

Insights into Innovative Classroom Practices with ICT: Identifying the Impetus for Change

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ABSTRACT

This paper draws on the literature of transformational leadership and learning organisation with a concern to foster innovative changes in classroom practices. Based on the understanding that effective use of ICT has to be construed in the pedagogical and organisational context, this study focuses on the impact of the relevant contextual factors on teaching and learning, and how these factors interact with each other, in particular the relationship between technological innovations and pedagogical innovations. By adopting a qualitative case study approach to examining the impetus for change, four different types of ICT implementation strategies have emerged from a sample of eight schools in Hong Kong and Singapore, the technologically driven type, the pedagogically driven type, the balanced type, and the uncoupled type. Those schools which have realized changes in classroom practices are characterised by ICT-pedagogical innovations. To make this happen, pedagogical innovations must be rooted in teachers' experiences of moving away from a teacher-centred approach to one that is more student-centred. Leadership and the climate for collaboration and experimentation are fundamental to the integration of technology into pedagogical innovations. However, other factors such as region, school level, and type of school do not seem to account for the differences.

Keywords

Leadership, ICT implementation strategies, Technological and pedagogical changes, Innovative classroom practices

Introduction

The ongoing, unprecedented growth of information and communication technology (ICT), coupled with the globalisation of the economy, has created a huge challenge for education. The implementation of ICT is in the forefront of education reforms locally, regionally, nationally and internationally. USA, Denmark, Japan, Finland, the Netherlands, Portugal and Spain, for example, have drawn up master plans for developing ICT in education (Cheng, 2002). This rapid growth of infusing ICT in education is confronting stakeholders with the effectiveness and the impact of technological applications. Following Fullan (1991), innovation cannot be assimilated unless its meaning is shared. In this light, it is highly relevant to conduct comparative case studies with a view to understanding the processes of change in different education systems, and of how technological innovations can be successful. Notably, Hong Kong and Singapore – the economic rivals – have launched similar educational policies and initiatives around the same period of time. However, despite their shared similarities in educational policies, the two regions have demonstrated different strategies for implementing ICT in education. In Singapore, the government is undertaking centralised measures to strengthen the coherence and co-ordination of educational policies (Kwong, 1997). By contrast, Hong Kong is moving towards a more decentralised approach, giving more autonomy to schools in policy implementation (Advisory Committee on School-based Management, 2000). This divergence directs us to explore how different visions and strategies relate to different classroom practices and learning outcomes in the process of implementing ICT in education.

With a prior concern with the implementation of ICT at school and classroom levels, the study addresses the following questions:

1. What are the impacts of ICT on classroom practices (modes of teaching and learning) in different schools within and between Hong Kong and Singapore?
2. What are the teachers' pedagogical beliefs and their perceived roles of ICT in education in different schools?
3. What kinds of ICT implementation strategies have emerged in these schools? How are they related to the different classroom practices (modes of teaching and learning)?
4. What are the different models of innovative classroom practices with ICT in the schools within and between Hong Kong and Singapore? How may these differences be explained?

Background

Currently, the ongoing and unprecedented development of ICT has led to a widespread intention of using ICT to advance educational goals (Cheng & Townsend, 2000). This is in part driven by the belief that ICT can play an important role in reshaping education to respond to contemporary information needs (Panel On Education Technology, 1997). Recent developments across the world have moved much beyond the vision of using ICT as a teaching and learning aid, but of reshaping the delivery of instruction and bringing about changes in education – transforming education in the industrial society to education in the information society (Law, Yuen, Ki, Li, & Lee, 1999). In and of itself, ICT, which contains neither pedagogical philosophy nor content basis (Means, 1994), is found wanting. Some researchers have suggested that effective use of ICT is embedded in a larger process of school change (Honey, Culp, & Carrigg, 2000); and that effort of ICT implementation needs to be examined as part of the multifaceted school reforms rather than in isolation (Bober, 2002). Along this line of reasoning, pedagogical and organisational interventions need to be addressed, if schools have the vision to move beyond using ICT to reinforce old pedagogies (Lankshear, Snyder, & Green, 2000; Papert, 1997).

According to Heppell (1993), reshaping the delivery of instruction is supposed to be in a scenario where ICT alters the learning environment and the learners. This requires an emphasis on participative media, radical change in pedagogy enabled by ICT, and recognition of the emergent capabilities of learners. In reshaping classroom practices, it has been suggested that ICT is a means for constructing knowledge but not an end in itself (Eib & Mehlinger, 1998; McCombs, 2000; Means, 1994); and that qualitative changes in the teaching and learning process are all that required (Itzkan, 1994; Thomas, Carswell, Price, & Petre, 1998; Twining, 2002). Basically, it involves changes in the curriculum content, the instructional process, and the teacher-student relationships (Plomp & Brummelhuis, 1999; Squires & McDougall, 1994). It is emphasised that students must be seen as knowledge generators and active participants in their own learning while teachers act as facilitators (Jonassen, Peck, & Wilson, 1999; McCombs, 2000; Means, 1994).

At school level, effective use of ICT requires organisational intervention since the benefits of ICT cannot be adequately separated from other variables that impact on learning in the larger instructional context (Honey et al., 2000; McCombs, 2000). A review of the literature indicates that school reforms in general call for a greater emphasis on transformational leadership and learning organisation in order to improve teaching and learning (van den Berg & Slegers, 1996). Transformational leadership focuses on increasing the organisation's capacity to innovate (Hallinger & Heck, 1998), and adopting a commitment-building strategy for school restructuring (Leithwood, 1994). The idea of learning organisation is about fostering a culture of changes in instructional practices and learning toward greater collaborative relationships among students, teachers and other potential partners (Fullan, 1993; Senge, 1990).

Research framework

Based on the understanding that effective use of ICT has to be construed in the pedagogical and organisational context, the analysis focuses on the impact of the relevant contextual factors on teaching and learning, and how these factors interact with each other, in particular the relationship between technological innovations and pedagogical innovations (Figure 1). From the pattern of interaction, it is possible to uncover the different ICT implementation strategies that have emerged from the schools, and see how these different strategies relate to different learning outcomes and classroom practices.

Variables constituting the research framework

The following sub-sections together with Table 1 describe the variables constituting the research framework and how they are set as indicators for the relevant changes.

Leadership

While the concept of transformational leadership has been subject to varying interpretations in the literature, they share a common focus with emphasis on the commitments and capacities of organisational members, and a common

concern for organisational culture (Leithwood & Duke, 1999). Along this direction, the leadership in this study measures the perceived school leadership with a focus on measuring the school principal's transformational leadership in four domains: i) the capability of establishing shared visions, ii) the capability of trusting and empowering teachers, iii) the capability of supporting innovations in classroom practices, and iv) the capability of supporting staff development.

