

Information Communication Technology

9

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Abstract

This chapter consists of the narratives of two principals in Singapore on how they had interpreted and communicated Information and Communication Technology (ICT) policies to their teachers, and how they had helped their teachers to design and introduce ICT activities and programmes in their classrooms. As the process of globalization and technological advancement has brought tremendous changes in Singapore, the Singapore government launched the first ICT Masterplan in 1997 with the aim to equip Singaporean students with the necessary skills and dispositions pertaining to ICT so that they are able to thrive in this ICT rich global economy. In order to strengthen this ICT initiative, the technological pedagogical content knowledge (TPACK) was adopted and introduced as a framework to Singapore schools to help educators build the necessary knowledge and skills to facilitate ICT integration in school (Koh et al. 2015). The TPACK contains three basic forms of knowledge, namely the technological knowledge, pedagogical knowledge and content knowledge and in order for TPACK to be successfully operationalized in school, school leaders need to ensure that the vision and philosophy, curriculum, professional learning, infrastructure and resources, communication and partnerships and research and development are provided for in their schools.

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9.1 Introduction

In this chapter, the narratives of two principals have been drawn to understand how Information and Communication Technology (ICT) policies have been translated and operationalized in schools in response to global change. The evolution of globalization as a phenomenon has definitely brought tremendous changes in Singapore, particularly the adoption of technology on students' learning. The government believes that it is important to harness technology so that Singapore will be able to stay ahead in the global economy. For example, in order to attract foreign investments in Singapore, there has been a strong emphasis on the need to strengthen and enhance technological capacity (Budget 2017: *Response by*, 2017).

To achieve this aim, the Ministry of Education (MOE) took on the responsibility to better develop these skills by ensuring that the education system was restructured and moved towards embracing ICT at all levels in schools. In response to this new demand, the first ICT Masterplan was launched in 1997 to transform Singapore into an information hub (Koh and Lee 2008). This was to prepare Singaporeans to perform effectively in the IT-enriched economy through the extensive use of advanced technologies so that they will acquire the necessary skills and dispositions pertaining to ICT. Besides schools, the government has been investing in ICT infrastructure and transforming the country into a "Smart Nation". More recently, in 2014 the government announced that it will be investing S\$500 million in the ICT for Productivity and Growth Programme (IPG) over the next three years so as "to accelerate the adoption of ICT solutions among SMEs [Small and Medium Enterprises] and boost SMEs' productivity and growth" (IDA 2014). The aim is to enhance the use of technology by providing the resources for businesses to be more innovative in embracing technology to increase productivity. The swift response by the Singapore government to the demands of the fast-moving IT industry is resulting in part to its highly centralized approach in running the country since it gained independence in 1965. The MOE similarly adopts a combination of a centralized and school-based autonomy approach in managing the education system. Its main role of MOE is to formulate and implement "education policies on education structure, curriculum, pedagogy, and assessment" and oversee "the management and development of Government-funded schools, and the Institute of Technical Education, polytechnics and universities" (MOE Singapore 2017).

9.2 ICT Masterplan in Singapore—Phases One to Four

To maintain a world-class workforce, the government ensures that education in Singapore keeps pace with advances in technology. This is because the current knowledge-driven economy requires innovative workers who are able to create new products and services, often with the help of the latest technology (O'Shea 1999). As technology is a key driver of development, the MOE introduced the first Information and Communications Technology Masterplan (ICT Masterplan 1) in 1997 as a form of investment to prepare Singaporean students for the twenty-first century. The underlying philosophy of the ICT Masterplan is to ensure

that Singapore education prepares its students to meet the future needs of society. In order to strengthen the ICT Masterplan, the government also introduced the concept of *Thinking Schools, Learning Nation* (TSLN) in the same year with the aim to ensure that the education system is geared towards the needs of the twenty-first century (MOE: About us 2017). These changes in the education system were to “reshape and restructure the Singapore society in the interest of nation-building” (Yip et al. 1997, p. 4). TSLN was conceived as a means to increase the country’s productivity by creating a total learning environment that allowed students to become active learners. By doing so, it sought to develop the creative and critical thinking skills of students, and to equip them with the desired technological skills needed for the future development of the country (Chua 2006).

The second phase (ICT Masterplan 2) lasted from 2003 to 2008. It focused on strengthening the use of ICT by integrating it into the curriculum. Its aim was to build on the technology infrastructure provided in phase one and transform students’ learning experience by enhancing critical and creative thinking. To complement the integration of ICT in schools, MOE introduced five future schools in 2007 (*FutureSchools@Singapore*) to lead in innovative teaching methods and engaging lessons (MOE 2007). This extended to eight future schools in 2011 (Yang 2016). These schools were intended to prototype what future schools would look like. Unlike conventional schools, these pioneering schools are picked “as test beds for the use of educational technology, are according to the MOE, “trailblazers” in engaging in information and communications technology (ICT) projects” (Yang 2016). In addition to these future schools, the government also introduced the *Teach Less, Learn More* (TLLM) initiative to give mainstream students more time to learn, integrate and apply what they have learned in schools to real-life situations, and this initiative also involved the use of IT in schools (Chua 2006). The third phase was from 2009 to 2014. ICT Masterplan 3 built on the first two phases and focused extensively on the integration of ICT into school curriculum with the aim to cultivate twenty-first-century skills, particularly self-directed and collaborative learning and critical thinking skills. There were four goals for this phase: (1) Strengthen competencies for self-directed learning; (2) Customize learning; (3) Deepen learning; and (4) Expand learning beyond classroom (Info-communications Media Development Authority 2018).

