Emphasis is on research, development and the diffusion of the innovation, that is, making it readily available in attractive, easy-to-use formats. The rationale is that if an innovation is shown to be effective, it will be adopted by rational end-users.

Subsequent experience shows that this model does not always work in schools because teachers do not always respond as expected to the quality of the materials presented and the ideas underlying an innovation (Siti Hawa Ahmad, 1986). The classic illustration of the failure of this model is the rejection of the Biological Sciences curricula designed in the early 1960s and the Rand Study of 1975-78, which showed clearly that the success of an innovation depended not only on its nature and the funding available but also on the characteristics of the organization and its management system (Horsley, 1990; Owens, 1992).

Another weakness of this model is its assumption that potential adopters are passive players in the adoption process. Hativa, Shapira and Navon (1990) found that far from being passive, teachers were extremely critical and evaluative when it came to adopting computer-assisted instructional material. Research also suggests that teachers' perceptions and mental beliefs in the efficacy of an innovation impacted upon adoption (Bear, Richards & Lancaster, 1987; Christensen, 1998; Dupagne & Krendl, 1992; Lawton & Gerschner, 1982; Sheingold and Hadley, 1990; Washington, 1990; Woodrow, 1992).

To sum up, the R, D & D model advocates that empirical verification of an innovation's effectiveness will guarantee its adoption by passive but rational end-users in the school setting. However, the historical inability of this model to produce lasting change coupled with research findings highlighting the importance of factors besides the nature of the innovation suggest that the major tenets of this model are not always valid.

The social interaction model

The third model of change is Rogers' (1995) social interaction model, also known as diffusion-of-innovation (DOI) model, which maintains that the crucial key in the diffusion process is interpersonal networks and social modeling. Rogers categorized potential adopters as either innovators who introduced ideas; early adopters or opinion leaders who disseminated information; the early majority who adopted before the innovation spread to other members; the late majority who adopted after the innovation has been declared safe, and laggards who only adopted after the adoption process had slowed to a crawl.

The strength of this model is that it not only looks at adopters' characteristics and the decision-making process but also examines the pre-innovation stage by evaluating the relative advantage, complexity and compatibility of the innovation. The assumption is that adoption is more likely to take place when an innovation is perceived to be better than – and easy to adapt to – current practices, when it can be easily tried out (trialability) and when the results yielded are easily visible (observability). Research suggests empirical support for this model. The study by Hativa, Shapira and Navon (1990) for instance, supported the relevance of notions like trialability, compatibility and relative advantage. Ely (1990) also found that teachers who were allowed to try out an innovation were also more likely to adopt it.

To sum up, Rogers' model not only explains how and why individuals adopt innovations but also addresses the issue of what happens to an innovation before and after it has been adopted. However, the weakness of this model as it applies to schools is its heavy reliance on interpersonal communication networks. As schools are loosely-coupled systems where teachers often work in isolation in their "egg-crate" classrooms (Lortie, 1975), the opportunities for developing interpersonal networks are sadly limited in schools.

The organizational development (OD) model

This model, which had its beginnings in business settings and was adapted for use in schools only in the 1960s, relies heavily on the principle of organizational self-renewal as the primary vehicle for change (Owens, 1992). It is based on the assumption that change is a complex process involving various subsystems identified as task, structure, people and technology systems in schools (Owens, 1992). In essence, this model sees schools as comprising systems of people moving from task to task, collaborating with other sets of individuals. The ultimate objective is to enhance effective functioning of all the subsystems so as to develop organizational adaptability.

Research suggests empirical support for this model. Ely's (1990) study, for instance, identified four subsystems as crucial to technology adoption – the *people* component, the *technology* component, the *structure* component (including time and opportunity to master software and hardware), and *task* considerations (visible leadership, school climate, etc). Carstens (1995) injected elements of OD theory into his study of microcomputer implementation in a secondary school and discovered that teachers were primarily involved with primitive "first order" use of technology, advancing to sophisticated "second order" uses only when the organisation has developed appropriate systems to support such uses.

