CHAPTER 8

Summary of findings, discussion and conclusion

This research study deals with the adoption, diffusion and use of technology-integrated instruction in four technology-enriched, pilot smart schools. Input concerning the technology implementation initiative in these schools was obtained via an ethnographic style, qualitative paradigm. Field work was loosely guided by three theories – Rogers' (1995) diffusion of innovation (DOI), Hall et al.'s (1973) Concerns Based Adoption Model (CBAM) and Weick's (1976) loosely coupled systems (LCS). This chapter discusses some of the findings and the conclusion of the study.

Roger's DOI theory posited stages in the adoption process. Field observations supported this, showing clearly that the teachers spearheading technology-integrated instruction in the case study schools also went through distinct stages or phases of instructional evolution. Five stages were observed – entry, early adoption, crisis, adaptation and invention. The first wave of the technology adoption initiative saw teachers reacting differently to the innovation – some were innovative pioneers like trailblazer Shah, some steadfast beacons like Ling, the majority were ambivalent adopters like Anna, several worked the system like shrewd strategist Chin, while a few resisted the innovation all the way like Mei.

The use of the SoCQ in Hall et al.'s (1973) CBAM confirmed the existence of different composite concerns profiles in the case study schools. Ling was preoccupied with management concerns and towards the end of the research time frame, the impact of the innovation; Chin was struggling with personal concerns and managed to overcome them to move on to management concerns; ambivalent Anna and her friends wrestled with information concerns, while resistor Mei found herself so overwhelmed by personal concerns that she ultimately rejected technology use. However, the overall composite concerns profile which emerged was that of teachers on the threshold or in the early stages of adoption.

And finally, Weick's (1976) LCS theory proved invaluable in understanding teachers' attitudes towards change and acceptance of innovations. A literature review of the basic tenets of his LCS theory matched against field observations confirmed that the case study schools had LCS characteristics. For instance, Weick's contention that LCS were places with "a limited amount of inspection and evaluation" (Weick, 1982) held true for the schools which were subjected only to annual inspections and evaluations by the School Inspectorate. Secondly, Weick said that LCS had little control over the supply and quality of raw material, and therefore "no firm standards to judge the impact of their work" as well as "no clear theory of causation" (Weick, 1982). The schools observed had little control over the supply and quality of students whose diverse backgrounds made it difficult to pinpoint the exact reasons for success (or failure) with the innovation. Thirdly, Weick's observation that in LCS, "...few (were) constantly involved in everything that happens" (Weick, 1982) was reflective of the scenario in schools where not every teacher was involved in all events. His comment that LCS were "reservoirs of flexibility" (Weick, 1982) was also applicable to the case study schools which enjoyed great autonomy between departments.

Accepting that the four case study schools were LCS, two points raised by Weick (1982) are particularly relevant to this study. One is the observation that leaders of LCS needed to balance adaptation with adaptability – between "stability to handle present demands and flexibility to handle unanticipated demands". This means that school heads needed to maintain a certain degree of stability while remaining open to change. The other observation is that changes in LCS occurred slowly, thus making it unwise for heads of LCS to depend on single policy incentives in change initiatives if they desired quick results. Consequently, multi-pronged approaches were favoured and school heads were encouraged to "start projects earlier, start more projects, start projects in a greater variety of places, talk more frequently about those projects… and articulate a general direction". In short, school leaders had to be very adept and committed to promoting the innovation if they wished to see it institutionalised.

A model for teachers' acceptance of technology

Chapter 5 outlined in detail the factors which impacted upon the technology adoption-diffusion process in the case study schools. To recapitulate, field observations and interviews revealed four levels of factors at work.

At the bureaucratic level, a shared technological vision, adequate support system and sufficient funding were deemed crucial factors. At school level, effective leadership, sufficient hardware and software, a conducive cultural climate, adequate staff development opportunities and flexibility to handle time constraints were important. At teacher level, technology competencies, positive perceptions of computer efficacy and previous experience with computers were predisposing factors. And finally, at student level, the students' responses to teachers' novice attempts at technology adoption and support from the parents of students in the school also played important roles.

Field work suggested that while these factors did set the stage for technology adoption and diffusion, another combination of variables – described in chapter 6 as the 'T' or teacher factor – appeared to be more potent in accounting for variations in the teachers' responses to technology, especially if they were serving in the same physical and technological setting.

Briefly, the 'T' factor comprised the teachers' mental beliefs about teaching, their risk tolerance levels, their teaching goals and their technological quotient or ability to visualise the details of a technology not yet fully put in place. These four components of the 'T' factor acted as a sieve which filtered the impact of systemic factors and predisposed teachers to react to the innovation in particular ways. The dynamic interplay of all these factors is put together as a theoretical model which I propose to call the SMaT (System, Mediator and Teacher) model of technology adoption. This is diagrammatically represented as in Figure 16 on the following page.

As shown in Figure 16, once the decision was made to integrate technology into classroom instruction, new practices were either 'added on' to traditional paradigms of instruction or took new forms as groundbreaking constructivist practices.

However, if the teachers rejected the innovation, mediating influences in the shape of change facilitators, students and even parents may act on the 'T' factor to get teachers to rethink their decisions. Alternatively, the mediators may even act on the system, and the set of factors contained within the system, to make it more conducive to technology adoption. The cycle of decision-making then starts again.