In addition, school leaders were given greater autonomy to create ICT supportive environment that would enable teachers to innovate, share and improve innovative teaching pedagogies in the use of ICT (MOE 2008). The ICT Masterplan has moved into its fourth phase in 2015. Building on the previous Masterplans, the fourth ICT Masterplan tasks school leaders as culture builders and teachers as designers. It focuses on creating a new culture of teaching and learning for the twenty-first century with the emphasis on subject mastery and responsible use of technology. Greater emphasis has been placed on providing more learning space and opportunity to allow students to have greater access to digital teaching and learning resources. Schools are further encouraged to be more innovative in harnessing technology on teaching pedagogies so as to provide high-quality teaching and learning experiences for all students regardless of their academic background (Ng 2014).

9.3 The Translation of ICT Policy from Macro to Micro Level

Effective policy implementation becomes critical because inconsistency in macro and micro planning can result in undesired policy outcomes. Policy communication can take many forms (Fowler 2013); it can be written, expressed from ministry to principals and principals to teachers, or it can be communicated in group settings such as in the annual Work Plan Seminar during which the Minister of Education will give his annual speech on the ministry's plans for education. The transmission of policy message across multiple levels of the school system depends on how education policy is communicated and disseminated to individuals by the ministry at the macro level and the principals to the teachers at the micro level. In view of this, the role of the school leader is critical because s/he will have to go through a process of unpacking, understanding and interpreting these ICT policies before communicating it to the rest of the staff (Spillane et al. 2002; Klein 2001; Weick 1995). Thus, communications between the principal and teachers will help determine the outcomes of ICT policies.

Clemons and McBeth (2008) defined implementation as a series of “organizational activities directed towards the carrying out of an adopted policy by administrative bureaucracies at the nation, state, and local levels” (p. 79). Transferring this definition to ICT policy implementation, this means that there will be a series of activities that are communicated to schools. Principals will then have to engage teachers, and to provide the support needed to bring about school-related ICT programmes (Schneider and Hollenczer 2006). The translation from school principals to teachers is usually done through the middle leaders such as department heads who are usually the content subject specialists in their respective departments. They would then look into how best ICT can be integrated in the curriculum along with the appropriate support. Between MOE and school principals, cluster superintendents also have a part in monitoring and supporting the implementation of ICT in schools as part and parcel of their role in terms of providing supervisory oversight to their respective cluster of schools.

9.4 Building Technological Pedagogical Content Knowledge (TPACK) Throughout the System

In response to the ICT macro policy, the technological pedagogical content knowledge (TPACK) (see Mishra and Koehler 2006; Chai et al. 2013) has recently emerged at the micro level as a framework that is frequently used to unpack the form of teachers' knowledge necessary for effective ICT integration to happen. The TPACK knowledge is dynamically constructed by researchers and teachers through design thinking by relating and synthesizing the three more basic forms of knowledge, namely the technological knowledge, pedagogical knowledge and content knowledge (Koh et al. 2015). While the three basic forms of knowledge

with pedagogical content knowledge (Shulman 1986) are foci of teacher education syllabi, technological pedagogical knowledge, technological content knowledge and TPACK require active sense-making by the teachers. It is also obvious that as technology changes rapidly and in a major way, TPACK has to be constantly redesigned. The design capacity of school teachers and leaders has hence draw attention from researchers (for example, see Boschman et al. 2015), and Tsai and Chai (2012) have identified that design capacity is the third-order barrier for ICT integration.

Chai et al. (2014) further argued that creating TPACK should not rest on the teachers alone. Rather, all educators should be creating TPACK in the forms of cultural knowledge, national policies, education technologies, school structures and lesson designs. In terms of the strategic dimensions that school leaders have to consider, Lim et al. (2011) have identified six aspects. They are vision and philosophy, curriculum, professional learning, infrastructure and resources, communication and partnerships and research and development. Principals, in particular, need to articulate an appropriate vision based on their school history, mission, current state of development, students' and teachers' profile. The vision needs to be co-owned by all stakeholders, and therefore the process of co-visioning needs to carefully consider all stakeholders' interest without compromising students' benefits. In order for the vision to be impactful, it should be intrinsically motivating to educators rather than extrinsically driven. Once the vision is soundly established, instructional leaders will need to translate it into desirable teaching and learning practices. In order to achieve this, it is critical for principals to communicate their school vision in a manner that gains trust rather than incites fears and fatigue. This would inevitably require professional learning to address a diversity of challenges and issues, such as the building of physical or organizational structure and resources; changing the beliefs and practices of teaching and learning, and building the design capacity of teachers (Tsai and Chai 2012). On top of that, leaders are encouraged to establish partnerships with others, especially with educators from higher education, as this will enable schools to stay in close contact with the latest development of pedagogical ideas. Lastly, research and development could be a much healthier and effective way to seek continuous improvement than evaluation and judgment. Essentially, school leaders are encouraged to be a knowledge creator, and ensure that the curriculum is generally constructivists oriented.

This chapter illustrates how two principals interpreted and communicated ICT policies to their staff, and together with their staff translated them into desired activities, practices and programmes for their schools. The narratives provide insight into how Singapore schools can support, empower and enable the development of ICT skills and competencies in the context of the modern classroom.

9.5 Method

The following section presents the findings drawn from two case studies of two mainstream schools. The two principals were purposively selected as both schools are renowned for their ICT integration both locally and internationally. The schools are Crown Secondary School and Aspire Primary School.¹ Both principals gave consent to the interviews for the purpose of explicating their experiences in school change. Two interviews were conducted for each principal; the first to gather the initial set of data while the second to provide the initial analysis for members checking, and to probe deeper in unclear areas. Each interview lasted for about an hour, and the data were analysed through inductive coding (Thomas 2006). The findings, presented in narratives, show how each principal had interpreted and translated ICT policies into specific strategies and programmes, and how they had impacted teaching, learning and students' outcomes in their schools.