The advantage of the OD model is that it recognizes the extensive interaction of the four subsystems of tasks, technology, people and structure, and views schools as dynamic and holistic institutions. However, its weakness lies in the difficulty of finding empirical validation due to the innate complexity of the model (Maney, 1994).

The concerns-based adoption model (CBAM)

And finally, the last model of change to be discussed in this literature review is the Concerns-Based Adoption Model (CBAM) developed by Hall, Wallace & Dossett (1973) after more than 10 years of research. This model was developed at the Center for Research And Development in Teaching in the University of Texas at Austin to allow researchers to monitor the implementation of educational innovations. Several assumptions underscore the application of the CBAM to the technology initiative in schools.

Firstly, the CBAM emphasizes that change is a highly personal experience of which chances of success are affected by the teachers' personal perceptions of the innovation, in this instance, technology-integrated instruction. Secondly, the CBAM posits that as change is not an event but a process which requires time to institute, teachers have to be prepared for the long-term nature of the change effort. Thirdly, the CBAM suggests that change is developmental, with identifiable stages through which individuals progress at different paces. Thus, the adoption process can be enhanced by providing appropriate assistance at each stage. Fourthly, the CBAM stipulates that as the focus of change is the individual, the impetus for change is greater if it comes from students and teachers rather than administrative mandates. And finally, the model recognises that anyone can be a change facilitator.

The thrust of the CBAM is that teachers involved in the change process will experience related characteristic concerns, defined as "the composite representation of the feelings, preoccupations, thoughts and consideration given to a particular issue or task" (Hall & Hord, 1987, p. 58), as they are brought face-to-face with an innovation. These concerns are organised in clusters or stages as depicted in Figure 1 on the following page.

The presence of these stages of concerns means that composite profiles of teachers can be drawn to yield information about where they stand in relation to the innovation. For instance, teachers with peak Stage 0~2 scores are preoccupied with 'self' concerns and are primarily concerned about either finding out more about an innovation (peak Stage 1 or 'information' concerns) or about their ability to cope (peak Stage 2 or 'personal' concerns) with the demands of the innovation. This profile is typical of teachers on the verge of adoption.

Cluster	*Stage*	*Concern*	*Concern defined in behavioural form*
Impact concerns	6	Refocusing	Questions existing computer use and evaluates and modifies the innovation to make it more effective or consider alternative innovations.
	5	Collaboration	The focus is on collaboration and cooperation with others regarding use of the innovation – computer user groups, support group meetings, team teaching, etc, are frequent.
	4	Consequences	Attention focuses on the impact of computers in the classroom. The teacher is concerned if there will be positive outcomes if he adopts the innovation and notes successful practices.
Task concerns	3	Management	Attention is focused on the processes and tasks of using the computer. The teacher is concerned with the nitty-gritty of how, when and where the innovation is to be implemented.
Self concerns	2	Personal	The teacher is uncertain about the demands of the computer and her ability to meet those demands – begins to question how the innovation will affect her personally.
	1	Informational	A general awareness of computer integrated instruction. The teacher's primary concern is learning more about the innovation, including what it is and what it can do.
Unrelated concerns	0	Awareness	The teacher has little awareness of the innovation and is not concerned about it. The person may express anti-computer feelings such as "I hope I retire before they make me use one".

Figure 1: Stages of concerns in the concerns-based adoption model (CBAM)

(Hall, G. & Hord, S., 1987:60)

However, teachers with peak Stage 3 or 'management' concerns are considered adopters of the innovation as they are preoccupied with the nitty-gritty of actually managing it in the classroom. As the teachers become more experienced at the innovation, their peak concerns move to the higher stages or impact concerns (Hall & Hord, 1987).

Since a combination of concerns may be manifested at any one time (Hall, George & Rutherford, 1979; Hall & Griffin 1982), an analysis of the two highest stages of concerns provides illuminative data about the teachers' feelings in respect of an innovation. It is generally accepted that developing the conditions that stimulate arousal of impact concerns takes a fairly long time – "...for most innovations and innovation bundles, it takes three to five years" (Hall & Hord, 1987).