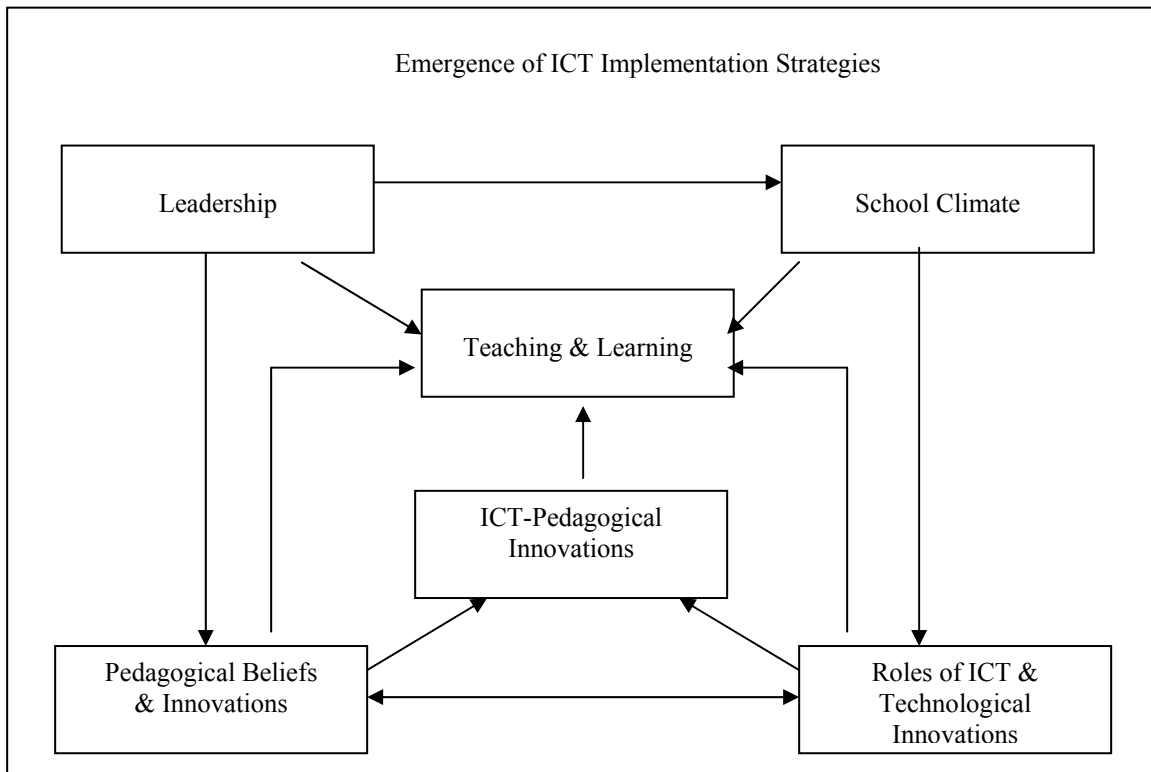


Figure 1. Emergence of ICT implementation strategies at school and classroom levels

School Climate

School climate refers to the atmosphere in a school, and is generally considered to be positive or negative (Gonder, 1994). Specifically, school climate is described as the quality of a school that stimulates teachers' creativity, enthusiasm, and sense of belonging (Freiberg & Stein, 1999), in particular the collegial relationships (Reinhartz & Beach, 2004). Conceptualisation of school climate in the present study is along the direction of collaboration and experimentation, and it measures among teachers their i) collegial relationships, and ii) spirit to strive for progress.

Pedagogical Beliefs & Innovations

This study uses a constructivist paradigm to frame pedagogical beliefs and innovations, and the variable measures the degree of shift in teachers' beliefs and pedagogy towards a more student-centred approach. Pedagogical innovations are conceptualised with reference to the HKSAR official document "Learning to Learn: Life-long Learning and Whole-person Development" (Curriculum Development Council, 2001) and the design document for the Second International Technology in Education Study (SITES) Module 2 (M2) (Kozma & Anderson, 2002). Pedagogical innovations refer to emerging practices that involve changes in what teachers and students do and learn in the classroom, which prepare students for lifelong learning in the information society. Examples of such practices can be activities that promote active and independent learning in which students take responsibility for their own learning, and activities engaging students in collaborative learning in which students work with others on complex, extended, real-world-like problems.

Teaching and Learning

Similar to the frame of reference for pedagogical beliefs and innovation, this study uses a constructivist paradigm to frame teaching and learning. It is an outcome variable that measures the evidence of significant changes in roles of teachers and students towards a student-centred approach in the classroom practices. Evidences of measurable positive student outcomes capture two indicators: ability and attitude. Ability indicator measures whether students are independent in their learning, active in constructing knowledge, and whether they make use of collaborative work to facilitate learning. Attitude indicator measures whether students have courage to express ideas, whether they are motivated in learning, and whether they enjoy learning. Acknowledging that there is a variety of instructional strategies to suit the needs of students with different learning abilities and learning styles, instructional strategies of teachers are also documented as an evidence for tracing changes in teaching and learning towards a student-centred approach. Instructional strategies range from mere exposition to exploratory learning.

Roles of ICT & Technological Innovations

In measuring the roles of ICT & technological innovations on teaching and learning, this study uses two major indicators: an indicator measuring whether ICT transforms rather than supports or extends the curriculum; and another indicator measuring the kinds of technological innovations used in classroom practices. If use of ICT is to support the curriculum, the instructional process becomes more efficient but the content remains unchanged. If use of ICT is to extend the curriculum, the content changes and/or the instructional process changes but they could have been achieved without the use of ICT. When entering into the ideal transformation stage, the curriculum content and/or instructional process changes and they could not have been achieved without the use of ICT (Twining, 2002). As technological innovations open up many new ways of teaching and learning, technological innovations used in classrooms are also documented as an evidence for tracing changes in teaching and learning towards a student-centred approach. Technological innovations may take the form of PowerPoint, World Wide Web, mindtools, and simulation software etc.

Table 1. Pattern Coding Developing Categories and Subcategories

Categories	Subcategories	Remarks
Transformational Leadership	Establishing shared visions Trusting and empowering teachers Supporting innovations Supporting staff development	---
Climate for collaboration and experimentation	Collegial relationship Spirit to strive for progress	---
Pedagogical beliefs & innovations	Shift in pedagogical belief towards a student-centred approach Pedagogical innovations	Emerging practices involving changes in what teachers and students do and learn in the classroom, which prepare students for lifelong learning in the information society, e.g. activities promoting active and independent learning, engaging students in collaborative learning (Curriculum Development Council, 2001; Kozma & Anderson, 2002).
Teaching and learning	Instructional strategies Evidence of a shift in learning to student-centred approach	Ranges from mere exposition to exploratory learning Ability: independent in learning, active in constructing knowledge, make use of collaborative work to facilitate learning. Attitude: courage to express ideas, motivated in learning, enjoy learning.
Roles of ICT & technological innovations	Roles of ICT Technological innovations	ICT supports, or extends, or transforms the curriculum (Twining, 2002) PowerPoint, WWW, mindtools, and simulation software, etc.

Methodology

A qualitative case study approach is adopted to gain a deeper understanding of infusing technological innovations and pedagogical innovations in a sample of schools in Hong Kong and Singapore. Case studies are particularly suited for uncovering the interaction of relevant contextual factors, and the characteristics of situations or phenomena, where it is impossible to delineate the variables involved (Yin, 2003). In this investigation, school is chosen as a unit or an object of study. Since the study is not aimed at hypothesis testing or confirmation, and the number of case studies that could be conducted is necessarily small compared to the whole population of schools, random sampling is deemed inappropriate. Instead, purposeful sampling (Patton, 1990) is employed, and a number of information-rich cases are chosen for gaining insight into relevant critical issues. Accordingly, schools that have demonstrated positive changes in pedagogy and learning as a consequence of using ICT are recruited. Positive changes in pedagogy and learning is defined as whether ICT has facilitated teachers in adopting a more constructivist approach in the pedagogical process, by means of infusing generic skills (e.g. critical thinking/creativity/communication) into the curriculum and collaborative teaching, resulting in a shift to student-centred pedagogical practices. To better understand how the process and outcomes of using ICT are qualified by local conditions, two primary and two secondary schools in the state-maintained sector are selected from each region. And to increase diversity, the case schools are of elite and non-elite types, and at primary and secondary levels. “Elite” schools are those with restrictive admissions criteria and a highly selective reputation to match.

Instrumentation

Lesson observations (of English, Chinese, general studies and mathematics at primary levels; and English, geography, physics and mathematics at secondary levels) and interviews (with the head of school, head of ICT, heads of departments, teachers and pupils) were used to probe the multifarious phenomena that constitute the use of ICT in classroom practices.

Lesson Observations

A semi-structured and participant kind of observation was conducted to allow for exploration of the classroom practices. Each lesson observation was conducted by two observers, and the whole sequence of events was also video-taped for further analysis. During observations, field notes were taken with reference to the relevant variables described in the research framework (pedagogical innovations, teaching and learning, and roles of ICT & technological innovations). While lesson observations captured data from the perspectives of researchers, it was also necessary to take into account how teachers and students viewed the learning environment. The observation data would then be triangulated with the data collected from interviews with teachers and students concerned.