9.6 Crown Secondary School

Ms. Sinha² is a principal in a secondary school with students performing well academically at national examinations. The school believes in the use of technology to bring about engaged learning as a means to develop twenty-first-century competencies. The school has established an effective 1:1 computing programme. The staff use technology extensively and ICT has become an integral part of the school's culture and identity. The narrative collected surfaced four key findings:

1. Technology as instrumental tool of education
2. ICT infused curriculum
3. A strong and innovative ICT culture
4. Working in teams

9.6.1 Technology as Instrumental Tool of Education

Ms. Sinha believes that technology is a critical component of education but it should not dominate or determine the education process. Instead, the school places a heavy emphasis on students' outcomes by adopting student-centred approaches in their teaching pedagogies. She explained that as with other mainstream government schools the primary focus is to ensure that students continue to perform well in the national examinations, in this case, the GCE "O" Levels examinations. To her,

¹The names of the schools have been changed to maintain confidentiality.

²The name of the principal has been changed to maintain confidentiality.

technological tools are merely one of the enablers that strengthen teaching pedagogies which in return will help the school to achieve better students' outcomes.

Considerations about the use of technology in schools and how effective technology can be in education cannot start with a discussion on technology. We always foreground what are the students' outcomes that we want to see and we always start with the big picture in mind. Technology should be used to serve these larger issues, and not dictate the direction of education.

Ms. Sinha stressed that the focus must be on the “big picture” and not on the technology itself. The “big picture” refers to the holistic development of the students; that they are to become excellent and well-balanced individuals. The “big picture” also includes the use of technology to develop twenty-first-century competencies and dispositions through the school's programmes.

As a result, the school does not have a specific ICT programme. Instead, it uses a wide array of ICT tools and students use these tools and applications to learn better.

Along with the instructional programmes, there is Character and Citizenship Education and undergirding all these would, of course, be the subject areas outcomes, the 'O' level exams and the associated outcomes for the new syllabuses. There are the character outcomes, which are difficult to measure and we don't want to measure that; and for our school we also put in 21st century competencies as student outcomes that we want to develop. So with that as the premises we then ask ourselves how that translates into the instructional programme, the CCE programme and how do we infuse the teaching of the 21st century competencies into the total curriculum.

Clearly, the school has put in much effort to realize its strategies for developing appropriate and effective ICT tools to enhance teaching and learning across the curriculum.

9.6.2 ICT Infused Curriculum

The staff is encouraged to infuse ICT into the curriculum. While Ms. Sinha refrains from prescribing specific pedagogies, she would constantly encourage staff to create engaging ICT lessons for students. This is in keeping with her conviction that the adoption of ICT in education should be to support, empower and enable educators to develop twenty-first century teaching pedagogies. The key is to ensure that ICT is used meaningfully and in a sustained manner by both teachers and students. Teachers are given a suite of pedagogies that they can choose from and build into their teaching packages with a view to achieving the desired student outcomes.

When ICT is properly infused, it should fade into the background. In traditional teaching nobody talks about the importance of the chalk board. Similarly, ICT should always be available and accessible to support teaching and learning. I worry if the teachers talk only about technology.

ICT resources such as broadband connectivity are readily available at the school. The challenge for Ms. Sinha is to ensure that ICT is infused in a meaningful way into the school's programmes and curriculum. How can teachers use ICT to make lessons more engaging and to bring about greater depth in learning as envisaged by the TLLM initiative? And learning, in this case, has to be understood broadly to include non-academic subjects and activities. Ms. Sinha always makes it a point to remind staff that "technology is not to improve academic achievements only. Technology use is for the development of attitudes and dispositions as well". This message reflects Ms. Sinha's belief that the appropriate dispositions and attitudes have to be cultivated in order for ICT to be successfully and extensively infused into the school curriculum. This change has to come from the teachers. Essentially, the teachers must believe in the value of using ICT as broad based tool for school improvement and student development.

An example of an innovative programme was the "Com Arts Program", a secondary one programme that seeks to integrate literature and English. The aim of the programme is to give opportunities for students to express themselves better in English and to build their confidence as effective communicators. The programme adopted the "Trail Shutter" Application, a free web-based toolkit.³ The toolkit allows for the integration of English lessons into out of school activities. It has features that enable teachers to design their own interactive mobile learning trails for the students and for students to design learning trails for one another. Besides speaking and literary skills, the programme also helps to advance students' creativity, authentic learning and appreciation of history, as well as their ability to use various literary devices. Students can be quite enthusiastic in the use of such software, and here too Ms. Sinha stresses that ICT should play a supporting role and not be the main focus in the learning experiences of students.

9.6.3 A Strong and Innovative ICT Culture

According to Schein (1992), culture is defined as organizational behaviour that has developed based on shared assumptions of the organization. This behaviour reflects the organization's values, norms, habits of thinking and of acting collectively or individually. In school, a positive and effective school culture is important in promoting teacher involvement and in implementing curriculum reforms that aim at school improvement.

The school is fortunate to have had a long runway in one to one computing. We started in 2003, so it's been 10-11 years. So the use of ICT has become a part of our culture.

Besides establishing the physical and technological infrastructure, creating a supportive culture is important in determining the success of the ICT policy. A positive culture encourages active collaborative work and the fruitful exchange of ideas

³Key features include animated 3D object, MCQ, fill-in-the-blanks- short answers, OneMap, chat, etc.

among teachers and students (Fullan 1993), and this will in return improve student learning. In Crown Secondary school, the principal places a strong commitment to establish a collaborative work culture among teachers and an open culture to innovation and new things.

Our school has also a very innovative technology development culture. So I have a very strong team of technology savvy teachers who are always scanning the environment to discover and try out new technologies. And when they find something appropriate they introduce other teachers to these innovations. Overtime we have accumulated many useful resources: some we developed in house and others are like free web tool materials.