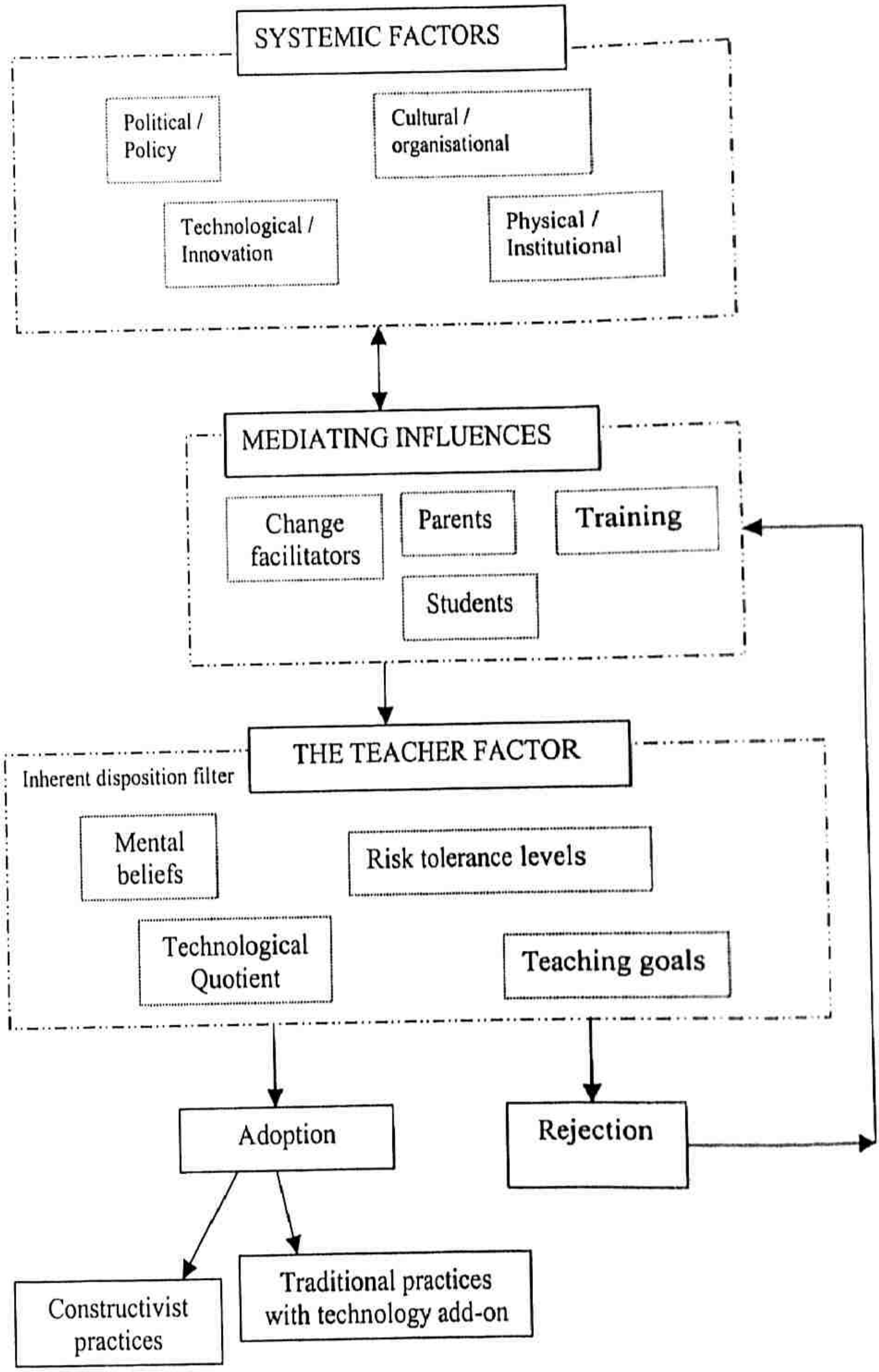

Figure 16 : The SmaT model for teacher acceptance and use of computer technology

Levels of technology use

This research study also examined the teachers' levels of technology use in the four case study schools, using the CBAM's LoU as the diagnostic tool to review their practices. However, although the LoU provided a good gestalt of teachers' levels of technology use at the lower levels, the picture was not so clear at the higher levels, in particular, after LoU3 (mechanical use) where the teachers were observed lingering right till the end of the research time frame, with little further progression.

Based on this observation, two inferences are possible.

The first inference is that the diffusion of innovations is indeed very slow and stretches over a long period of time, so much so that the 20 months of field observations in the school setting were insufficient to capture the LoU's higher levels of use.

The second inference that may be drawn is that the decision points differentiating the higher levels of use in the CBAM's LoU were too refined and unsuitable for adoption studies in the local context. If this second inference is accepted, then the implication would be that adjustments to the CBAM's LoU are required.

There seems to be some grounds for accepting both inferences.

Previous research on change and innovation does support the notion that the research time frame of 20 months may be insufficient to fully capture the diffusion cycle which usually takes three to five years to play out (Hall and Hord, 1987).

However, it is also true that the original CBAM's LoU may be less suited to review levels of technology use in Malaysian schools as our education system is extremely examination oriented and offers teachers little leeway to reach the "new goals for self and the system" (Hall and Hord, 1987, p. 84) stipulated as indicators of higher levels of use in the original LoU. Minor adaptations to the LoU thus seem called for.

Based on this line of reasoning, a review of literature regarding levels of technology use in schools was again carried out. Work by several researchers in this area merit mention. Maddux et al. (1997) for instance, differentiated between Type I (trivial) and Type II (complex) levels of use. Carstens (1995) adopted a similar typology using the terms Level 1 and Level 2, and concluded that it was very difficult to move teachers from mundane Level I use to more sophisticated Level II uses. Synthesising these ideas together, I feel that the teachers' levels of use of technology in the four case study schools could perhaps have been more adequately captured by collapsing the eight levels of use in the original CBAM's LoU to only five levels as shown in Figure 17 on the following page.

The adapted LoU model in Figure 17 posits only five levels of use, starting from LoU0 or non-use. This refers to the initial stage when teachers have little or no knowledge of an innovation. At Lou1, the "orientation" and "preparation" stages of the original LoU are collapsed into one level of use as the former is merely a mental version of the latter while the latter is but a physical manifestation of the former.