Interviews

A semi-structured kind of interview was conducted with teachers and heads of department concerned, which was used to triangulate with the data from lesson observations. To capture the organisational factors of leadership and school climate, interviews with school principal and head of ICT were also conducted. The semi-structured interview was of 1-hour in duration, and a list of questions with reference to the relevant variables (leadership, school climate, pedagogical beliefs & innovations, teaching and learning, and roles of ICT & technological innovations) would guide the interviews. The interviews were all audio-recorded and transcribed for further analysis.

Focus-group Interviews

Six students were chosen to participate in a focus-group interview according to their levels of participation in the double lesson under observation: that is, three active participants versus three passive participants. The interview was of 30-minute duration, and a list of questions with reference to the relevant variables (leadership, school climate, teaching and learning, and roles of ICT & technological innovations) was used to guide the group discussions. The interviews were all audio-recorded and transcribed for further analysis.

Data analysis

Pattern Coding for Individual Case Analysis

The ultimate aim of data analysis in this research is to describe and explain the various relational patterns based on a set of conceptual categories (Figure 1 and Table 1). Following the procedures of grounded theory, data collection, analysis and the conclusion stand in close relationship to one another (Strauss & Corbin, 1998). Using the pattern coding process, the researcher will begin with generating categories for each case school from a multiple sources of data, which are then systematically developed and linked with their subcategories (Table 1 and Table 2). These categories do not constitute specific data of an individual, but are highly conceptual terms reduced from classroom observations as well as the spoken accounts of the principal, heads of departments, teachers and pupils. In this way, the data are reduced into the same set of categories that represent the voices of many people within a school. Using relational statements, the findings about each case school centre on a relational pattern based on the established conceptual categories, rather than the descriptive details (Strauss & Corbin, 1998).

Case-oriented Approach for Cross-Case Analysis

For the cross-case analysis, as the research aims at finding specific patterns common to small sets of cases, a case-oriented approach will be adopted. It is a method that considers the case as a whole entity, and the cases are then inspected to see whether they fall into groups that share certain patterns (Miles & Huberman, 1994). In this way, the researcher allows the different ICT implementation strategies to emerge from the data, and finally to tease out the factors that contribute to successful ICT implementation in education within and between the two regions.

Findings about individual Hong Kong schools

HKP1 is a 42-year-old non-elite primary school in Hong Kong. The principal was strong in setting priorities, and willing to eliminate unnecessary work so as to create space for teachers. While there was sharing of pedagogical resources among teachers, the climate for collaboration and experimentation was not so strong (there was no clear evidence of jointly developing lesson plans or teaching resources among teachers). With a top priority on academic performance, the teachers were rather sceptical about the inquiry and collaborative modes of learning which put more pressure on time. Teachers have been trapped into pedagogical dilemmas when they adopted the more complex approaches to designing curriculum and fashioning learning experiences. The school introduced level-wide special programmes such as multidisciplinary project work with an attempt to integrate technology into pedagogical innovations in producing new learning experiences. However, the four lessons we observed were typically teacher-driven, with exposition as the main instructional strategy and PowerPoint as the major ICT tool. Pupils' participation was generally confined to answering teachers' questions, with occasional chances for small group discussions. ICT simply acted as a tool to support teaching and learning, and had fair impact on changing the curriculum content and process. Curriculum came first and ICT innovations were seen as secondary. Teachers in general adopted a teacher-centred pedagogical approach, and therefore great efforts have been made in achieving a paradigm shift in teaching and learning. As for monitoring the use of ICT in instruction, the principal described the management system as 'half monitoring and half encouraging'. With an awareness of the differential competence in ICT among teachers from different age groups, he was concerned to provide relevant equipment and basic training for teachers in the first place. However, neither did the teachers nor the pupils find the school strongly oriented to ICT, in terms of its physical infrastructure (e.g. networked classrooms) and technical support. As the resistance to using ICT in teaching and learning was very high among teachers, the principal has shifted the school's focus to curriculum reform. In fostering pedagogical innovations, the curriculum reform has created the need to use ICT in teaching and learning.

HKP2 is a seven-year-old elite primary school in Hong Kong. The principal demonstrated strong leadership and possessed a clear vision. She communicated a strong conviction and determination in following the 'correct' path that the school should take. She has been initiating a lot of innovations since its establishment. In fostering a climate for collaboration and experimentation among teachers through a compulsory policy of producing "quality lesson plans", the principal was the main driving force in shaping the pedagogical beliefs of teachers, who are young with a few years' teaching experience. Despite the tension felt by some teachers, the prevailing climate cannot be described as top-down or bureaucratic. They had a shared vision on inquiry and student-centred learning, and their readiness to

change was relatively high. The requirement of producing quality lesson plans created the chances of collaboration and discussion among teachers, which at the same time made peer classroom observation a culture and a positive pressure for continuous improvement by integrating technology into pedagogical innovations. Compared to the lessons we observed in HKP1, the pupils were given more chances for collaborative learning in HKP2. In both the Chinese and general studies lessons, the pupils were instructed to browse among relevant websites, to search for relevant information, and to give short presentations. In the mathematics lesson, pupils were asked to complete a task using Excel and relevant data extracted from a website. Most pupils participated in the class activities enthusiastically, and appeared to have mastered the necessary ICT skills. These keen learners also had clear ideas about the objectives of the lessons and the subject contents. Although the teachers still adopted exposition as the major instructional strategy, the pupils were provided with time and resources to explore the subject matters on their own, whether in pairs or in small groups. ICT acted as a tool to transform teaching and learning. ICT has changed the process of learning with new learning experiences: students were able to make use of ICT to learn collaboratively and to construct knowledge. With a climate for collaboration and experimentation, some teachers moved beyond using ICT as a teaching and learning aid, and were able to integrate ICT with pedagogical innovations to reshape the delivery of instruction - from a teacher-centred approach to one that is student-centred.

HKS1 is a seven-year-old non-elite secondary school in Hong Kong. The principal was a facilitator for change, ready to accept new ideas. The teachers generally acknowledged the benefit of adopting a student-centred pedagogical approach, but they were constrained by the large pupil-teacher ratio, and the tight study schedule in preparation for the public examinations. Having established a strong collaboration with the business sector, the principal has infused appropriate levels of technological innovations into the school from time to time. The process of learning to use the technological innovations has maintained an ICT learning culture, which may then foster collaboration and experimentation among teachers. All the lessons under observation were conducted in ordinary classrooms. There is one set of computer and LCD projector in each classroom. Naturally, the teachers were in control of the equipment, and the pupils became passive recipients of information. This description is particularly apt for the English and social studies lessons, in which the teachers used PowerPoint and overhead transparencies to facilitate their exposition. Pupils' participation was restricted to answering questions, or engaging in language drills. The situations in the mathematics and physics lessons were slightly different. The teachers supplemented their PowerPoint presentations with relevant software items that were illustrative of the concepts being taught. However, the pupils were not engaging in any exploratory activities or collaborative tasks. Although the pupils were generally attentive and motivated, their responses in class were not particularly impressive. The pupils seldom initiated questions, and only over half of each observed class responded to the teacher's questions. There was little evidence of active learning or enthusiasm among the majority of pupils. ICT acted mainly as a visual tool in making learning more focused. With block-timetabling for a short period of time, the school introduced multidisciplinary project work with an attempt to integrate technological innovations with pedagogical innovations in producing new learning experiences. At the school level, ICT innovations fostered pedagogical innovations. Whenever new technologies were introduced into the school, training would be provided for teachers, which nurtured a culture of learning among teachers. While ICT was not deemed to be a way to create new learning experiences, the school took pride in using ICT in teaching and learning. The drive for change mainly came from ICT innovations brought about by the principal, but the resistance to change arising from pedagogical dilemma was also relatively high.