According to Ms. Sinha, it is important that the principal takes the lead in setting the tone for the right approach to technology as a pedagogical and developmental tool, and to ensure that its pervasive applications all work to achieve the desired student outcomes. Together with the principal, a team of teachers has been formed to take the lead to constantly reinforce the importance of identifying and introducing up to date and relevant technologies to other teachers. Nonetheless, Ms. Sinha stressed that establishing such positive culture takes time.

Change management is never easy. But I think our teachers have gotten used to ask how can we do things better... that is a good sign of the kind of culture we seek to cultivate.

9.6.4 Working in Teams

Professional Learning Teams (PLTs) refers to collaborative teams of teachers who work together to engage in collective learning with the aim to improve their teaching. PLTs spend considerable time addressing students' learning needs to arrive at the best strategies to improve their students' learning. PLTs are basically "teacher initiated and teacher led" (Sather 2006, p. 2), and such team-based professional learning focus on "new practices and work together to advance improvements" (Sather 2006, p. 4). In this connection, Ms. Sinha said that in her school PLTs,

have to do with establishing a culture of professional development, and of collegiality, of sharing and of innovation, and of being able to engage in professional discourse on learning outcomes and how to get there.

To her, such interactions and professional discourses are important for teachers because the professional community promotes intellectual and professional development, which will then keep the teachers updated on new teaching pedagogies.

There is protected PD [Professional Development] time for team teaching and team design. We also make sure that there is communication across the teams. We have senior people who are in teams working and communicating with other teams.

Communication across teams is essential in ensuring the success of the ICT infused curriculum in Crown Secondary School. As there are programmes and projects that

involve the work of various teams, good communication and coordination helps to eliminate misunderstandings and to keep teachers focused on improving students' outcomes. Nonetheless, despite a strong ICT culture, there are still challenges in implementing ICT activities and programmes.

9.6.5 Challenges

Time Factor

Unlike the traditional drill and practice mode of teaching, the use of ICT as an effective pedagogical tool means that more time is needed for the teachers to design interactive lessons that encourage in-depth learning. In this regard, Ms. Sinha explained that,

Time is a major factor. It takes a lot more time to develop learning trials and set up all the different things. This adds to the workload of teachers, who have to make sure that they have covered the curriculum and syllabus. It also takes a little more time for the kids to learn the process of discovery and inquiry and to go on that process rather than following strict rules and procedures—A, B, C. This is it. Go and study. Do more worksheets and then come back.

Many of the ICT infused lessons require students to approach learning differently. Instead of merely absorbing knowledge, they are now expected to enquire, question and learn in a more indirect way. Ms. Sinha remarks that “*working with this approach is less efficient but actually if it is done properly, it will be more effective*”. These new approaches to learning also point to a further challenge; namely, teachers' competency.

Teacher's Competency

The tasks of teachers have evolved as twenty-first-century teaching requires twenty-first-century attitudes, skills and competencies. According to Darling-Hammond (2006): “Today's classroom call for teachers to prepare virtually all students for higher order thinking and performance skills once reserved to only a few” (p. 300). In keeping with this perspective, Ms. Sinha says,

The skills of teachers are quite crucial; the facilitation skills, the types of questions the teacher needs to be able to ask, the setup of the lessons, guiding the students. As we implement ICT, we have to be sure that the learning outcomes been achieved through the lesson and not in spite of the lesson, and that very much depend on the skills of the teachers. For this reason teacher professional development is crucial. And therefore it is important that the school provides resources to enable teachers to learn continually and to improve themselves.

The Issue of Sustainability

The incorporation of technology into the classroom is one of the most important challenges for educators today. It is not merely about the placement of hardware in the classrooms but rather about how teachers use ICT to facilitate learning (Lebaron et al. 2009). To further complicate this challenge, technology tends to become obsolete quickly. Teachers not only have to keep up to date with the latest technological developments, but they also need time to become effective users of these new technologies. Hence, the issue of sustainable technology must be addressed. Ms. Sinha is deeply aware of this challenge in the use of ICT: “once you put technology at the forefront, once you start using it, it becomes outdated”. Therefore her strategy for sustainability of ICT practices in Crown Secondary school is to establish partnerships with industries.

My teachers are teachers, they are not technological innovators, they are not programmers, they are also not agents for private companies who will be able to sell things, they are just teachers. So we work with the industry partners. They have the responsibility to sustain the software and to move forward with the technology. As for us, we focus on the use of technology.

9.7 Aspire Primary School

Mr. Wen⁴ was appointed the principal of Aspire Primary School seven years ago. Aspire Primary School is a school known for its strong academic performance, and is a popular school in its neighbourhood. The school aspires to be a leading school both in academic performance and in nurturing students’ twenty-first-century competencies. Through the collective effort of the school’s senior management team with inputs from researchers at the National Institute of Education, the school was able to obtain funding to equip primary 3 and 4 students with mobile computing devices. In addition, the school puts emphasis on the development of technological pedagogical content knowledge (TPACK, see Mishra and Koehler 2006) among its teachers through continuous professional development activities. Teachers at the school possess good knowledge and deep experiences of ICT integration. The narrative collected at Aspire Primary School surfaced five key findings:

1. Pervasive twenty-first-century learning.
2. Distributed leadership.
3. Redesigning curriculum.
4. Developing Teachers’ TPACK.
5. Leveraging on collaborative partnership.

⁴The name of the principal has been changed to maintain confidentiality.