The next level of use – LoU2 or mechanical use – is characterised by teachers engaged in hands-on management of the innovation in the classroom. Once teachers have got the hang of integrating technology into classroom instruction, they move into LoU 3 or routine use which sees them engaging in stabilised uses of technology but making few attempts at innovative practices.

A small number of teachers will eventually venture into LoU4 or creative use. As this level of use emphasises the exploration of alternatives and sophisticated applications of technology as well as promotes collaboration and the creation of new material, subsequent higher levels of use – namely, refinement (IVb), integration (V) and renewal (VI) – are subsumed within this level.

Level	Type	Description
4	Creative	The user constantly varies use and experiments with design of new materials. Focus is on impact on clients. There is increased collaboration and exploration of alternatives. Creativity rules this level of use.
3	Routine	Use is stabilised but mundane. There may be minor changes and adaptations but these are introduced with little thought to innovation.
2	Mechanical	The user is actively working with the technology in the classroom. Use may be continuous or sporadic but is usually superficial. The focus is on the task at hand and resolving user needs rather than client needs.
1	Preparation	The user has acquired or is acquiring information about computers and preparing, mentally or physically, for initial, first use.
0	Non use	The user has little or no knowledge of the innovation and is not using it in instruction.

Figure 17 : Adapted model of teachers' levels of technology use

Several criteria – again crystallised from field observations – are adopted to serve as guidelines to differentiate between routine (LoU3) and creative (LoU4) uses of technology.

Firstly, students in LoU4 classrooms should be more *intellectually involved* in the technology than those in LoU3 classrooms who tended to sit at computers and merely clicked on options. An example of LoU 4 was observed when the students of Temasik used Microsoft Publisher to create a class newspaper.

Secondly, students in LoU4 classrooms should exhibit *more user control* over the computer screen. They should not merely move through steps predetermined by software developers, selecting only levels of difficulty and speeds of presentation but should actually manipulate the direction of technology progression by evaluating information, weighing options and making decisions on how to convert the data into relevant information to solve authentic problems.

Thirdly, LoU4 classrooms should emphasise *creativity and higher order thinking skills* rather than rote learning. They should encourage students to be actively involved in constructing meaning rather than passively ingest information regurgitated by the technology at the click of a mouse.

And finally, LoU4 should offer students an *emotionally empowering* experience with the technology by stimulating them in diverse, multiple ways and providing user satisfaction, thereby urging them, in the long run, towards independent learning.

Interestingly, field observations seem to suggest that LoU4 is more likely to emerge from classrooms where students work independently in small groups around clusters of technology rather than from labs which see students engaged in mostly linear learning from computers.

To summarise, an adaptation of the CBAM's LoU is suggested as more appropriate to examine the teachers' levels of use in this particular research study. The five levels of use in the adapted model are (as depicted in Figure 17) non use, preparatory, mechanical, routine and creative use. The highest level of use, LoU4 or creative use, should be characterised by the following traits:

- More active intellectual development
- User control of almost everything that happens on the computer screen
- *Focus on creative instead of rote tasks*
- Involve multiple senses and capabilities
- Empower students and teachers alike

Crystallising the notion of 'optimal uses'

Chapter 7 examined the teachers' patterns of practice with technology. Field observations showed that although most teachers were able to adapt technology to suit students' needs, they worried whether they were doing the right thing and repeatedly asked for exemplary practices or optimal uses to benchmark against. This desire for models of good practices was confirmed in a questionnaire where 68% of the teachers (Table 15 on p. 161) quoted the lack of exemplary uses of technology as the primary obstacle to technology adoption.

A literature review suggests that this clamour for optimal uses has long been heard among teachers involved in technology-integrated instruction (Gilbert, 1996; Whitaker, 1993). Whitaker (1993), for instance suggested that:

> Good practice by highly effective teachers… (needs to be) held up for emulation by others who have not been informed of the experience and theory underpinning it…
>
> (p. 2)

Unfortunately, the search for optimal practices of technology is made more difficult by the fact that 'good' and 'optimal' are words loaded with value judgment, as what is good and optimal to one person in one situation may be trivial and mundane to another person in the same or different situation. However, an attempt will be made in this discussion to refine the notion of optimal uses of technology so as to provide guidelines for teachers in their search for benchmark practices. At the very least, it is hoped that my attempt to crystallise the notion of optimal uses will stimulate reflection on the issue.

Based on the ideas that developed from field observations and interviews with people involved with the innovation at grassroots level – and shaped by my readings and reflections on what the desired outcomes of education are – I propose that optimal uses of technology should satisfy four criteria.

Firstly, an optimal use of technology should break down the physical walls of the classroom so that multi-sensory instruction can take place in a borderless learning environment which allows students to access knowledge from anywhere in the world via the virtual global database. Borderless learning also implies that knowledge should no longer be compartmentalised or restricted by physical boundaries.

At the same time, the technology should physically hone students' technological skills so as to prepare them for new challenges at the work place. In other words, technology should not only break down walls in learning but also build bridges for knowledge acquisition by helping students pick up the relevant skills needed for the Information Age.

Secondly, as our education system aims to develop critical and creative thinking skills in students, optimal uses of technology should emphasise and enhance higher order cognition. Field observations show that when students were given the freedom to explore and to innovate with technology, they often surpassed expectations in producing creative work of high quality. All the teachers readily attested to this. An optimal use of technology should therefore allow students to engage in multi-faceted, authentic tasks which unleash creative potential and make lessons come alive in ways not possible with the traditional paradigm.

Thirdly, an optimal use of technology should enhance students' social skills by creating opportunities for collaboration and cooperation in the classroom. Field work suggests that teachers and students alike craved opportunities to socialise and to connect. Optimal uses of technology should therefore create avenues for students to work together towards common goals, either within a classroom and school, or on a wider scale, with global communities online. There is a latent 'we-power' in technology that may, once unleashed, scaffold and enhance learning in zones of proximal development by leaps and bounds.

Finally, an optimal use of technology should provide students with user satisfaction leading to emotional confidence and ultimately, feelings of empowerment.