HKS2 is a 34-year-old elite secondary school in Hong Kong. The principal took the lead to bring in pedagogical innovations; while at the same time he was open to participative decision-making. Starting with top-down policies, bottom-up suggestions have gradually emerged. There is an established climate for collaboration, resources sharing and experimentation among teachers – for example, action research was conducted within the English department; and a pilot study on using ICT to develop lesson plans was carried out by the mathematics team. While teachers in general demonstrated a prudent attitude in trying out innovations, they still followed a relatively secure but concrete path to foster inquiry and student-centred learning. They perceived the usefulness of ICT in teaching and learning, particularly in lower forms, where there is less public examination pressure. In fact, project-based learning was designated as a subject in secondary two, in which mind-mapping was used to facilitate the infusion of generic skills. ICT was integrated into project-based learning to facilitate the pedagogical shift. With such readiness to use ICT, the proactive principal acted as the main impetus in terms of integrating technology into pedagogical innovations. One example was adopting the TARGET approach, with an emphasis on task, authority, recognition, grouping, evaluation and time. With a marked degree of autonomy and flexibility, some teachers moved beyond using ICT as a teaching and learning aid, and were able to integrate technological innovations with pedagogical innovations to reshape their delivery of instruction – from a teacher-centred approach to one that is evidently student-centred. In two of the four

lessons we observed, the teachers of English and geography in HKS2 combined exploratory learning with exposition – the pupils were given many opportunities to explore the subject matter, and to solve the problems collaboratively. The role of technological innovations was prominent in acting as a good source of support for carrying out the exploratory activities designed by teachers. In the English lesson, the pupils were paired up to conduct interviews, and to complete an oral task using relevant software items. With the assistance of technology, the pupils were able to record and play back their interviews, as well as share the spoken output with their peers. In the geography lesson, based on the information on relevant websites, each pupil was given a set of worksheets in preparation for group work. On both occasions, the pupils displayed competent ICT and collaborative skills – and most of them were able to complete the tasks on time. However, the PowerPoint presentation and the videos used in the mathematics and biology lessons seemed to act only as a visual aid to motivate pupils. According to the head of mathematics, it was common for teachers to use freeware in providing hands-on practice for pupils to explore relevant concepts and to deepen understanding.

Findings about individual Singapore schools

SGP1 is an 80-year-old elite primary school in Singapore. The principal was strong in setting directions and communicating visions. While holding on what she believed and pushing through for 10 years, the principal was regarded as encouraging, open-minded, welcoming innovations, and approachable. With top priority on ICT, the principal built in the school a niche in ICT and made the school well known for using ICT in education. The school has become popular since then. The popularity has attracted students coming from higher SES, though the majority of students are of lower SES. The principal was the main drive to build a climate for collaboration and experimentation, and was also the main source to introduce both technological innovations and pedagogical innovations in the form of school-wide programs. Having a major concern on consolidating pupils' knowledge, teachers in general have no consensus on the inquiry and collaborative modes of learning. There were no signs to indicate that ICT created new learning experiences in classroom practices. Three out of the four lessons we observed were typically teacher-driven, with exposition as the main instructional strategy, and CD-ROM as the major ICT tool. While teachers managed to stimulate pupils to inquire at certain points of time, pupils' participation was generally confined to answering teachers' questions, with occasional chances for small group discussions. However, pupils in the Chinese lesson were instructed to browse relevant websites, to search for relevant information, and to give short presentations. Apart from giving good scaffolding to pupils, the teacher in the Chinese lesson also adopted peer evaluation that encouraged critical thinking, appreciation, and collaboration. Most pupils participated in the class activities enthusiastically, and appeared to have mastered the necessary ICT skills and generic skills. While in general teachers recognised the supportive role of ICT in teaching and learning, by large they seemed to prefer the teacher-centred pedagogical approach. ICT had fair impact on changing the classroom practices. ICT remained as a visual tool in making learning more interesting, and as an online assessment tool in making evaluation of performance more efficient. However, the technological innovations fostered limited pedagogical innovations in the form of special programs at the school level (multidisciplinary project work with performance assessment, IT composing music, and emailing kids aboard). In these programs, technological innovations were integrated with pedagogical innovations to form ICT-pedagogical innovations to provide new learning experiences for students: critical thinking and collaboration. As the teachers at the very beginning were quite resistant to using ICT in classroom practices, the approach was largely top-down in creating a climate for collaboration and experimentation among teachers. These included compulsory weekly IT training sessions, monthly level team meeting, yearly learning festival, and buddy system. At the same time, great effort was devoted to talking to teachers and selling the ideas of using ICT. Along the way the approach became a little bit bottom-up, still the principal felt the need of some kind of straighter monitoring system to push through (compulsory IT-based lesson observations, 30% IT integration, portal and lab use records).

SGP2 is a six-year old non-elite primary school in Singapore. The school had a strong leadership who was very open to new ideas and support innovations. The principal was also able to get hold of extra funding and tap on industrial sectors to get ICT resources. The school was new and the teacher's readiness to change was relatively high. The teachers generally shared a vision on exploratory learning, critical thinking, and problem solving. They tended to adopt non-traditional teaching strategies catering for a variety of learning styles. An example is the curriculum innovation named "Human Dynamics", which was a bottom-up suggestion from teachers. With a prior focus on understanding pupils' personality and learning styles, the teachers attempted to use a variety of teaching strategies that would fit in with the ways pupils think, and to the different learning preferences of pupils. In the Human

Dynamics lesson we observed, the pupils were offered ample opportunities to make choices. With the wireless LAN and laptops in place, the pupils appeared to be very independent in their learning and were engaged in exploratory activities. In both the English and Social Studies lessons, with teachers' guidance, thinking map as a kind of technological innovation was used as a mental structure in facilitating the pupils to think and reflect on their moves. Most pupils participated in the class activities enthusiastically, and appeared to have demonstrated critical analysis. In the Chinese lesson, pupils were instructed to browse relevant websites, to search for relevant information, and to have group discussions. The situations in the mathematics lesson were slightly different. The teacher supplemented his PowerPoint presentations with relevant websites that were illustrative of the concepts being taught. However, the pupils were not engaging in any exploratory activities or collaborative tasks. In most cases, with the assistance of the thinking map and websites, teachers adopted exploratory learning as the main instructional strategy, and the pupils were provided with opportunities to explore the subject matters on their own in small groups. Technological innovations were integrated with pedagogical innovations to provide new learning experiences. In other words, ICT acted as a tool to transform teaching and learning. Some teachers also perceived that there had already been a shift in the mindset of teachers from teacher-centred to student-centred approach. The principal fostered a climate for collaboration and experimentation among teachers through a compulsory policy of sharing (weekly whole-school based, and monthly level-based). Her mandatory policy of videotaping teachers' lessons also served as a positive pressure for continuous improvement in ICT-pedagogical innovations. Catching on the strength of collaboration, some teachers moved beyond using ICT as a teaching and learning aid, and were able to integrate ICT with pedagogical innovations (ICT-pedagogical innovations) to reshape the delivery of instruction from a teacher-centred approach to a student-centred approach. While the principal provided the momentum for change at the very beginning, teachers began to initiate bottom-up changes.