The CBAM is adopted as the main theoretical framework for this study as it is deemed best able to capture the role of individuals in the adoption process. Furthermore, its tenet that management concerns are most intense during the first use of an innovation (Hall & Hord, 1987) enables adopters to be identified via peak Stage 3 concerns. Maney (1994) based his doctoral dissertation on this tenet, citing that "arousal of Stage 3 Management concerns indicates that an innovation has been adopted". This criteria is also used in this research study to determine the extent of technology adoption in the four case study schools.

Besides the Stages of Concerns Questionnaire (SoCQ), the CBAM also contains the Levels of Use (LoU) protocol and the Innovations Configuration (IC). There are three levels of non-use (non-use, orientation, preparation) and five levels of use (mechanical, routine, refinement, collaboration and renewal) in the LoU protocol, as shown in Figure 2 on the following page. The IC focuses on the operational forms of the innovation as teachers tend to make adaptations to an innovation as they use it (Redman, 1989).

Level	*Level of use*	*Behavioural indices of level of use*
VI	Renewal	User reevaluates the quality of use, seeks modifications or alternatives, examines new developments in the field and explores new goals for self and the system
V	Integration	User combines own efforts with colleagues' efforts to improve impact on students
IVB	Refinement	User varies use to increase the impact on clients (experiments with software and lesson designs, develops materials with authoring systems and assists students in developing own material with the computer)
IVA	Routine	Use is stabilized; little thought to improving current uses
III	Mechanical	The user focuses most effort on the day-to-day use of computers with little time for reflection. Changes are made more to meet user needs than client needs. Disjointed and superficial use (with little modification to software packages)
II	Preparation	The user is preparing for the first use of computers. She has participated in preliminary instruction in its use and is planning to use it
I	Orientation	The user has recently acquired or is acquiring information about computers and exploring how other teachers are using it
0	Non use	The user has little or no knowledge of the innovation, is not involved and is doing nothing towards becoming involved

Figure 2 : Levels of use in the concerns-based adoption model (CBAM)

(Hall, G. & Hord, S., 1987: 84)

All three diagnostic tools of the CBAM may be used independently or in combinations as an adopter may be at any particular SoC or LoU with any particular IC at any time. Together, they provide a diagnostic and prescriptive framework (as shown in Figure 3 below) to help change facilitators decide on what change strategies to implement and which resources to provide to whom. However, in this particular research study, only the SoC and the LoU were adopted.

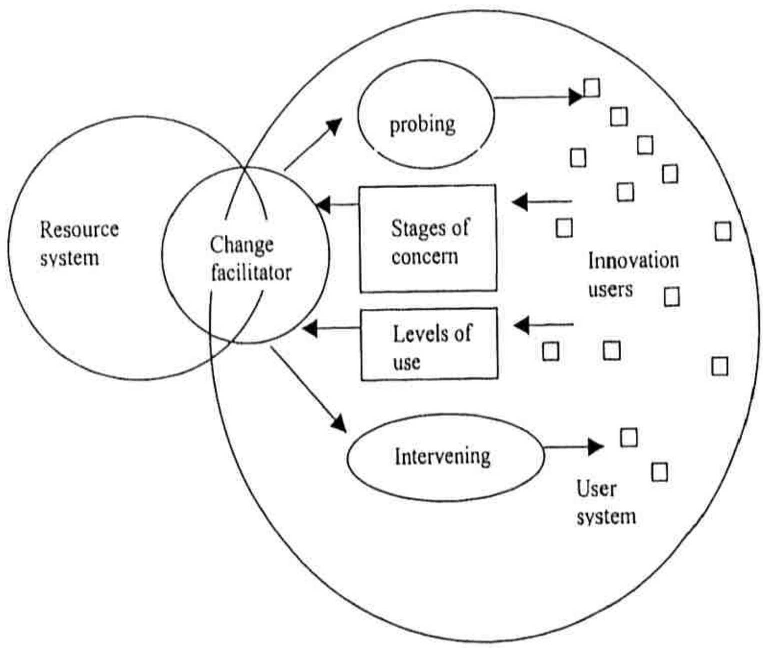

Figure 3 : A diagnostic–prescriptive framework for CBAM

(Hall, G. & Hord, S., 1987: 340)