9.7.1 Pervasive Twenty-First-Century Learning

Recognizing the socio-technological and cultural changes that have prevailed since the proliferation of computing devices, the principal stated that “with these changes teaching and learning cannot be done in the same way anymore.” Accordingly, Mr. Wen initiated strategic discussions with staff and collectively they reached consensus that the school should embark on fostering twenty-first-century competencies among students facilitated through mobile technologies for pervasive learning. In the principal’s words,

My role is to lead the key personnel, including the vice principals and the HODs (heads of department) to contextualize the MOE (ministry of education) 21st century competencies framework for our school. This involves looking at what we have in terms of technology capacity, manpower capital, and the students’ general learning and family profiles. We went through rounds of intensive discussion and we agree to focus on values and key 21st century competencies students need to have without compromising their foundational knowledge.

After setting the strategic direction of promoting values-driven twenty-first-century competencies, the school also set the basic standards for academic achievement in order not to compromise on students’ foundational knowledge. This approach, which is anchored on a values-based education, is both futuristic and pragmatic at the same time. Mr. Wen recognized the challenges teachers may face to design and implement twenty-first-century-oriented pedagogy while maintaining basic standard, but he did not think that the status quo would do justice to students’ educational needs. Neither would relaxing the demands of foundational knowledge or ethics be acceptable. It was recognized that twenty-first-century learning is about improving and innovating foundational knowledge with more knowledge creation-oriented pedagogies without compromising the ethical dimension. The school thus devoted its effort to resolve the tensions between foundational knowing, ethical values and twenty-first-century learning through design efforts described below.

9.7.2 Distributed Leadership

In order to create a culture of change in school, the principal and staff must work together; the responsibilities for change should not be borne by the principal alone, but shared among staff at all levels (Tyack and Tobin 1994). This is because the creation of an IT-rich environment will be extensive since it includes setting up the physical and technological infrastructure, restructuring curriculum and class time, innovating instructional and assessment practices. Such a major undertaking is well beyond what a single leader can hope to accomplish on his own. Distributed leadership at multiple levels is necessary and this has been reported to lead to organizational improvement (Harris and Spillane 2008). Mr. Wen played a leading role in the initial conceptualization of the overall strategic thrust, while staff contributions helped to improve and refine the strategic vision. In the actual

implementation, Mr. Wen liaised with external stakeholders, such as MOE, industry partners, parents and researchers from local as well as foreign institutions of higher education. His ability to establish good working relationships with these parties greatly facilitated the school improvement process. The vice principals, on the other hand, were responsible for setting up, monitoring and maintaining the school's technological infrastructure to ensure that learning "anytime and anywhere" would be a reality within the school compound. Each of the heads of the department took charge of one or two curriculum restructuring projects. Senior teachers of various subjects experimented with new pedagogies and coached their younger colleagues in the use of these pedagogies. One of the teachers who was tasked to lead the knowledge building (KB) project said,

Having to create new practices and procedures in my teaching, this is a rather drastic shift towards student-centered learning as part of 21CC skills. It takes a lot of getting used to especially relinquishing control of the students' everyday learning. A KB teacher is no longer a 'vessel' of knowledge to the students and requires a unique set of skills to manage the classroom in order to facilitate students' knowledge creation. In every lesson, students are required to use various KB principles in their research and discussion.

9.7.3 Redesigning Curriculum

As noted above, teachers face challenges when they attempt to shift the curriculum towards constructivist pedagogy. Windschitl (2002) has shown that there are at least four dimensions of change needed in such reform, most notably the conceptual and pedagogical dimensions. The conceptual dimension involves teachers' understanding of the philosophical, psychological and epistemological underpinnings of the innovative pedagogies they are engaged in; while the pedagogical dimension is about mastering the pedagogical skills needed for successful implementation. Mr. Wen recognizes these challenges and he has taken a design and redesign approach to address these needs. Recognizing that conducting workshops would only transmit basic knowledge, Mr. Wen is firmly of the view that instructional leaders should "get their hands dirty". According to Mr. Wen, "The types of teaching and learning we want must be developed in a knowledge creation context. The teachers have to at least contextualize the pedagogical models according to the profile of the students in our school...they have to learn through designing, implementing, redesigning so that they have deep understanding of the pedagogies and mastery of the relevant skills".

Mr. Wen helped put together teams of teachers and researchers to engage in long term projects to redesign the school's curriculum and pedagogy. For example, the primary three and four social studies programmes were redesigned to use the knowledge building approach (Scardamalia and Bereiter 2006) as a means to cultivate a deeper sense of national identity among students. The students were challenged to address questions such as "Is Singapore a good country? Why?" and "How can we achieve sustainable development?" The students were also taught

basic internet search skills and collaborative ways of speaking that focused on claims, evidence and warrants. A team of teachers together with a professor from the National Institute of Education took two years to develop a series of lesson plans and resource materials for the redesigned programmes. They are currently documenting the pedagogical skills enacted in the classrooms with a view to implementing this pedagogical approach to social studies across all levels. In science, the 5E models of inquiry (Bybee et al. 2006) were implemented with mobile phone applications, and the teachers redesigned all the lessons in primary three and four to create a seamless science curriculum. The English and Chinese language departments have also created whole level lesson plans to engage students in web-based and apps supported language learning. Such systemic and sustained change has helped to transform the school, and now the school is helping other schools to redesign and transform their curriculum.

9.7.4 Developing Teachers' TPACK

Mr. Wen engaged experts in TPACK to provide talks and conduct workshops, and subsequently implemented the TPACK framework for teachers to co-design ICT-based lessons.

The PD plan looks into the teacher's capacity building in three areas i.e. curriculum, pedagogy, and technical aspects. In delivering the PD to the teachers, we worked closely with Prof D (anonymous), the curriculum developer and the team of ICT support staff.

Given the diverse curriculum redesign work and the teachers' knowledge requirements, the TPACK framework was utilized to help teachers in active sense-making and designing of new lessons that were supported by technologies.