Field observations highlighted many instances when uses of technology in the classroom achieved this. Based on Whitaker's (1993) definition of empowerment as the capacity of individuals to assume responsibility for satisfying personal and professional needs, an optimal use of technology should inculcate within students the life-long learning skills necessary to realise professional objectives and bring about personal enrichment.

To sum up, an optimal use of technology in the classroom should exhibit the following characteristics:

- *Physically* extend the boundaries of learning to beyond the walls of the classroom
- *Cognitively* nurture creativity and the development of higher order thinking skills
- *Socially* create opportunities for collaboration and cooperation
- *Emotionally* satisfy and empower students involved so that they are better prepared to cope with life in future.

As an illustration, witness the following lesson when all four criteria for consideration as an 'optimal use' of technology appeared to have been adequately met:

> (The class: Form One. The topic: Descriptions of Animals. The venue: A simulation room with four computers. Duration of lesson: 90 minutes.)
>
> The students were seated on the floor in the center of the room, gathered around the teacher's computer which was linked to an LCD panel projecting a screen onto the white board. The teacher clicked on a picture of dugongs and asked, "What is this?"
> S: Dugongs.
> S: Mermaids.
> T: What do they look like? How would you describe them?
> S: Rounded.
> S: Like rocks…
> T: What do you know about dugongs?
> S: It's a mammal.
> T: When you say 'mammals' what do you mean?

S: Give birth to the young.
S: Warm blooded.
T: What do they eat?
S: Herbivorous.
T: What do you mean?
S: They eat grass.
T: Yes, that's why they are called 'cows'. Now dugongs are an endangered species. Do you know what that means?
S: They're going to be out of this world.
S; Extinct.
T: Yes, soon they will not be found in this world anymore. So what should we do about this?
S: Take care of them
S: Preserve them
S: Stop killing them

[Note the use of probing questions to lead students on to higher order thinking – starting from simple comprehension questions, the teacher led them to make inferences and apply ideas to new situations.]

The teacher then clicked on a slide. A passage entitled 'Save the sea cows' flashed onto the screen. The students read aloud the passage. This was followed by a question and answer session during which the teacher highlighted descriptive words.
S: Teacher, are they hard or soft?
T: Look at their ears. What do you think? How do they look? What do they have on their lips?
S: Whiskers
T: Right. There is lots of information here. Let's read the last part.
This was followed by five minutes of chorus reading.
T: So what do you know about dugongs?
S: Gentle.
S: Friendly.
S: Lovable.
T: Do you remember the story of Tenang? Can anyone tell us about Tenang?

[Tenang was a dugong found in Malaysian waters by a fisherman who cared for her. The authorities pressured the fisherman into releasing Tenang into the sea. After much controversy, he did but unfortunately, Tenang died. The case was widely publicized in the press.]

A girl put up her hand, stood up and related the story.
T: Very good. Now I'll give you some tasks to do. Get into your groups.
The students moved to sit in their groups. There were seven groups in all. On each table, a placard with the words "We need help!" stood ready to be

used to direct the teacher's attention to the group. A table with task sheets stood in a corner of the room. The leaders collected and distributed them.

Multiple level tasks were set.
Group 1 had to read the passage 'Save the sea cows' and identify verbs, nouns and adjectives. The leader brought dictionaries for the students to refer to.
Group 2 had to read a newspaper cutting entitled 'Tug of war over dugong' and write an autobiography of the dugong via slide presentations, explaining why Tenang's death was not in vain.
Group 3 had to refer to the same article and role play an interview with Atan, the fisherman who had caught Tenang.
Group 4 required the students to surf the Internet for information on the dugong and prepare points for a debate on whether the dugong should have been released as soon as it was caught. As the group comprised four students, two proposed while the other two opposed the motion.
Group 5 asked the students to describe a fictitious creature or robot.
Group 6 asked the students to surf the Internet for information about endangered animals based on the following questions:
What are endangered species?
Where are dugongs found?
What do they eat?
How can these animals be protected?
How could Tenang have been prevented from dying?
The students then had to create a poster on a powerpoint presentation on how to save this endangered species.
And Group 7 had to create a poem on their feelings about the dugong, either on the computer or on paper.

The students worked in their groups. Every now and then, the placard was put up and the teacher hurried over to help. At a computer station, a girl keyed in sentences, prompted by her partner who had drafted an autobiography on the dugong:
"Hello, I am a dugong. I am born in Northern Australia and I am related to manatees. I am a mammal..."

At another computer station, the students were seen, surfing for information on endangered animals. A few students prepared a poem on another computer. There were bursts of laughter as they worked.
The teacher walked round the classroom, helping out where necessary.
T: We have half an hour left. Are you ready with your presentations?
The students acquiesced.
Group 4 presented first. The students listened raptly as a representative argued why Tenang should have been released immediately.
"I agree it should have been released because..."

Among the points raised by the proposing team were that it needed sea grass, it needed to learn how to live on its own, it belonged to the wild, it needed its mother as all mammals do, etc.
The opposing team then objected, raising points like how vulnerable Tenang was as it was injured, how mammals had feelings and could develop attachment, how releasing it into the wild was equivalent to leaving a baby on the streets, etc. There was an animated discussion as students exchanged opinions and the teacher had to stop the discussion so that other groups could make their presentations.
When Group 5 presented, there were hoots of laughter as the students showed off their pictures of their imaginary creature or robot.
Group 6 compared the endangered panda and the cheetah and suggested ways to help by building places for them to multiply, breeding them in captivity, etc.
The last group presented their poems on the computer, with the leader using a laser pointer to point to the stanzas as the group members recited them. They were enthusiastically applauded.
The lesson closed with the teacher asking the students for feedback.
The students looked pleased when hard copies of work on the computer were printed out and pasted onto the board at the back of the classroom.

The above lesson can be considered an example of an optimal use of technology in the classroom as it fulfilled all the criteria outlined earlier.