The literature review suggests widespread support for the CBAM. Initially, Fuller's (1969) pioneer studies with teachers' concerns provided empirical support for the theory but later work (Adams & Martray, 1981; Demarte & Mahood, 1981; Hall & Loucks, 1978) also confirmed and refined Fuller's work. Harvey, Kell, & Drexler (1990) verified the usefulness of the CBAM in their research study on the Apple Language Series-Early Learning (ALS-EL) project when they compared two samples of the SoCQ taken at different times of the year and found a steady progression of teachers' concerns consistent with the Stages of Concern scale.

Dwyer, Ringstaff & Sandholtz (1990) compacted teachers' concerns into three stages (adoption, adaptation and appropriation) and developed a model which later found verification in the *Apple Classrooms of Tomorrow* (ACOT) study. ACOT's first year teachers struggled with survival concerns (similar to CBAM's Stages 1~3) such as coping with technical glitches, chalk dust in computers, monitor glare, technical breakdown, student misbehaviour, excessively high noise levels in the classroom, disks being erased, etc. Mastery concerns (reflective of the CBAM's Stages 4~5) clouded ACOT's second year whilst impact concerns emerged during ACOT's second and third years as teachers began to focus on instructional impact.

The CBAM is a relevant model to study the adoption-diffusion process. Many studies have been conducted using the instruments in the CBAM both singly (Maney, 1994; Redman, 1989) and in combinations (Hope, 1995). Quantitative studies include Martin's (1989) examination of how a software change impacted a faculty's concerns profile and Maney's (1994) survey of the adoption of multimedia technology in selected K9-12 public high schools in Northwest Ohio. Qualitative CBAM studies include Wesley's (1996) study on the role of voluntary K-12 faculty adoption activities in promoting innovation and Frame's (1991) and Sarmiento's (1991) studies which explored the effects of computer training on K-12 faculty concerns and faculty post-training computer usage, respectively. Most of these studies confirmed the importance of adopting a holistic, systemic perspective in looking at the adoption and diffusion process.

To conclude, it is clear that all five models of organizational change highlighted in this literature review have different strengths and weaknesses. However, this particular research study draws strongly upon the constructs of the CBAM as it is firmly believes that teachers are important considerations in the change effort and that cataloguing their concerns paves the way for setting up appropriate intervention measures which resonate to the actual needs of teachers in the frontline of the innovation.

Factors impacting upon the technology adoption-diffusion process

A review of literature on the factors impacting upon the technology adoption-diffusion process in schools suggests a kaleidoscope of factors at work. Many researchers have examined these factors (Holden, 1989; McCormick, 1992), either from an administrator-versus-teacher perspective (Maney, 1994), or via a three-dimensional typology that views resistance to change as people-determined, technology-determined and environment-determined (Bishop-Clark & Grant, 1991), or eclectically (Hueth, 1998). Let us now briefly examine some of these factors.

Availability and access to technology

The availability of, and accessibility to, technology has often been cited as a critical factor affecting technology adoption (Becker, 1994; Hueth, 1998). In a study on Malaysian schools, Zuraidah (1998) found that lack of computers, as measured by a large pupil-to-computer ratio, was the main factor impeding technology adoption. At the Model Technology Schools (MTS) project in Cupertino-Fremont in California, Stearns (1991) reported the same factor as a major obstacle.

Likewise, access issues were listed among the top seven barriers to technology adoption in Sheingold and Hadley's (1990) survey of technology-using teachers. Ely's (1990) exhaustive review of literature also highlighted availability and access to technology as an essential prerequisite for adoption. When access to technology was limited and unreliable, teachers were reluctant to devote time and energy to planning technology-integrated lessons as they feared being unable to implement such lessons when the time came (Denk, Martin & Sarangarm, 1993). As Gay (1997) so aptly put it: "Teachers will rarely spend the additional time to plan a technology lesson if they are not assured that they will have access to a machine or machines on that day and time when they need them."