SGS1 is a six-year old non-elite secondary school in Singapore, with many students coming from non-English speaking homes. The principal was described as leading by example and believing in empowering teachers. To quickly establish its name in the neighbourhood, the principal thought that he needed to quickly get it strong in ICT. Not wanting to push too hard, he did not expect the school to be strong in academic results too. Along this direction, the principal viewed ICT mainly as an info-communication tool to help students in terms of building up confidence and language skills. These were realized in the cases of co-curricular activities, where pupils were taught how to create a film in a studio, and how to organize news broadcasting programs. While teachers in general acknowledged the importance of exploratory learning, technological innovations were largely uncoupled with pedagogical innovations. In classroom practices, ICT had fair impact on changing the curriculum content and process, and ICT was mainly used as a teaching tool, and a tool for self-learning and in E-learning. This description is particularly apt for the English lesson, in which students seemed to use the technological innovation for the sake of using it. It was because before the pupils were instructed to use the mind-mapping tool to organize their thoughts of the story in the English lesson, they already worked out their mind map using pen and paper yesterday. Although the English teacher thought that the mind-mapping tool had the visual impact of keeping the pupils on task, she admitted that actually it was of no difference with putting the task on paper in terms of depth of learning. For the Mathematics and Physics lessons, technological innovations served as a tool for teaching rather than a tool for learning. The teachers supplemented their PowerPoint presentations with relevant software items that were illustrative of the concepts being taught. However, the pupils were not engaging in any exploratory activities or collaborative tasks. There was little evidence of active learning among the majority of pupils, yet some pupils were eager to ask questions, and a few were able to argue against teacher's assertion. The situation in the Geography lesson was slightly different, in which pupils were given opportunities to think and make decisions in playing a software game. The Geography teacher described himself as slowly moving towards a student-centred approach of teaching and learning. In general, the teachers strived for improvement in pedagogical practices towards a student-centred approach, but they faced the constraints of time and of public examinations. In addition, technological innovations and pedagogical innovations were viewed as two separate issues with no direct connection. Curriculum and instructional approach came first and ICT was seen as secondary. Teachers were given a high level of autonomy in using ICT in classroom practices, with the principal's support and encouragement in the background. There was no explicit monitoring on using ICT, and the principal also allowed departments and teachers to follow their own pace. The autonomy served as a motivating force in fostering a climate for collaboration and experimentation. Tapping on the culture of collaboration and experimentation, a minority of teachers opened their mind about the theory of constructivism and saw the need to integrate pedagogical innovations with technological innovations. However, the resistance to change arising from pedagogical dilemma was also relatively high.

SGS2 is an elite secondary school in Singapore with a long history of over 100 years. As an independent school funded by the government, the principal is flexible in allowing adjustments in curriculum, instruction and assessment in keeping with the school vision. Accordingly, the school had much room to adopt pedagogical innovations in nurturing pupils (representing the top 3% of primary leavers) to be thinkers and leaders. The principal was able to keep a shared vision, and to identify what exactly were the important issues out of a lot of noises. She described herself as being tolerant and flexible in allowing adjustments as long as the innovations adopted was in line with the vision. The teachers in general were strong supporters of student-centred learning, and were willing to give pupils the avenue to explore and stimulate higher order thinking. The school-wide implementation of pedagogical innovations (e.g. Understanding by Design and Macro Concept) served as a main driving force for change, and made teachers more selective in their pedagogy in order to facilitate student-centred learning. “Understanding by Design” was a holistic approach to planning lesson backwards, and “Macro Concept” provided teachers with a theoretical basis for transferring learning output into macro concepts. ICT was not a very critical tool to transform teaching and learning in classroom practices, though it had the potential to do so. Focusing on implementing the school-wide pedagogical innovations, teachers viewed technological innovations as a good resource in helping design more student-centred activity to facilitate discovery learning. ICT was used only when teachers think it was feasible. In the four lessons we observed, all teachers used exploratory learning in addition to exposition, and the pupils were given many opportunities to explore the subject matter and to solve the problems collaboratively. The pupils were very independent and always initiated questions, and most of them were also actively engaged in discussions. The role of technological innovations was more prominent in the Physics and Geography lessons, in which the web and applet applications acted as a good resource to support exploratory activities designed by teachers. On the other hand, the PowerPoint presentation and the videos used in the English and Mathematics lesson seemed to act only as a visual aid to motivate pupils. Stressing a lot on critical thinking and creativity, the school was very supportive about not just using ICT but using ICT in a cognitive-wise way. Teachers were given a fair amount of autonomy to implement the school-wide pedagogical innovations. There was no mandatory policy in terms of ICT use, but teachers were encouraged to attend ICT training courses provided by the school and outside. The school has established a very strong culture in innovations and pursuing excellence. The teachers in general were very open-minded to pedagogical innovations through international networks (e.g. attending conferences, joining international education organisations, and going on visits).

Cross-case analysis: emergence of ICT implementation strategies

In the process of identifying specific patterns common to the eight schools through a case-oriented approach, the strategies for implementing ICT may be technologically or pedagogically driven, and of a balanced or an uncoupled type. The emerging patterns of interaction direct us to the crucial relationships between technological and pedagogical innovations.

Technologically driven strategies

Both HKS1 and SGP1 belong to what we term “technologically driven schools” (Figure 2). In these schools, technological innovations have created the needs to learn new pedagogies among teachers. Nevertheless, neither the technological nor the pedagogical innovations had prominent impact on shifting teaching and learning towards a student-centred approach. Apart from introducing technological innovations into the school, the principal in SGP1 also served as the main impetus in terms of building a climate for collaboration and experimentation. In the case of HKS1, the climate was built more spontaneously among teachers with the assistance of technological innovations. Although technological innovations have fostered pedagogical innovations in these schools, ICT mainly acts as a visual tool in making learning a more interesting and focused experience. This was partly due to the strong resistance to change arising from relevant pedagogical dilemmas in terms of balancing between the public examinations and alternative approaches to learning within the tight study schedule. However, both schools attempted to integrate technology into pedagogical innovations in producing new and worthwhile learning experiences, by introducing level-wide special programmes (e.g. multidisciplinary project work).

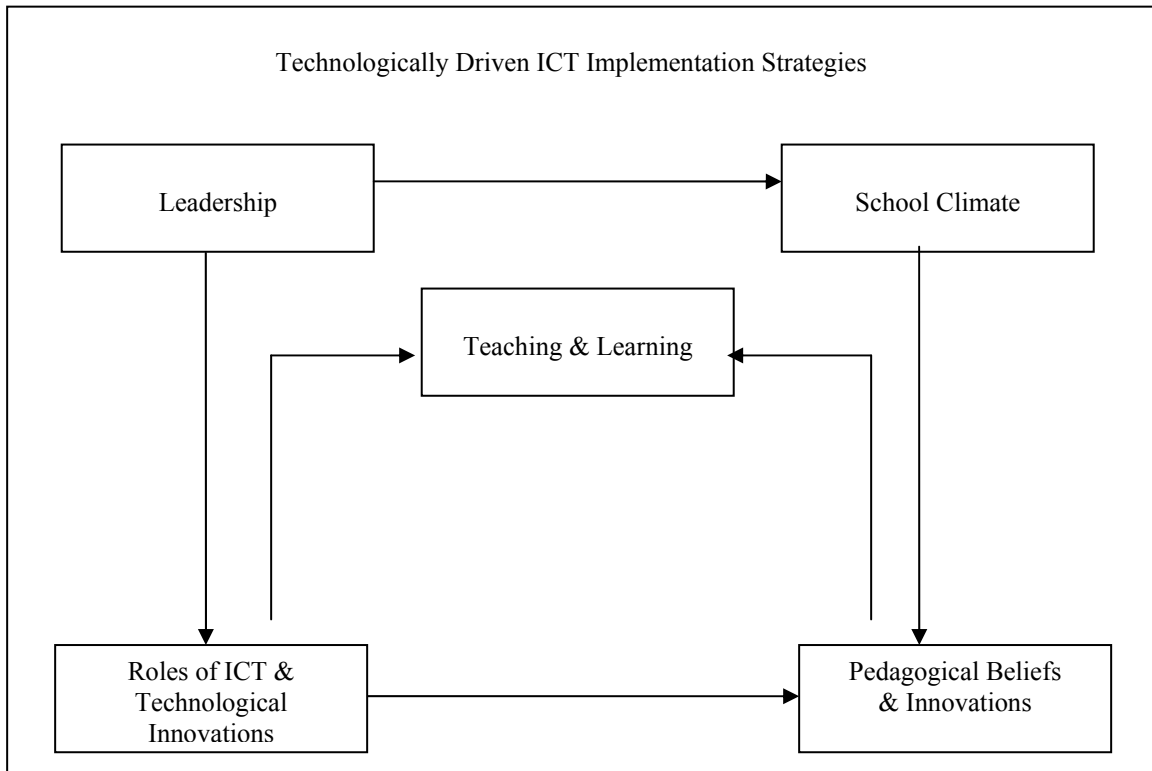


Figure 2. Emergence of technologically driven ICT implementation strategies and their impact on teaching and learning