Firstly, learning was extended to beyond the physical walls of the classroom when students were encouraged to surf the Internet for information on the dugong. The students explored different web sites – science, biology and nature – and worked hard, checking multiple sources of information as they reflected on issues and discussed the problem.

Secondly, the students were engaged in higher order thinking as they prepared autobiographies, debates and poems which required them to access, analyse, evaluate and then synthesise information into new forms. The computer was not just a word processor but a mind tool for creativity as the students came up with original poems, as shown on the following page.

Poem 1
I am a dugong,
Big and fat and slow
I swim with my paddle like tail
I eat sea grass and plants.

Although I am fat and defendless (sic)
You might mistake me for a mermaid
Stop running over me with boats
Cause its hurts my head a lot

Being so big
You might thing (sic) *I would roar*
Instead I make little squeaking sounds
And don't mistake me for a rock.

Poem 2
Dugong or sea cows are marine animals
They are a type of herbivorous mammal
Slow moving and defenceless, this mermaid of the sea
Is going to be extinct and deserves our pity.

We should feel sorry for these poor things
Unlike birds, they can't fly away with wings
Their lives are in danger and time is running out
Unless we take action and not pout.

They may look like stones but when you look close
You might find out more than anyone knows
Dugongs are endangered and need our care
Why don't we help the dugongs there?

The third criteria stated that the technology should promote student-centered collaboration. Field observations showed students actively involved in and collaborating with each other in diverse, multiple-level learning activities centered around the computer as they negotiated and delegated tasks to create new products.

Fourthly, the lesson was emotionally satisfying as confirmed by an interview with the students at the end of the lesson.

Besides honing technological skills, all four language skills of listening, speaking, writing and reading were inculcated. The students appeared satisfied as the technology allowed them to utilise diverse abilities – good students assumed leadership and showed off their talents to the maximum while less proficient ones helped out in other ways and enjoyed success at their tasks. The lesson also gave them the chance to acquire practical research skills.

Since the above lesson fulfilled all the criteria set out earlier, it can be regarded as an example of an optimal use of technology. Many teachers had requested, within the research time frame, such benchmark practices. Clearly, the setting up of a bank of exemplary lessons should facilitate the technology adoption-diffusion process.

A theoretical summary of the study

To recapitulate, the discussion thus far has suggested that teachers' acceptance and use of computer technology in the case study schools can be explained via a theoretical model referred to in this study as the SMaT model. A five-stage adaptation of the original CBAM's LoU was also proposed to examine the teachers' levels of technology use in the case study schools. And finally, an attempt was made to crystallize the notion of what is meant by the notion of optimal uses of technology in the context of this particular research study.

Thus far, all the research questions pertaining to the 'what', 'why' and 'how' of technology-integrated instruction appear to have been answered. What remains now is to look into some of the implications of this study and suggestions for future directions – the 'what next?', so to speak. This final section thus offers readers a brief, theoretical summary of the entire study together with recommendations and suggested course of action for stakeholders in education serious about imparting technology skills in schools.

Although this study initially began as an exploration into how teachers who had attended the *14 Weeks In-Service Training Program for Teachers of Smart Schools* coped with technology-integrated instruction in school, it gradually evolved into a much broader investigation into a whole gamut of issues related to the technology adoption-diffusion process – the teachers' thoughts about the innovation, their levels of use, variations in responses and their quest for optimal practices.

Right from the beginning, field work hinted at the complexity of the innovation, in particular, the importance of the teacher culture helming it. For that is the crux of the technology adoption-diffusion issue which emerges clearly from fieldwork– that the key lay in the hands of the teacher corps. Although the SMaT model depicted in Figure 16 posits a complex interplay of systemic factors, mediating influences and teachers' innate predispositions to explain acceptance of technology in schools, the teacher factor appeared to be more potent than the others.

It is true that systemic factors such as the physical environment, cultural ethos, technological infrastructure and the political pulse driving the vision were necessary conditions to encourage technology adoption. Similarly, mediating influences in the form of students, parents and change facilitators were also powerful forces to persuade teachers to think positively about technology. However, field observations revealed that the teacher corps, with their varied juxtaposition of mental beliefs, risk tolerance levels, technological quotients and teaching goals, were often able to minimise the adverse impact of these factors if they so desired.

Take Chin for instance. Gemilang had all the necessary systemic prerequisites for technology adoption. Yet Chin resisted technology for a long time because of her mental beliefs of what constituted good teaching and her priority goal to retain the locus of classroom control in her hands.

Likewise, over at Rajawali, Ling managed to implement technology-integrated instruction quite early in the research time frame even though the technology was not fully in place. She persuaded a teacher to loan the school a modem for Internet dial-up access, roped in a private company to donate old computers and practised 'remote control technology' by getting her students to patronise Internet cafes. She achieved all this because of two factors – her teaching goals (which were pastoral in nature) and her progressive mental beliefs about teaching. The former spurred her to overcome negative systemic factors because she wanted her students to be 'with her' and she perceived that they were most "with her" when she used technology in the classroom. The latter motivated her to carry on with her attempts as she perceived technology as the way forward. Both these observations confirmed the pivotal role of teachers in the technology adoption-diffusion process.

Thus, my theoretical construct is that the key player in the technology adoption-diffusion equation is the teacher in the classroom. This theoretical construct was just a suspicion at the beginning of the study but gained momentum as field work progressed. I became convinced of the potency of the teacher factor as I interacted daily with the teachers in schools where technology stared them in the face, to little avail. The crystallisation of this construct was fuelled by intensive observations over a longitudinal time frame, and then slowly confirmed and triangulated. Research findings from other studies (Honey & Moeller, 1990; Saye, 1994) lent further credence to this construct.