Time constraints

Time constraints is another recurring theme in literature on technology adoption (Becker, 1991; Cuban, 1993; Marcinkiewicz, 1995). Gallo and Horton (1994) emphasised the need for teachers to have uninterrupted time with computers so that they may become comfortable enough with the technology to want to integrate it into instruction. Other researchers have backed the call for more release time to explore technology, pointing out that teachers needed time to acquire multiple skills ranging from understanding the operating system to running the host of applications and managing peripheral devices and networking (Croft, 1994; Ely, 1990; Schofield, 1995).

Beasely & Sutton (1993) recommended at least 30 hours of computer instruction to reduce computer anxiety and another practice period of 3 to 6 years for teachers to familiarise themselves with computer use. Unfortunately, most schools are unable to provide teachers with this amount of release time. The time constraints problem is compounded by the fact that the learning curve for technology is steep and never levels off completely, meaning that teachers constantly need to upgrade skills acquired earlier. Besides acquiring and upgrading technological skills, time to trouble-shoot and resolve technical glitches constitute another facet of the time constraints problem.

Technical glitches are part and parcel of technology use – "You decide to use technology; well you also decide to deal with the problems at the same time" (Gay, 1997). Unfortunately, the time needed to resolve such glitches can take anything from a few minutes to a few months and this drains teachers who work with tight datelines in tightly-scheduled environments (Gay, 1997).

Previous experience with computers

Sheingold and Hadley (1990) cited teachers' prior experience with computers as another important factor impacting upon technology adoption. Their study found that teachers with five to nine years of previous computer experience were most likely to adopt the technology whilst teachers with no previous computer experience were the least likely to be interested in hardware and software paraphernalia and to want to integrate them into instruction. Washington (1990) also reported a positive correlation between teachers who used computers at work and the success of computer programmes in schools. Similarly, research by Harvey et al. (1990) in the Apple Language Series-Early Learning (ALS-EL) project also found a positive correlation between teachers' self perceptions of computer expertise and the implementation quality of computer programmes. Scott, Cole & Engel (1992) found that teachers with computer experience were usually more confident about using the technology effectively in the classroom.

Training

Although research studies have often highlighted the need for more training initiatives to promote technology adoption (Hannafin & Savenye, 1993; Siti Suria Salim, 2000), this factor is often overshadowed by the rush to install hardware and software. The school district technology budget allocations by the United States Congress in 1995 for instance, allocated 55% of the total budget for hardware and 30% for software but only 15% for staff development activities (Conte, 1997).

The call to give more emphasis to technology-based training has already been made (Burkholder, 1995; Christensen, 1998; Kearsley & Lynch, 1994; Shermis, 1990; Stoddart and Neiderhauser, 1993). Marcinkiewicz (1994) for instance, reiterated time and again that the key to promoting technology adoption lay in helping teachers understand effective ways of utilizing computers in instruction. Hueth (1998) pointed out the plight of low-technology using teachers who found themselves in a Catch 22-dilemma when they were denied technology-related staff development opportunities simply because they were perceived as low-technology users. Joyce and Showers (1983) suggested that teachers be allowed to practise new skills in controlled environments until they acquired a minimum degree of executive control over the technology. Evans-Andris (1996) advocated more directed learning in technology training initiatives.

Unfortunately, the training of teachers to prepare them to implement technology-integrated instruction is centrally organized in Malaysia. Due to limitations in finance and manpower, not all teachers desirous of being trained are given the chance to attend the training programme and those not selected are offered few incentives to seek training on their own. Consequently, the lack of adequate technology-based staff development opportunities constitute a huge bottleneck in efforts to promote technology adoption in schools.

Support

The setting up of an adequate backup support system is essential for technology adoption although this invariably adds to the cost of the technology implementation initiative (Becker, 1994; Evans-Andris, 1996). The need for backup support is especially important for networked schools which require trained professionals to cope with technical problems. In order to reduce the negative impact of cost constraints, clusters of coordinators may service an entire district as in the Jefferson County in Kentucky which has 153 schools serviced by a Computer Education Support Unit comprising 22 professionals who assist teachers in their use of technology in the classrooms (President's Committee of Advisors on Science and Technology, 1997).