The TPACK framework draws on the intersection of three knowledge domains, namely, pedagogical content knowledge, technological pedagogical knowledge and technological content knowledge, to design pedagogically sound lessons supported by technology. The TPACK framework helps to activate various forms of teachers' knowledge such as their knowledge about students' learning difficulties about the subject matter (pedagogical content knowledge). It also guides teachers to search for possible solutions especially from technology-related knowledge domains (for example, see Koh and Chai 2014). To deepen the pedagogical transformation afforded by TPACK, the principal initiated a series of discussions on changing the school's standardized lesson planning template. The template was subsequently modified to help the teachers in developing their pedagogical methods and enhancing their use of technology.

These initiatives show clearly that the school is not focused on ICT for its own sake; rather its focus is on the pedagogical value that technology-based lessons would bring to build students' learning capacity and content mastery. Structured timetable for curriculum reform supported the creation of ICT integrated lessons. As a consequence of these reforms, teachers are now more aware of the possibilities

of transferring technological applications tested in one subject to another subject, and they are also learning to draw upon pedagogical methods used in one subject for the teaching of other subjects. For instance, teachers from the mathematics department formulated a series of lessons by adapting the 5E model from science as the pedagogical framework. The art teachers, on the other hand, having observed the discussion platform used for social studies realized that they could use the same platform to support students' ideation for their artwork. The principal welcome and encouraged such cross-disciplinary appropriation of teaching and learning strategies. Using TPACK as a framework for making sense of technology has also been manifested in many of the subject areas taught in the school.

9.7.5 Leveraging on Collaborative Partnership

The TPACK framework shows that creating new teaching and learning practices with technology involves multiple areas of expertise (i.e. technological/pedagogical/content knowledge and their intersections). Chai et al. (2014) have also shown that classroom-level TPACK creation is dependent on agents and events beyond the classroom. These include policy formulation at both national and school levels that determine the general technological and pedagogical vision, service providers for appropriate and timely technological solutions and parents for their understanding and support of new teaching and assessment initiatives. Mr. Wen's resourcefulness in locating and gaining supporters and collaborators from industry partners, university researchers as well as officers from MOE HQ is remarkable. As he says: "The world is changing so fast and school leaders have to recognize that it is necessary to collaborate. We simply do not have all the knowledge and resources that we need to innovate".

Meetings and workshops that involved the teachers, ministry officers, well-known researchers from both local and foreign universities, as well as top executives from the IT sector frequently take place in his school. Mr. Wen actively seeks a collaborative partnership that would enhance the school technological capacities, as well as the teachers' content and pedagogical capacities. The common goal of the school's partners and collaborators is to improve students' learning experiences. Several of the school's research projects have yielded published articles in international journals. These publications attest to the innovative pedagogies that have been successfully implemented in the school (see for example, Chai et al. 2016; Norris et al. 2011; Wong et al. 2011).

9.7.6 Challenges

The main challenges to school reform are well documented: teacher expertise, time and systemic issues such as the assessment regime. These challenges have been encountered in the school and there are ongoing refinements to school processes to address these challenges. In the case of Aspire Primary School, there is a further

challenge posed by working with multiple collaborators. Additional time and effort are needed to coordinate the activities of the various teams of collaborators. The interests and needs of collaborators may not be in sync all the time; therefore care and sensitivity are needed to resolve these tensions. In addition, many parents tend to be overly focused on academic results; for this reason, they may not fully understand and appreciate the school's efforts in innovating curriculum with technology (Hung et al. 2003). Deep engagement and effective communication with parents is necessary in these cases to assuage their anxieties.

9.8 Discussion and Conclusion

While the two case reports surface different ways between the two principals in describing their journey, the themes of their discourse are very similar. Their experiences have illustrated the need to plan and design appropriate actions based on the available resources of the schools in order to elicit the desired changes in the classroom. Their accounts reaffirmed Chai et al.'s (2014) perspective about the meso-level (local community and institution) design of TPACK that institution leaders need to perform. Both principals envisioned that education in an era where technology is changing rapidly needs to be reframed to foster students' twenty-first-century skills without compromising content mastery. Basically, they explored and drew on various financial resources to build the school infrastructure, and focused on developing teachers' capacity to integrate ICT. The dimensions that the principals focused are in line with Lim et al.'s (2011) account of the six aspects of strategic dimensions for institutional change. Nonetheless, the principals are also cognizant about the challenges that schools and teachers face, which correspond to Windschitl's (2002) observation.

Schools need to change and keep pace with technology advances. The educational landscape is growing more and more complex. The acronym volatile, uncertain, complex and ambiguous (VUCA) has been used to describe the environment that is taking shape in our midst. In such a context, school leaders will be constantly confronted by many perplexing challenges and dilemmas. The two principals seem to possess considerable qualities that have enabled them to navigate the complex terrain of the new educational landscape. As noted in this chapter, one outstanding quality they have in common is the clear vision they have on the use of ICT in advancing both the teaching and learning process. Although they are aware of the factors that can inhibit ICT integration in their schools such as insufficient time, they still hold positive attitudes towards ICT integration into the school's curriculum.

From the findings, both internal and external factors have been found to be significant in facilitating the ICT implementation process. The first internal factor is competent and distributed leadership (Harris and Spillane 2008; Hairon and Goh 2015). Together with their key personnel, the principals took the lead in interpreting the ministry's ICT policy prescriptions and adapting them to the school's context.

They also helped shape the framework that enabled their teachers to operationalize these prescriptions into specific activities in their respective schools. The principals worked closely with their department leaders to create an environment in which teachers were able to work freely and collaboratively with external partners to test out new ideas and innovations. In effect, the distribution of leadership went all the way down from the principal through the key personnel to teacher leaders (Hairon et al. 2015). Both principals are very clear about how ICT should be used in their schools without compromising their school's excellent academic standards. They both took the view that ICT should not dominate the teaching and learning process but used in appropriate ways to improve the teaching and learning process. The need to engage in school-based development and innovation without compromising academic rigour has been observed to be the current challenge for school leaders and teachers in the current Singapore education reform (Hairon and Dimmock 2012).