Pedagogically driven strategies

The ICT implementation strategies emerged from HKP1 and SGS2 are pedagogically driven (Figure 3). In these schools, pedagogical innovations have created the needs to use technological innovations among teachers. In terms of the impact on teaching and learning, pedagogical innovations assume a leading role, and technological innovations are not critical in reshaping the delivery of instruction. Although both schools are pedagogically driven, the impact on teaching and learning turn out to be rather different. ICT mainly acts as a visual tool to make learning more interesting in HKP1; but it serves as a useful resource for designing student-centred activities in SGS2. Such differences might be attributed to the fundamental conditions of implementing pedagogical innovations in the two schools. In HKP1, the teachers in general were quite sceptical about inquiry and collaborative learning, which put more pressure on time. In attempting to achieve a shift in teaching and learning, the principal introduced some school-wide pedagogical innovations, such as thematic approach and project-based learning, to create the needs to use technological innovations among teachers. However, with formative assessment and traditional instructional strategies still in place, some teachers seemed to be rather resistant to the school-wide pedagogical innovations. As a consequence, the pedagogical innovations did not lend its support from technological innovations. ICT by and large simply acts as a visual and presentation tool. By contrast, in SGS2, the teachers in general were very supportive and open to the student-centred learning approach, and the principal introduced school-wide pedagogical innovations, such as “Understanding by Design”, to support curriculum instruction. With an established coherence in curriculum, assessment and instruction, pedagogical innovations assume a leading role in creating new learning experiences in classroom practices, to which technological innovations are complementary.

Balanced strategies

The ICT implementation strategies emerged from HKP2, HKS2 and SGP2 belong to the balanced type, in which technology is integrated into pedagogical innovations to create new learning experiences (Figure 4). Notably, HKP2 and SGP2 share similar patterns of interaction. With the mandatory policies (e.g. classroom observations and regular

sharing) in place, the principal in HKP2 and SGP2 strove to build a climate for collaboration and experimentation among teachers. Apart from shaping teachers' pedagogical belief, the climate for collaboration and experimentation also served as a positive pressure for continuous improvement in integrating technology into pedagogical innovations (ICT-pedagogical innovations). As for HKS2, although the principal took the lead to bring in pedagogical innovations, the climate for collaboration and experimentation naturally evolved from the teachers' experience of using ICT, with only partial intervention from the leader. With a marked degree of autonomy and flexibility in their instructional approaches and use of ICT, some teachers were able to integrate technology into pedagogical innovations to reshape the delivery of instruction.

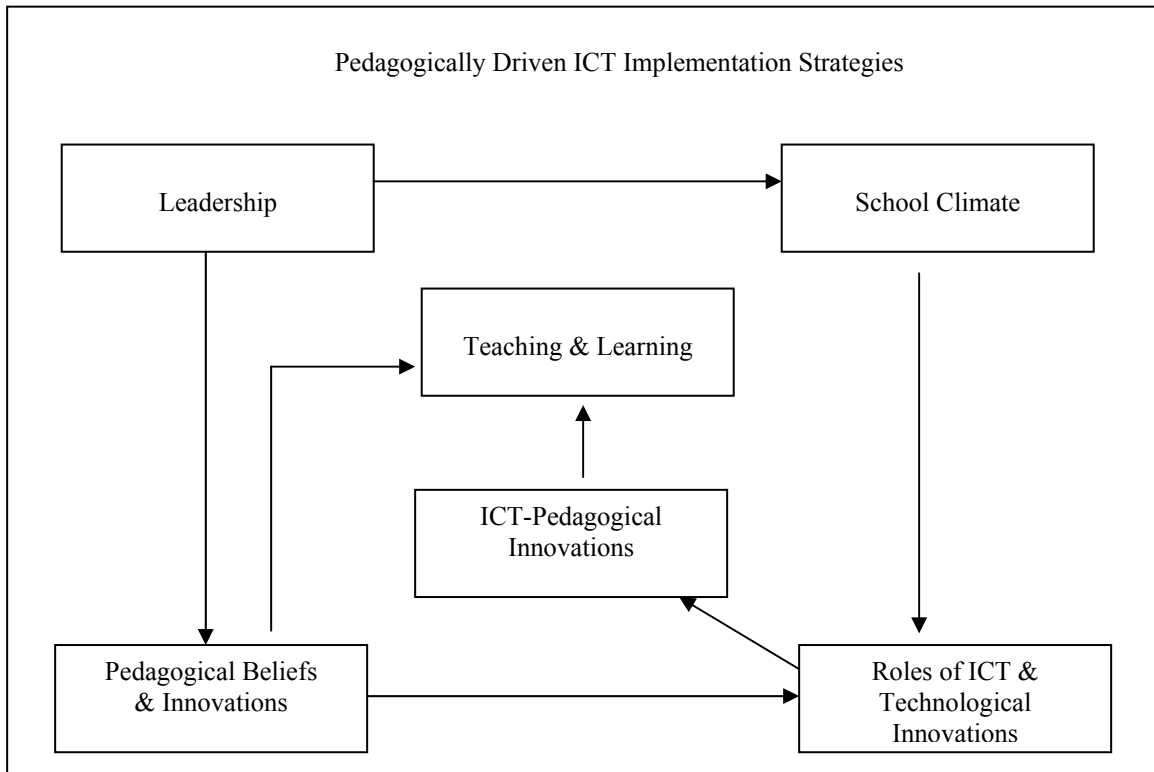


Figure 3. Emergence of pedagogically driven ICT implementation strategies and their impact on teaching and learning

Uncoupled strategies

The technological innovations are uncoupled with pedagogical innovations in SGS1 (Figure 5). Technological and pedagogical innovations have functioned along two separate lines in affecting teaching and learning. Although the drive for change was adequate, the resistance to change was equally high. Accordingly, neither the technological nor the pedagogical innovations has made any prominent impact on shifting teaching and learning towards a student-centred approach. In an encouraging and tolerant climate, the teachers were allowed to progress at their own pace in using ICT in teaching and learning. The principal considers ICT as an info-communication tool to facilitate learning. Along this direction, technological innovations have flourished in co-curricular activities in terms of building up communication and collaboration skills. Despite the lack of pressure in using ICT in teaching and learning, the support and encouragement from the principal, as well as the established collegiality, have acted as a motivating force in building a climate for collaboration and experimentation among teachers. Nevertheless, pedagogical innovations do not flourish against the resistance to pedagogical changes (e.g. inquiry learning) in connection with ICT. Such resistance is further amplified by the relatively lower academic competence of the pupils, as well as the time constraint in finishing the public examination content on the part of teachers.