Besides technical backup support, a strong moral support network among and between colleagues and the school leadership is also important (Nik Zaharah, 2000). Research findings show clearly that support from the school leadership unites teachers, making it easier for them to break from traditional modes of teaching (Boutwell, 1995; Kearsley & Lynch, 1994; Maney, 1994). Unfortunately, this support is sometimes lacking, especially in cases where school heads do not stay abreast of technological developments:

> Many principals and superintendents openly acknowledge how little they know about integrating technologies…(how they) feel threatened and try to hide their discomfort and lack of knowledge (with) indifference or bureaucratic roadblocks…
>
> (Foa, Schwab & Johnson, 1996:53)

In 1990, a survey of school superintendents in New York and Rhode Island showed that "85% knew nothing about computers, had never used a computer, and did not intend to use one... (but) made decisions about student and teacher uses of computers in schools" (Morton, 1996, p. 418). Naturally, this impedes technology adoption by teachers.

Collegial support is also important to novice technology users as these teachers are usually apprehensive about their abilities to cope and thus derive strength from peers grappling with similar problems (Armstrong, Davis & Young, 1996). The importance of collegial support and sharing in promoting technology adoption is also highlighted in the ACOT programme (Sandholtz, Ringstaff & Dwyer, 1997).

Attitudes

Another factor which impacts upon technology adoption is teacher attitudes. Researchers have often pointed to the link between the teachers' attitudes to technology and eventual technology adoption in the classroom, citing that teachers with positive attitudes towards technology were more likely to adopt it (Ely, 1990; Maney, 1994;

Sheingold & Hadley, 1990; Washington, 1990). To a certain extent, teachers' attitudes to technology are affected by their perceptions of its efficacy in instruction.

Among the many research studies which have examined the efficacy of computers in instruction is a meta analysis of related research (Kulik, 1983; Kulik, Bangert & Williams, 1983; Kulik & Kulik, 1986; 1987) which found that the use of computers in instruction had improved student achievement at all levels of schooling, had positive effects on student attitudes and yielded substantial savings in instructional time.

In 1990, Bialo and Sivin's analysis of 61 studies discovered that most students found technology-integrated instruction motivating, enjoyable, empowering, easy-to-stick-with and less anxiety-provoking than traditional methods of learning. Collins (1991) reported that technology-integrated instruction had resulted in more cooperative social structures in the classroom. A later analysis of 86 studies by Sivin-Kachala and Bialo (1993) confirmed these findings and helped boost teachers' attitudes to technology, thereby promoting adoption in the schools.

Summary

To sum up, the literature review recommends viewing technology adoption in schools via a systemic perspective because schools are loosely coupled systems with intricate, closely inter-linked systems and subsystems. Five models of change were examined to facilitate understanding of the change process.

The power coercive model which prescribed the direct exercise of power as the best way to effect change was found to produce only superficial changes and was thus less suitable to be adopted as a theoretical framework for this study.

The classic R, D & D model which emphasized empirically-tested and effective innovations was found to be rather difficult to adapt to current situations. Its assumption that teachers played passive roles in the adoption process was also debatable. Consequently, this model was also not adopted as the framework for this study.

Parts of Rogers' DOI model was found to have relevance to this research study but its heavy reliance on interpersonal communication networks makes it fall short of being the ideal choice for studying change in the loosely-coupled structures of schools.

The OD model approached change from a holistic point of view and also offered many aspects which had pertinent bearing on this study but since the innovation was still in its infancy stage, there was extreme fluidity in structures which resulted in difficulties in verification.

The CBAM approach which emphasized the importance of teachers in the change process and offered valid and reliable instruments for tracking the adoption process from non-use to initial, novice use and refocusing attempts was found to be most appropriate to investigate the scope of this study and consequently adopted as the main theoretical framework for this study.

The literature review also examined some of the factors which impacted upon the technology adoption-diffusion process in schools. The next section will look into some of the more common technological practices adopted by the teachers in the classrooms.