The second internal factor is the acceptance of the pedagogical uses of ICT by the teachers. Curriculum innovation will not happen if the teachers are unwilling to participate in the policy translation process (Fullan 2001). In both schools, the teachers are motivated to incorporate and use various innovative ICT programmes in their teaching pedagogies. As shown in both narratives, both principals have built a culture of collaboration among staff which has helped to enhance ICT integration into the school curriculum. A positive ICT culture reduces barriers to ICT integration.

Successful ICT integration in the school also depends on external factors, which include parental support, students' knowledge of ICT, and support from ICT industries. The vast majority of parents in these two schools are aware of the extensive use of ICT in schools and in their children's school work. At the same time, the schools have been successful in maintaining their good academic results, and this has reduced parents' resistance to the extensive use of ICT. In addition, the students are well equipped with basic ICT skills and this has made it easier for the teachers to incorporate technology into the curriculum. Lastly, both principals have been successful in garnering the support of external ICT vendors for the provision of resources and expertise. Such support helps to reduce the time teachers spend searching for appropriate ICT resources and in planning lessons. More importantly, industry support addresses the issue of sustainability; the industry will focus on maintaining and upgrading the software, while teachers concentrate on integrating technology into the curriculum.

The overall conclusion of the two narratives is that successful ICT integration in schools depends largely on school leadership. School leadership plays a critical role in understanding and interpreting the intentions of the ministry's ICT policies, before communicating them to the teachers. The principal's perceptions and beliefs regarding ICT policies will affect the teachers' perceptions of ICT policies as well as the development of the relevant competencies. Principal's actions in providing appropriate goals, distribution of roles and responsibilities to middle leaders and

teachers, and support structure form another form of communication to their school staff members, which would significantly impact the necessary changes to the curriculum and teaching practices. All of these would, in turn, will affect students' outcomes and outcomes of ICT policies.

9.9 Questions for Reflection and Discussion

1. What is your view about the role of ICT in education? Should it be transformative or merely instrumental? Why?
2. What are the differences in the perspectives of the two principals with respect to the infusion of ICT in the school curriculum, and how do these influence teaching and learning in their respective schools?
3. What other perspectives should one consider with regard to the use of ICT in education?
4. How can school leaders better build their capacity to envision the technological pedagogical culture of learning for all subject matter?
5. What further research questions need to be asked in matters of using technology in pedagogy in schools?

References

- Boschman, F., McKenney, S., & Voogt, J. (2015). Exploring teachers' use of TPACK in design talk: The collaborative design of technology-rich early literacy activities. *Computers & Education*, 82, 250–262.
- Budget 2017: Response by Minister for Communications and Information Dr Yaacob Ibrahim. (2007). Retrieved from: <https://www.gov.sg/microsites/budget2017/press-room/news/content/response-by-minister-for-communications-and-information-dr-yaacob-ibrahim>.
- Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, B. (2006). *The BSCS 5E instructional model: Origins and effectiveness*. Retrieved from https://bscs.org/sites/default/files/_media/about/downloads/BSCS_5E_Full_Report.pdf.
- Chai, C. S., Koh, J. H. L., & Tsai, C.-C. (2013). A review of technological pedagogical content knowledge. *Education Technology and Society*, 16(2), 31–51.
- Chai, C. S., Koh, E., Lim, C. P., & Tsai, C.-C. (2014). Deepening ICT integration through multilevel design of technological pedagogical content knowledge. *Journal of Computers in Education*, 1(1), 1–17.
- Chai, C. S., So, H.-J., Tsai, P.-S., Rohman, E., & Aw, I. L. P. (2016). Building epistemic repertoire among primary 3 students for social studies. In C. S. Chai, C. P. Lim, & C. M. Tan (Eds.), *Future learning in primary schools: A Singapore perspective* (pp. 109–128). Singapore: Springer.
- Chua, S. K. C. (2006). Singaporean education planning: Moving from the macro to the micro. *Current Issues in Language Planning*, 7(3), 214–229.
- Clemons, R. S., & McBeth, M. K. (2008). *Public policy praxis* (2nd ed.). NY: Pearson Longman.
- Darling-Hammond, L. (2006). Constructing 21st-century teacher education. *Journal of Teacher Education*, 57(3), 300–314.