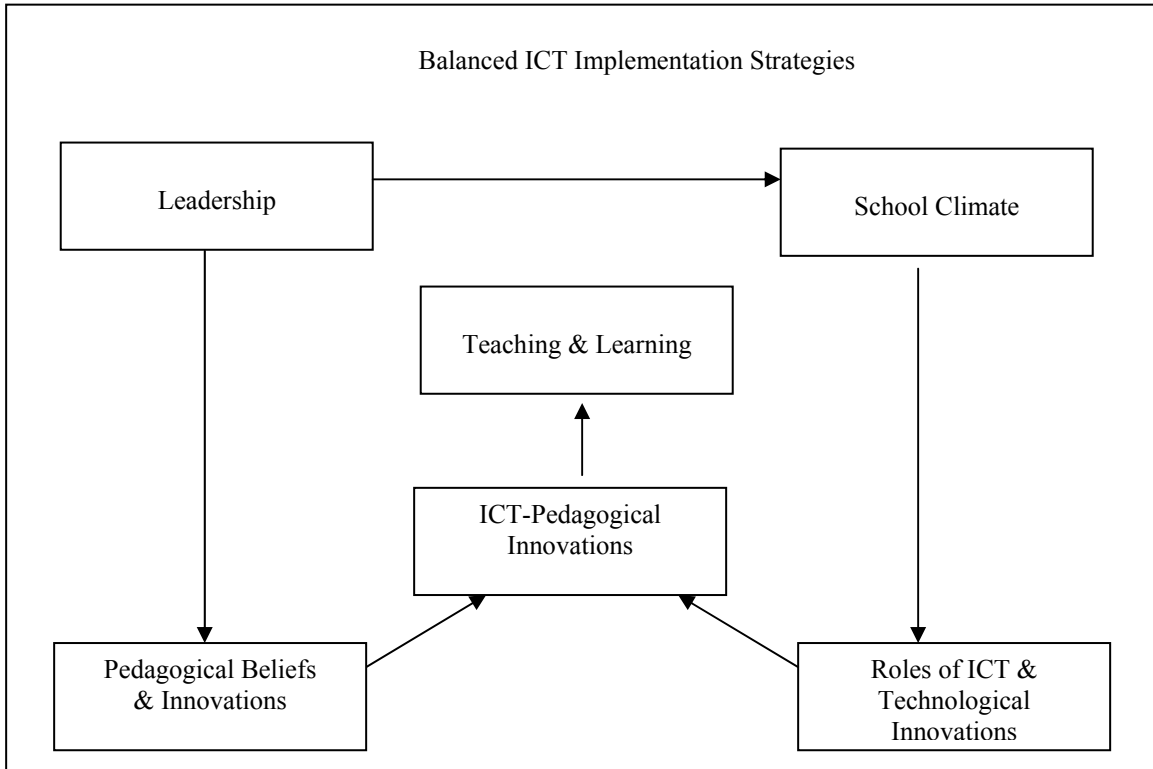


Figure 4. Emergence of balanced ICT implementation strategies and their impact on teaching and learning

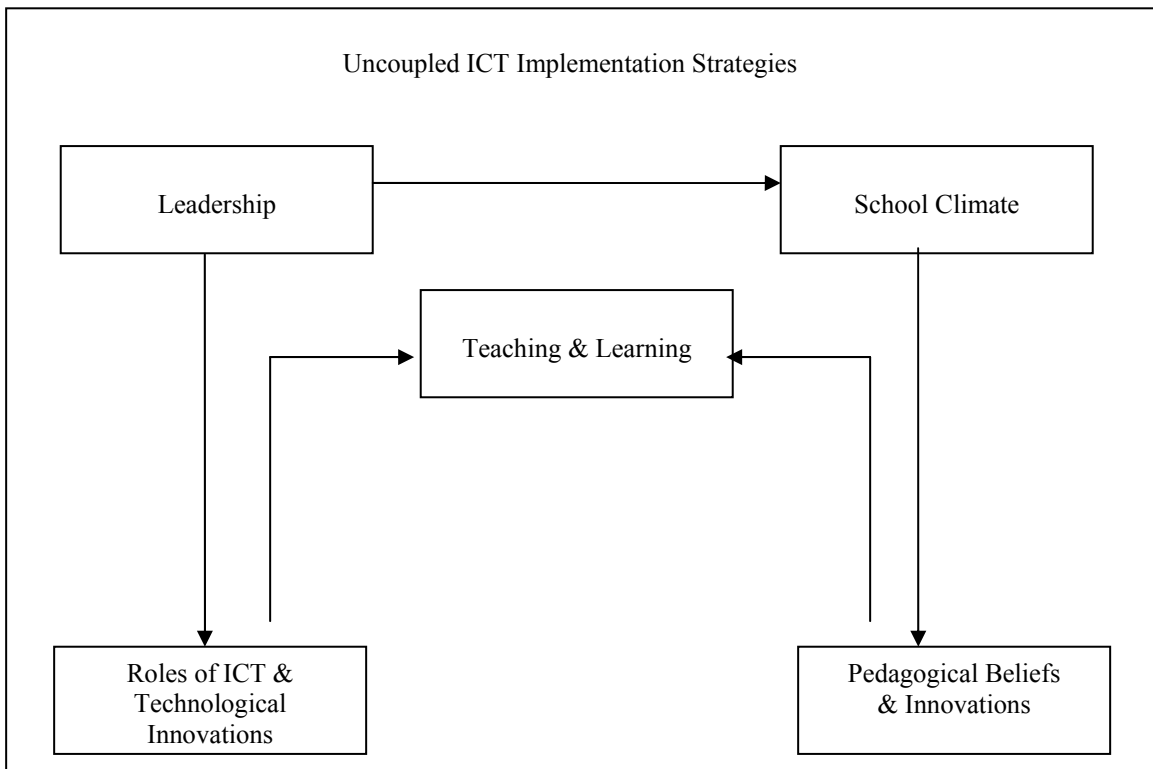


Figure 5. Emergence of uncoupled ICT implementation strategies and their impact on teaching and learning

Conclusions and implications

Table 2 summarizes the patterns of our findings for the eight case schools, from which we arrived to the following conclusions:

Impacts of ICT on classroom practices

The findings indicate that ICT has made a positive impact on changing the modes of teaching and learning in classroom practices from a teacher-centred approach to one that is student-centred, irrespective of region, school level, and type of school (HKP2, HKS2, SGP2 and SGS2). Yet, it may be argued that ICT has impacted on the modes of teaching and learning across all the case schools, if the analysis extended to out-of-class activities (e.g. extra-curricular/co-curricular activities and special programmes).

Pedagogical beliefs and roles of ICT

For those schools which have adopted a more student-centred pedagogical approach in classroom practices (HKP2, HKS2, SGP2, and SGS2), the teachers generally shared a vision on inquiry and collaborative learning. They also believed that ICT played an important role in transforming classroom practices with new learning experiences, except the case of SGS2, where most teachers attached high importance to pedagogical innovations. To the mind of these teachers, ICT was a useful resource for designing student-centred activities, but not a very critical tool to transform teaching and learning. Of the four schools without any important changes in classroom practices, the teachers in general acknowledged the benefits of inquiry and collaborative learning; but they were bounded by the tight study schedule in preparation for the public examinations. At the same time, very few of them recognised the important role of ICT in transforming classroom practices in terms of providing new learning experiences.

Emergence of ICT implementation strategies

Of the four kinds of ICT implementation strategies, those schools which have adopted balanced strategies (HKP2, HKS2, SGP2) all realize positive changes in classroom practices from a teacher-centred approach to a more student-centred one. On the other hand, those schools which have adopted technologically driven and uncoupled strategies all fail to bring about any changes in classroom practices. For those schools using pedagogically driven strategies, only the one which is stronger in pedagogical innovations could experience real changes in classroom practices (SGS2). It seems that the presence of ICT-pedagogical innovations is critical to creating genuine changes in classroom practices. Successful integration of technology into pedagogical innovations is obvious in schools adopting balanced strategies. For the case of SGS2 with the adoption of pedagogically driven strategies in the first place, the integration of technology into pedagogical innovations has proved to be possible.

Models of innovative classroom practices with ICT

Two models of innovative classroom practices mediated through ICT have emerged from the data: a balanced model and a pedagogically driven model. Those schools which have realized changes in classroom practices are characterised by ICT-pedagogical innovations. To make this happen, pedagogical innovations must be rooted in teachers' experiences of moving away from a teacher-centred approach to one that is more student-centred. Pedagogical innovations may come hand-in-hand with technological innovations (as in the case of balanced strategies); or pedagogical innovations may lend its support from technological innovations (as in the case of SGS2 adopting pedagogically driven strategies) to transform teaching and learning. The use of ICT supports exploratory activities designed by teachers, and facilitates pupils to construct knowledge collaboratively and to express ideas. On the other hand, without a good progress in pedagogical innovations, technological innovations alone do not suffice to bring about innovative classroom practices with ICT (as in the cases of technologically driven strategies and HKP1 adopting pedagogically driven strategies). Such findings have been consistent with previous research, which argued that it is impossible to talk of pedagogical integration of ICT without a good progress in pedagogical innovations (Karsenti, Brodeur, Deaudelin, Larose, & Tardif, 2002). From the models of innovative classroom practices with

ICT, leadership and the climate for collaboration and experimentation are two main factors that facilitate the integration of technology into pedagogical innovations. While transformational leadership has been studied a lot, this study has discovered that the role of transformational leadership could vary in the case of successful pedagogical integration of ICT. The role of the principal seems to be more prominent in the two innovative primary schools (HKP2 and SGP2), in which the leaders actively fostered a climate for collaboration and experimentation. For the case of the two innovative secondary schools (HKS2 and SGS2), despite the principals' leading role in pedagogical innovations, the climate for collaboration and experimentation was in fact the result of teacher collegiality within the established learning environment.