Patterns of practice with technology

Many researchers have called for more research into optimal uses or benchmark practices of technology-integrated instruction which teachers may adapt to individual classroom settings (Becker, 1994; Marcinkiewicz, 1994). Unfortunately, there are still limited studies in this area, especially in the local context. Consequently, what is set out in this section of the literature review is an overview of teachers' patterns of practice with technology rather than optimal practices. Nevertheless, note is taken of the call for more research into optimal uses of technology which can contribute to the knowledge base of teachers (Bozeman & House, 1988; Gilbert, 1996; Krendl & Lieberman, 1988; Marcinkiewicz, 1994).

Word processing

Word processing is a computer application that enables the user to write, edit, format, print, store and retrieve text easily (Mandell & Mandell, 1989). It is currently the most popular, most rapidly growing and perhaps most commonly used computer application in education (Maddux, Johnson & Willis, 1997). More than 60% of personal computer use revolves around word processing (Collis, 1988), so much so that it is now widely regarded as an invaluable tool at home, in schools and in the business world (Lewis, 1993). However, while many teachers sense the potential of this application in education, research on it is still limited (Geisert & Futrell, 2000; Maddux et al., 1997) although the few studies thus far completed suggest significant gains in writing ability as a result of its use (U.S. Congress, Office of Technology Assessment, 1988).

Another reason for the popularity of word processing lies in its ease of production and revision (Madduz et al., 1997; Vockell & Schwartz, 1992). Bangert-Drowns (1993) found that this application helps children concentrate on complex writing tasks by relieving them of the drudgery of mechanical revisions. Montague (1990) believes it promotes cognitive development during the composing process. Collis (1988) says that students collaborate more when working with word processors. Reidesel and Clements (1985) opine that word processing inculcates positive attitudes towards writing whilst Cannings and Brown (1986) point to the creation of positive learning environments via this use of technology:

> ...it (the microcomputer) does present a medium that makes a new social organization for reading and writing possible.
>
> (p. 149)

A variation of word processing especially helpful in developing writing skills among students is desktop publishing, a tool which allows writers to publish their own stories, books, reports, newsletters and newspapers. Research suggests students are more motivated to pick up writing skills when they have a "sense of audience" (Lewis, 1993).

On the negative side, Mitton (1987) researched spelling errors made by 15-year-olds and found that 40% of the errors could only be traced via human proof-reading rather than the use of the word processor. Similarly, Dalton (1991) compared use of a spelling checker with peer editing among fourth grade students and found that there were adverse effects from over-dependence on the spelling checker.

To sum up, research suggests that although word processing appears to improve the "quality of writing, length of compositions, number and kind of revisions and students' attitudes toward writing" (Roblyer, Castine & King, 1988), teachers have to clearly define their purpose and objectives (Montague & Fonseca, 1994), encourage peer editing and collaboration (Roberts & Mutter, 1991) and incorporate a process approach to writing (MacArthur, Graham & Schwartz, 1993) if they wish to maximize the potential of using this application.

Computer mediated communication (CMC)

Computer mediated communication or CMC involves students communicating with the teacher and / or each other through list serves, computer conferences, news groups, email or other technologies (Iseke-Barnes, 1996). There are two types of CMC – synchronous communication where individuals send and receive messages at the same time and asynchronous communication in which there is a time lapse between the messages.

While much of literature pertaining to the use of CMC relates to adult education, in particular, distance learning (Waugh, 1996), there is increasingly more research on the use of CMC in schools. Ghaleb's (1993) study on the impact of synchronous instructor-student CMC use in a college writing class found that CMC provided a positive writing environment for English-as-a-Second-Language (ESL) students. Harris (1994) described how American literature classes at two schools read *The Glass Menagerie* together and discussed the play via email. Similarly, Hoogstrate-Cooney (1995) examined the synchronous communication patterns, discourse and attitude of 10th-grade English students who used CMC to discuss the American play *The Crucible* and discovered that although the students' experience was positive, it did not really help to create a more egalitarian environment in the classroom.