If we accept that the key to technology adoption lay with the teacher corps, then it follows that measures to promote technology adoption and diffusion would encounter only limited success if they focused merely on improving hardware and physical amenities. The implication seems to be that more attention needs to be paid to the larger issues related to the teacher corps – training opportunities to enhance technological competencies, lighter workload, release time to explore and to experiment, lower student-to-teacher ratios, more teacher collaboration and generally more efforts to make schools appreciative of innovation and creativity. In other words, initiatives related to the technology implementation initiative should focus on human resources instead of hardware. For that is where change really begins.

Research findings from this study also suggest that mediating influences, in particular change facilitators, play dual roles in the technology adoption-diffusion equation. They can either try to alleviate the negative impact of systemic factors or strive to promote progressive change among the teacher corps. In both instances, the main vehicle for change is training.

Four areas are identified as possible new areas for trainers to focus on in future training initiatives – teachers' belief systems, risk tolerance levels, teaching goals and technological quotients. There is much scope for planning staff development activities around these four areas to help teachers re-examine mental beliefs, realign risk-challenge perceptions, refine technological quotients and redefine teaching goals to bring them more in line with constructivist principles.

However, before new training initiatives are set up, it might be worthwhile, at this juncture, to briefly review and evaluate the effectiveness of the current programme that has been specially implemented to train teachers to teach with technology in the pilot smart schools. Which brings us back to the starting point of this research study – *the 14 Weeks In-Service Training Programme for Teachers of Smart School.* This study would not be complete without an attempt to at least examine the training programme in question to gauge if it adequately meet the needs of teachers involved in the technology initiative and to determine the type of follow-up training most relevant to our needs. Thus, the concluding discussion to this study redirects the attention of the reader, once again, to the *14 Weeks In-Service Training Programme for Teachers of Smart School.*

A qualitative evaluation of the training programme

A quick literature review on evaluation models for assessing teacher development programmes suggests that Carney's (1998) examination of a teacher development model at the Shoreline Teacher Development Centre offers the most appropriate parallels for a cursory qualitative assessment of the *14 Weeks In-Service Training Programme for Teachers of Smart School.* Carney advocated four elements as essential for effective technology-based training.

Firstly, Carney suggested that technology-based training programmes should challenge teachers' existing *frames of reference.* Frames of reference are familiar understandings or beliefs which shape teachers' actions (Schon, 1987). If left unchallenged for a long time, these frames of reference can lull teachers into a stupor-like state and cause them to march unquestioningly to the beat of a fixed teaching repertoire. Thus, in order to get teachers to be receptive to technology adoption, there must be challenges to the teachers' frames of reference so that they are shaken out of their safe mode.

In the case of the *14 Weeks In-Service Training Program for Teachers of Smart Schools*, the call to embrace new technologies did challenge the teachers' frames of reference and caused many to wonder if their pedagogical skills were becoming obsolete. Many feared being left behind if they did not quickly pick up IT skills. Interviews with teachers in the training milieu revealed that many believed they needed to set new goals and strive for new understandings in teaching. All this was evidence that the training programme had, to some extent, challenged the teachers' frames of reference and stimulated them to question their belief systems again.

The second element highlighted as essential for effective technology-based training was *situated learning* (Ball, 1990; Carney, 1998; Jonassen, 1991). Ball (1990) stressed that teachers needed concrete models of what an innovation or vision looked like in practice and practical guidelines on how to get there. Challenging teachers' frames of reference opened up minds but teachers needed to be shown practical ways in which to reconfigure new knowledge and beliefs with real students, in real time, within real classrooms.

In the *14 Weeks In-Service Training Program for Teachers of Smart Schools,* elements of situated learning were contrived at when teachers were asked to create learning packages based on the actual syllabus and to test these packages in simulated classrooms. Unfortunately however, many of the learning packages prepared within the research time frame were specially created for ideal school scenarios which differed greatly from the harsh reality found in schools.

This problem was compounded by the fact that within the research time frame, there was no existing smart school for teachers to model from. Thus, elements of situated learning, though contrived at, were minimal. This was a weak link in the training programme as suggested by the clamour of teachers' voices requesting exemplary benchmark practices of technology-integrated instruction which emerged from this study.

The third element regarded as essential for effective technology-based training is *collaborative reflection* (Hasseler & Collins, 1993). A review of literature suggests that traditionally, teachers have generally lacked opportunities to engage in collaborative projects (Little, 1990; Lortie, 1975) and interviews with teachers confirmed this to be still the case today. However, the *14 Weeks In-Service Training Program for Teachers of Smart Schools* did make concerted efforts to promote collaboration among teachers by getting them to cooperate on learning packages. Field observations often showed the teachers engaged in collaborative work and reflective discussions with peers.

And finally, there were indications that the training programme did spawn the *long term collegial interaction* advocated by Sandholtz, Ringstaff & Dwyer (1992) and highlighted by Carney as the fourth crucial element for effective technology-based training. Interviews with the case study teachers showed that they continued to work closely with each other, long after completion of training. Many maintained contact via email and formed close-knit groups and "communities of practice" (Lave & Wenger, 1991), sharing lesson plans and tips on technology integration although they were emplaced in different schools.

Thus, in retrospection, the elements highlighted by Carney as essential for effective technology-based training programmes appear to have been present in the *14 Weeks In-Service Training Program for Teachers of Smart Schools*. These elements acted on the inherent dispositional filter in the teachers' psyche described as the 'T' factor earlier and affected, as well as caused variations, in their responses to technology. For instance, challenging the teachers' frames of reference stimulated examination of mental beliefs about teaching. Incorporating elements of situated learning in the training programme enhanced technology quotients and opened new possibilities and alternatives with technology. Encouraging collaboration and long-term collegial interaction changed teachers' risk-challenge perceptions by creating informal avenues of support for experimentation.

Furthermore, the *14 Weeks In-Service Training Program for Teachers of Smart Schools* did improve teachers' technological competencies as indicated in Table 25 on the following page. Table 25 compares the technological competencies of 69 teachers who were asked to self-rate their IT skills before and after participating in the training programme, using Russell's (1995) Stages of Technology Competencies (Appendix 8). The results show a clear jump in the teachers' technological skills, with the percentage of teachers at stage E increasing from 15 to 33 and those at stage F increasing from 4 to 23, by the end of training.