Table 2. A Summary of Findings for the Eight Case Schools

Categories	Sub-categories	HKP1	HKP2	HKS1	HKS2	SGP1	SGP2	SGS1	SGS2
School	History Level Type Region	42 years Primary Non-elite Hong Kong	7 years Primary Elite Hong Kong	7 years Secondary Non-elite Hong Kong	34 years Secondary Elite Hong Kong	80 years Primary Elite Singapore	6 years Primary Non-elite Singapore	6 years Secondary Non-elite Singapore	Over 100 years Secondary Elite Singapore
Leadership	Establishing shared vision, empowering teachers, supporting innovations	Strong in setting priorities, and willing to eliminate unnecessary work so as to create space for teachers.	A strong leadership who possesses clear vision and initiating a lot of innovations.	A facilitator for change but not an autocrat, ready to accept new ideas.	Taking the lead to bring in pedagogical innovations, and open to participative decision making.	Strong in setting directions and communicating visions, and holding on what she believes and pushing through. Encouraging, open-minded, welcoming innovations, and approachable.	A strong leadership who is very open to new ideas and support innovations. She is able to get hold of extra funding and tap on industrial sectors to get IT resources.	A facilitator for change, encouraging and supporting, ready to accept new ideas. Leads by example and believes in empowering teachers.	Able to keep a shared vision, and identify what exactly are the important issues out of a lot of noises. Tolerant and flexible in allowing adjustments.
Climate	Collaboration and experimentation	No clear evidence of jointly developing lesson plans.	Quality lesson plans enables collaboration and discussion, and peer classroom observation as a culture.	The process of learning to use the ICT innovations has maintained an ICT learning culture that fosters collaboration and experimentation among teachers.	Action research and pilot studies enable collaboration and resources sharing among teachers.	Top-down policy to create the climate for collaboration: Compulsory weekly IT training sessions, monthly level team meeting, yearly learning festival, and buddy system.	Top-down policy to create the climate for collaboration: Compulsory policy of sharing (weekly whole-school based, and monthly level-based).	The principal has given a lot of autonomy to teachers, which serves as a motivating force in fostering a climate for collaboration and experimentation.	Top-down policy of implementing school-wide pedagogical innovations has created a strong culture in innovating and striving for improvement.
Pedagogical beliefs & innovations	Student-centred pedagogy	Teachers are quite sceptical about the inquiry and collaborative modes of learning as they put more pressure on time.	The team of young teachers has only a few years' teaching experience. They have a shared vision on inquiry approach and student-centred learning, and their readiness to change is relatively high.	Teachers in general acknowledge the benefit of student-centred pedagogical approach, but they are still bound by time constraints in finishing the public examination content.	While teachers in general have a prudent attitude in trying out innovations, they are still ready to follow a relatively secure but concrete path to foster inquiry learning and student-centred learning.	Having a major concern on consolidating students' knowledge, teachers in general have no consensus on the inquiry and collaborative modes of learning.	Teacher's readiness to change is relatively high, and teachers in general have a shared vision on exploratory learning, critical thinking, and problem solving.	Teachers in general strive for improvement in pedagogical practices, but they are still bound by time constraints in finishing the public examination content.	Teachers in general are very supportive to constructivist learning, and are willing to give students the avenue to explore and stimulate higher order thinking.
	Pedagogical Innovations	Thematic learning with infusion of generic skills	Each year several topics will be selected for development of quality lesson plans	Block-timetabling for a short period of time for multi-disciplinary project work	Multi-disciplinary projects (with scaffolding like mind-mapping), and TARGET approach.	Multi-disciplinary project work with performance assessment, IT composing music, and emailing kids abroad.	Human Dynamics (a bottom-up suggestion from teachers)	News broadcasting program, and film production in a studio.	Understanding by Design and Macro Concept

Teaching and learning	Instructional strategies	Exposition as the main instructional strategy	Exposition as the major instructional strategy	Exposition as the major instructional strategy	Exploratory learning combined with exposition	Exposition as the major instructional strategy	Non-traditional teaching strategies catering for a variety of learning styles	Exposition as the major instructional strategy	Exploratory learning in addition to exposition
	Student-centred approach	Typically teacher-driven	Pupils are provided with time and resources to explore the subject matters on their own	Pupils become passive recipients of information, and participation is restricted to answering questions.	Pupils are given many opportunities to explore the subject matter, and to solve problems collaboratively.	Largely teacher-driven, with occasional changes for small group discussions.	Pupils are offered ample opportunities to make choices, explore, and have group discussions.	Little evidence of active learning among the majority of pupils.	Pupils were given many opportunities to explore the subject matter and solve problems collaboratively.
Roles of ICT & technological innovations	Roles of ICT	ICT acts as a tool to support teaching and learning. Curriculum comes first and ICT is secondary.	ICT acts as a good resource to support exploratory activities designed by teachers.	ICT acts as a tool to support teaching and learning, mainly as a visual tool in making learning more focused.	ICT acts as a good resource to support exploratory activities designed by teachers.	ICT mainly as a visual tool in making learning more interesting and in making student evaluation more efficient.	ICT acts as a good resource to support exploratory activities designed by teachers.	ICT is mainly used as a tool for self-learning and in E-learning. ICT and enquiry learning are viewed as two separate issues with no direct connection.	ICT is not a very critical tool to transform teaching and learning, though it has the potential to do so. ICT is used only when teachers think it is feasible.
	Technological innovations	PowerPoint	Websites and Excel.	PowerPoint and relevant software	PowerPoint, videos, relevant software, and websites.	CD-ROMs and websites	Wireless LAN, thinking map, websites, PowerPoint.	Mind-mapping tool, PowerPoint, relevant software.	Websites, applet applications, PowerPoint, videos.
ICT-Pedagogical innovations		No	Yes	No	Yes	No	Yes	No	Yes
Findings	Modes of change as a result of relating the categories	As the resistance to using ICT is very high, the principal has shifted the school's focus to curriculum reform. In fostering pedagogical innovations, the curriculum reform has created the need to use ICT in teaching and learning.	Fostering a climate for collaboration and experimentation among teachers through a compulsory policy of "quality lesson plans", some teachers have moved beyond using ICT as a teaching and learning aid, and able to integrate ICT with pedagogical innovations to reshape the delivery of instruction.	Technological innovations have fostered pedagogical innovations. Whenever new technologies are introduced into the school, training will be provided for teachers, which have nurtured a culture of learning among teachers.	With a marked degree of autonomy and flexibility, some teachers have moved beyond using ICT as a teaching and learning aid, and able to integrate ICT with pedagogical innovations to reshape the delivery of instruction.	Technological innovations have fostered limited pedagogical innovations in the form of special programs at the school level. In these programs, ICT provides new learning experiences for students: critical thinking and collaboration.	The mandatory policy of videotaping teachers' lessons has also served as a positive pressure for continuous improvement in pedagogical innovations with ICT use.	The autonomy enjoyed by teachers serves as a motivating force to foster change, and a minority of teachers have opened their mind about the theory of constructivism and have seen the need to integrate pedagogical innovations with technological innovations.	Having flexibility in curriculum design and assessment, the school has much room to adopt pedagogical innovations. Pedagogical innovations assume a leading role, and ICT is complementary in reshaping the delivery of instruction.

Limitations

With the purpose of gaining insight into the implementation of ICT at school and classroom levels, the recruited sample population represents schools that have demonstrated positive changes in teaching and learning as a consequence of using ICT. In this exploration, the relevance of our case studies should be understood as illustrative rather than definitive. Admittedly, more research will be needed to shed light on the larger pictures in Hong Kong and Singapore. The claim, however, rests on the overall consistency in the school-specific findings across the data sources. A consistent pattern with small samples of data cumulatively indicates a wider general tendency. The general perspective indicated by our approach to the empirical problem may reveal underlying processes for future interpretations.

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