Projects on asynchronous communication have also been carried out in schools. In 1994, the Camelot project linked Bayside Middle School in British Columbia with the Faculty of Education at the University of Victoria to deepen students' understanding of the Middle Ages through the use of email. Although research findings showed only limited increase in student understanding, there were signs of an emergence of student voices, especially those of shy students, and an increase in technical expertise (Berge & Collins, Vol. 2, 1998).

The main obstacle to the use of CMC in instruction is the high cost of getting students connected and the difficulty in getting enough computers, modems and telephones (Berge & Collins, 1998, Vol. 3). However, this computer application offers tremendous possibilities for developing thinking skills as students are encouraged to construct their own problem-solving solution path and to manipulate the problem environment for alternate solutions (Berge & Collins, 1998, Vol. 3).

Internet-based research

The Internet has been defined as a "network of networks, connecting over six million host computers in 100 countries... growing at the rate of 10-15 per cent per month" (Hueth, 1998). The thousands of networks that comprise the Internet enable data and information to be shared easily and make it an extremely powerful tool for information gathering.

The World Wide Web (WWW) is especially potent. Korolenko (1997) described the WWW as a "body of homepages that currently run on the Internet" and homepages as "...linked documents that contain text, graphics, sound and animation as well as hypertext-written words presented so that the user can jump form topic to topic" (p. 88). The WWW is a global storehouse of knowledge which has facilitated students' research in various fields including Social Studies (Dale, 1997), Science (Nelson, 1997) and English (Davis, 1995).

To date, there is still limited research on the effects of the Internet on students and instructors although much has been written about its mind-broadening allure (Maddux et al., 1997) and its ability to capture the interest of students (Zainal Abidin Hassan, 1999). Maddux et al. (1997) for instance, talked about the thrill of the search and described how the Internet broke down the walls of the classroom – "expand the horizons of students everywhere…" – but warned that students may "…get lost in the electronic forest and never find (their) way to the highway" (p. 168). Teachers who frequently use the Internet for instructional purposes usually advocate imposing some form of structure and control on the students as opposed to simple free browsing (Maddux, et al. 1997). While some researchers echo fears concerning the ready availability of adult material on the Internet, many feel that this characteristic of the Internet offers students an opportunity to learn responsibility (Maddux, et al., 1997).

Simulations

Curry and Moutinho (1992) describe a computer simulation as a software package which assumes the characteristics of reality. Maddux et al. (1997) highlights simulations as a fun and inexpensive way of providing students with experiences in areas where it is dangerous to allow them to experiment freely. Simulations encourage better transfer of knowledge by allowing students to experiment with alternatives in an atmosphere of socialization and collaboration. Perhaps their greatest strength is that they are realism-adjusted, that is, they represent aspects of the real world in the classroom.

The use of computer simulations in instruction can be traced to the game 'Monopologs' which required participants to perform as inventory managers in the Air Force supply system (Faria, 1987). Early research focused on the mechanics of integrating simulations into instruction. Horn and Cleaves (1980) for instance, identified three phases when integrating simulations into classroom instruction – preparation, supervision and debriefing – whilst Willis, Hovey and Hovey (1987) added the phases of selection, adaptation and evaluation. Maddux et al., (1997) emphasized the need for supervision to capitalize on teachable moments. Recent research however has focused on comparing the effectiveness of computer simulation games to other educational mechanisms (Thompson & Thompson, 1995; Worrell, 1995)

Constructivist uses of this computer application require considerable planning, flexibility, on-the-spot analysis and decision making (Maddux et al., 1997). Perhaps its edge over other modes of computer use is that students are more actively involved in the learning process, something long championed by renowned educationists such as Vygotsky (1978).

Conclusion

To conclude, this literature review advocated a systemic perspective in looking at the adoption-diffusion process in schools, examined several models of change, highlighted factors impacting upon the technology adoption-diffusion process and described common practices with technology in schools. However, it must be reiterated that as is often the case with qualitative studies, the literature review is by no means exhaustive but ongoing and symbiotic with data collection. Hence, as fieldwork progresses, related literature will continue to be reviewed, with relevant research findings subsequently highlighted and incorporated into the succeeding chapters.