Table 25 : Teachers' self-perceived stages of technology competencies

Stages of Technology	Pre-Training N	Pre-Training (%)	Post-Training N	Post-Training (%)
A (Awareness)	5	7	-	-
B (Learning the process)	18	26	2	3
C (Understanding & application)	19	28	18	26
D (Familiarity & confidence)	14	20	10	15
E (Adaptation)	10	15	23	33
F (Creative Application)	3	4	16	23
Total	69	100	69	100

To sum up in a nutshell, all five indices adopted as the criteria for effective technology-based training in this research study – challenges to teachers' frames of reference, situated learning, collaborative reflection, long-term collegial interaction and enhanced technological competencies – suggest that the *14 Weeks In-Service Training Program for Teachers of Smart Schools* was effective in preparing teachers in the case study schools to teach with technology.

Implications and future directions

Certain implications can be derived from this research study.

Firstly, since research findings pinpoint teachers as the gatekeepers to technology adoption in the four case study schools, more attention should be given to nurturing their potential and expanding their roles as change agents in the schools. Towards this end, certain measures can be implemented.

A task force comprising curriculum, technology and change specialists should perhaps be set up to monitor the progress of the innovation and to help teachers involved in the smart school project resolve concerns related to the innovation. It would be ideal if members of this task force can be trained in the use of the CBAM's SoCQ and LoU so that teachers' concerns profiles can be drawn and monitored from time to time, and appropriate intervention measures effected when necessary. This monitoring of concerns would go a long way towards nipping problems in the bud and helping teachers come to terms with technology use as soon as possible.

The monitoring of teachers' concerns should be augmented with frequent visits to schools so that teachers are provided with more site-based assistance and support. Alternatively, members of the task force can be based in the school milieu for short stints so that they may better understand case specific concerns. Field observations show that teachers are usually very busy people with hectic schedules who will not spend time mulling over technology-related problems if they can help it. Providing them with readily available, site-based assistance and experts who can resolve their concerns as soon as these arise would make them more willing to spend time on technology and move them to higher levels of use.

The setting up of a task force linking policy-makers with trainers and teachers in the frontline of the innovation might also facilitate better communication between the various stakeholders involved in the project. However, it must be emphasised that the objective of such a task force is not so much to give technical support (there is already a

Help Desk for this purpose) as to provide a communication channel to help teachers resolve technology-related concerns.

Since field observations suggest that teachers wish to upgrade technological competencies and are looking for optimal practices to emulate, it might be timely to consider liberalising training opportunities for teachers so that they are able to upgrade their technological skills as and when they wish. The lack of equitable access to training opportunities has long been a lament of teachers in schools and a contributory cause to the low morale observed. If teachers were allowed to source for their own technology-related staff development opportunities within pre-determined budgets, the pressure might be taken off central providers of training like TED to constantly come up with diverse training packages to meet different needs. Such a move would not only enable teachers to tap into more sophisticated skill training offered by cash-rich private companies thereby injecting a breath of fresh air into in-service training in schools, but would also give teachers more freedom in charting their career development path.

Many private companies have indicated interest in sharing their expertise. As a case in point, the Multimedia Development Corporation which adopted the Dengkil smart schools has already sponsored teachers for training, both locally and abroad. The recruitment of assistance from the private sector to upgrade teachers' technological skills has long been lauded in research (Carrs, Grice, Galbraith & Warry, 1991) and should be seriously explored as a viable alternative to centralised staff development on the local education scenario.

Besides liberalising training opportunities, the current 'en bloc' approach to training should perhaps be reviewed in favour of more individualised and needs-based follow-up training. The setting up of training clusters to allow teachers with similar concerns to be trained together might prove helpful. For instance, teachers with peak information concerns can be trained in different clusters from those with peak impact concerns so that the former do not feel 'lost' and the latter bored. Likewise, teachers with collaborative concerns would probably benefit more from interaction with like-minded teachers seeking to implement collaborative projects. Such a move would probably optimise training benefits as well as create the avenues for support, collaboration and collegial interaction that teachers crave. Eventually, this could pave the way for a more systematic synergy of teachers' efforts.

Another implication which arose from the study is the need to look into ways to improve the teaching profession and make it more attractive to teachers. It is not the focus of this study to highlight the plight or low morale of teachers (and no attempt was made to delve into this issue in detail) but the perceived brain drain of techno-savvy teachers – isolated incidences or otherwise – mentioned by principals in this research study is cause for concern as low morale definitely impedes the technology adoption-diffusion process. Clearly, there is a need to explore ways to boost the morale of teachers if policy-makers expect teachers to be progressive and innovative. This issue merits urgent attention.

Research findings also point to the need to set up more technical backup support systems to encourage teachers to adopt technology. The presence of on-site technology coordinators would definitely help but manpower constraints are real. A possible source of manpower is the pool of latent expertise among parents of students in the schools. Encouraging techno-savvy parents to volunteer their services on a rotational basis in schools is a viable possibility. Perhaps lessons can be learnt from the Japanese education system (I draw upon my observations of schools in Japan where I stayed three years) which invites parents to assist in the instructional process once a month. Parents are, as yet, an untapped source of teacher assistance in Malaysia.

The setting up of technology libraries with item banks of lesson plans and benchmark practices of technology should also boost the technology implementation initiative. Teachers should be encouraged to visit schools involved in successful technology projects so that they may observe techno-savvy teachers in action. Opportunities should be created to allow them to team-teach and to engage in reflective dialogues with peers. Towards this end, lessons can be learnt from the Clear View Charter School in Chula Vista, California, which organizes weekly "technology hours" for teachers to discuss student work, give moral support to each other and share successful technology practices (Conte, 1997). Clearly, efforts must be made to celebrate the teachers' success stories to boost their morale and motivate them.