- Fowler, F. C. (2013). *Policy studies for educational leaders* (4th ed.). USA: Pearson.
- Fullan, M. (1993). *Changing forces*. Bristol, PA: Falmer Press.
- Fullan, M. (2001). *The new meaning of educational change*. NY: Teachers College Press.
- Hairon, S., & Dimmock, C. (2012). Singapore schools and professional learning communities: Teacher professional development and school leadership in an Asian hierarchical system. *Educational Review*, 64(4), 405–424.
- Hairon, S., & Goh, J. W. P. (2015). Pursuing the elusive construct of distributed leadership: Is the search over? *Educational Management Administration and Leadership*, 43(5), 693–718.
- Hairon, S., Goh, J. W. P., & Chua, C. S. K. (2015). Teacher leadership enactment in PLC contexts: Towards a better understanding of the phenomenon. *School Leadership and Management*, 35(2), 163–182.
- Harris, A., & Spillane, J. (2008). Distributed leadership through the looking glass. *Management in Education*, 22(1), 31–34.
- Hung, D., Tan, S. C., & Chen, D.-T. (2003). IT integration and online learning in the Singapore schools. *Educational Technology*, 43(3), 37–45.
- Infocomm Development Authority of Singapore (IDA). (2014). *ICT for productivity and growth (IPG) programme*. Retrieved October 24, 2014, from <http://www.ida.gov.sg/Collaboration-and-Initiatives/Initiatives/Store/ICT-for-Productivity-and-Growth-IPG>.
- Info-communications Media Development Authority. (2018). *Singapore unveils third Masterplan for ICT in Education*. Retrieved March 28, 2018, from <https://www.imda.gov.sg/infocomm-and-media-news/buzz-central/2008/9/singapore-unveils-third-masterplan-for-ict-in-education>.
- Klein, G. (2001). The fiction of optimization. In G. Gigerenzer & R. Selton (Eds.), *Bounded rationality: The adaptive toolbox*. Cambridge, MA: MIT Press.
- Koh, J. H. L., & Chai, C. S. (2014). Characterizing TPACK transformations in the design of school-based pedagogical innovation. In C.-C. Liu, et al. (Eds.), *Proceedings of the 22nd International Conference on Computers in Education*. Japan: Asia-Pacific Society for Computers in Education.
- Koh, J. H. L., Chai, S. C., Wong, B., & Hong, H.-Y. (2015). Technological pedagogical content knowledge (TPACK) and design thinking: A framework to support ICT lesson design for 21st century learning. *The Asia-Pacific Education Researcher*, 24(3), 535–543.
- Koh, T. S., & Lee, S. C. (2008). Digital skills and education: Singapore's ICT master planning for the school sector. IN S. K. Lee, C. B. Goh, B. Fredriksen, & J. P. Tan (Eds.), *Toward a better future: Education and training for economic development in Singapore since 1965* (pp. 167–190). Washington, DC: The World Bank.
- Lebaron, J., Robinson, J. M., & McDonough, E. (2009, December 8). *Research report for Gessometa review of ICT in education phase two*. Retrieved on December 8, 2010 from <http://www.gesci.org/assets/files/Research/meta-researchphase2.pdf>.
- Lim, C. P., Chai, C. S., & Churchill, D. (2011). A framework for developing pre-service teachers' competencies in using technologies to enhance teaching and learning. *Education Media International*, 48(2), 60–83.
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017–1054.
- MOE: About us. (2017). Retrieved March 27, 2017, from: <https://www.moe.gov.sg/about>.
- MOE. (2007). *MOE selects first five futureschools@Singapore*. Retrieved September 20, 2014, from <http://www.moe.gov.sg/media/press/2007/pr20070522.htm>.
- MOE. (2008). *MOE launches third masterplan for ICT in education*. Retrieved September 19, 2014, from <http://www.moe.gov.sg/media/press/2008/08/moe-launches-third-masterplan.php>.
- Ng, K. (2014) Singapore education minister shares 4 principles on ICT use in education. Retrieved September 20, 2014, from <http://www.futuregov.asia/articles/2014/apr/10/singapore-education-minister-shares-4-principles-i>.
- Norris, C., Hossain, A., & Soloway, E. (2011). Using smartphones as essential tools for learning. *Educational Technology*, 18, 18–25.

- O'Shea, M. P. (1999). *Recognising the challenges of the new millennium: The changing face of art education in Singapore*. Paper presented at the Proceedings from the InSea 30th World Congress "Cultures and transitions", Brisbane Australia.
- Sather, S. (2006). Implementing professional learning teams. *Principal's Research Review: Supporting the Principal's Data-Driven Decisions*, 1(5). Retrieved September 30, 2014, from <http://www.nassp.org/portals/0/content/54161.pdf>.
- Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 97–115). New York, NY: Cambridge University Press.
- Schein, E. H. (1992). *Organizational culture and leadership* (2nd ed.). USA: Jossey-Bass Publishers.
- Schneider, E. J., & Hollenczer, L. L. (2006). *The principal's guide to manage communication*. Thousand Oaks, California: Corwin Press.
- Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4–14. <https://doi.org/10.3102/0013189x015002004>.
- Spillane, J. P., Diamond, J. B., Burch, P., Hallet, T., Jita, L., & Zoltners, J. (2002). Managing in the middle: School leaders and the enactment of accountability policy. *Educational Policy*, 16(5), 731–762.
- Thomas, D. R. (2006). A general inductive approach for analyzing qualitative evaluation data. *American Journal of Evaluation*, 27(2), 237–246.
- Tsai, C. C., & Chai, C. S. (2012). The “third”-order barrier for technology-integration instruction: Implications for teacher education. *Australasian Journal of Educational Technology*, 28(6), 1057–1060.
- Tyack, D., & Tobin, W. (1994). The ‘grammar’ of schooling: Why has it been so hard to change? *American Educational Research Journal*, 31(3), 453–479.
- Weick, K. (1995). *Sensemaking in organizations*. Sage Publications.
- Windschitl, M. (2002). Framing constructivism in practice as the negotiation of dilemmas: An analysis of the conceptual, pedagogical, cultural, and political challenges facing teachers. *Review of Educational Research*, 72(2), 131–175.
- Wong, L. H., Chen, W., Chai, C. S., Chin, C. K., & Gao, P. (2011). A blended collaborative writing approach for Chinese L2 primary school students. *Australasian Journal of Educational Technology*, 27(7), 1208–1226.
- Yang, C. (2016). Students, as digital natives, are more involved when technology is used in teaching, say educators. *The Straits Times*. Retrieved March 27, 2018, from <http://www.straitstimes.com/singapore/education/more-schools-tap-tech-tools-for-learning>.
- Yip, J. S. K., Eng, S. P., & Yap, J. Y. C. (1997). 25 years of education reform. In J. Tan, S. Gopinathan, & W. K. Ho (Eds.), *Education in Singapore: A book of readings* (pp. 4–32). Singapore: Prentice Hall.