Other implications arising from the study include a need to re-examine the current evaluation system in schools to bring it more in line with the demands of technology. If policy-makers are serious about implementing technology-integrated instruction, this issue needs to be addressed quickly. There is little point in pushing for technology adoption if the technology does not add value to the issue closest to the hearts of teachers, parents and students – good examination results! Similarly, the curriculum needs to be reviewed to reduce rote learning in favour of the problem-based authentic approach that is the new wave of the Information Age.

Policy-makers also need to look into ways to give teachers more release time to experiment with technology in schools. Providing release time, even if only for a few hours a month, will improve teachers' technological competencies by leaps and bounds.

To sum it all up in a nutshell, a four-pronged approach – with emphasis on the teacher corps – seems to be in order if we wish to promote the technology adoption-diffusion process in schools:

1. Help teachers grow professionally

   Training initiatives should be more needs-based. Four new areas have been identified as worthy of attention in future training initiatives -- challenging teachers' mental beliefs, realigning risk-challenge perceptions, refining technology quotients and re-examining teaching goals. Encourage alternative sources of professional development such as technology mentors, release time, self-renewal programmes, group development hours, technology clusters etc. The keywords are collaboration, networking, team-work, self help and group support.

2. Make technology-enriched classrooms more teacher-friendly.

   Provide teachers with dependable technical back-up support, lesson banks of exemplary practices, lighter workloads, smaller teacher-student ratios, more pastoral care/counselling services to address discipline problems etc.

3. Enhance the image of teachers

   Fieldwork suggests that teachers' morale in the pilot smart schools is at a disturbing low and this is something we should heed if we wish schools to remain relevant in society.

4. Revamp the evaluation system in schools to bring it more in tune with the demands of technology-integrated instruction. As fieldwork so clearly shows, technology cannot really take off if teachers impart the skills of tomorrow with the tools of today and the evaluation criteria of yesterday.

Recommendations for further research

The following areas are recommended for further research:

Since this is a qualitative study using a naturalistic framework of inquiry which seeks to describe the phenomenon of technology use in schools in order that we may better understand what has happened and is happening in the case study schools, the findings may not be fully generalisable to other pilot smart schools. Thus, it would be helpful if similar qualitative investigations are conducted on a nation-wide basis, especially in smart schools outside the Klang Valley, so that a more comprehensive picture of the progress of the technology implementation initiative can be obtained.

It would also be interesting and illuminative if a national survey is conducted on all pilot smart schools to determine the exact extent of adoption of technology-integrated instruction to date, using the CBAM's SoCQ as a quantitative instrument to differentiate between adopting schools and non-adopting schools. Such a study, somewhat along the lines of Maney's research into K12 schools (1994) would certainly be diagnostic and give policy-makers a pulse on the rate of adoption of the innovation.

Studies which explore the inherent dispositions of teachers as regards technology adoption, especially if conducted with psychometric instruments to test some of the four factors identified in this study or to determine if other factors are involved as well, may cast new light on the technology adoption-diffusion process. Although this study has highlighted some of the dispositional differences in teachers, it is unable to investigate deeply into these dispositions as they only crystallised and emerged as research findings towards the end of the study. However, a cursory literature review suggests the work of Dweck and Legget (1988) and Katz (1992) may provide guidance for studies of this nature.

Further work on teachers' mental belief systems – perhaps life history work to trace the evolution of teachers' worldviews or ethnographic studies to explore the relationship between belief systems and classroom practices with technology – should also prove useful and interesting. And if quantitative instruments can be developed to complement qualitative approaches, even more information can be gleaned about these complicated relationships.

And lastly, a quantitative evaluation of the *14 Weeks' In-Service Training Programme for Teachers of Smart Schools*, perhaps based on Stufflebeam's (1971) Context-Input-Process-Product (CIPP) model, would probably be helpful to pinpoint in detail, new directions and fresh approaches to take in future training initiatives as regards technology-based training. This would definitely prove useful to educationists striving to promote technology use in instruction.

Epilogue

I will end this study by again borrowing from a scene form Chaplin's *Modern Times*:

It is dawn and we see the Tramp busily fanning himself on a lonely country road with rolling hills in the distance. His girlfriend quietly cries beside him.

"What's the matter?" he asks gently.

The girl sobs in frustration, "It's no use. What's the point of trying?"

The Tramp is as upbeat as ever: "Never say die. We'll get by."

He guides her as they continue their trek down the lonely country road.

When the Tramp notices her morose demeanour, he smiles and points to his face, gesturing that she should do the same. She offers him a small, timid smile in return.

Quietly offering each other solace, they walk away from the camera towards the horizon and the new dawn.

This closing scene from *Modern Times* is symbolic as it represents the Tramp's escape from the troubles of the factory and the city as he turns his back on modern times and heads for the simpler life in the rural countryside.

It is a powerful analogy as it offers lessons to learn in our attempts to move our teachers towards technology adoption. This research study has highlighted the trials and tribulations of the teachers pioneering technology-integrated instruction. It documented their concerns and conflicts as they traded old horse-and-buggy approaches for new, space age methodologies in the classroom. It recorded their pains as they nursed the innovation through its birth pangs. It traced their battles as they, reluctant technology warriors, some of them, fought to implement the technology as best they could in technologically-enriched environments mired in problems.

The teachers have spoken. It now remains for the authorities to listen to their voices and to set into motion appropriate measures that will help them – and thousands of others like them – as they begin their long and lonely trek towards realising the nation's technology vision. For lonely the trek is indeed – there are thousands of students and teachers and consequently, thousands of inherent dispositions, mental beliefs, teaching goals which need to be juxtaposed harmoniously into a common education system with common goals. Care must be taken lest, discouraged by the lack of support, they too, like the Tramp, turn away from the innovation and move off in the opposite direction, back towards the traditional paradigm.