

Two Decades of ICT Masterplans : A Comparison

Horn-Mun Chea, SIM University, Singapore
Laura Lynn LEE, Singapore

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Abstract

Since information and communication technologies (ICT) first came into popular use in the early 1990s, educational jurisdictions have been actively endeavouring to make meaningful use of ICT for teaching and learning. Quite often, these efforts were expressed in system-wide plans that aimed to enhance education. This paper will share some observations on the similarities and distinctiveness of the approaches across the four jurisdictions of Beijing, Hong Kong, Singapore and Taiwan. While these jurisdictions have broadly common foci, primarily in infrastructure build-up, curriculum reviews, teacher professional development and school leadership, both the balance of the plans' components as well as their implementation can differ in instructive ways, reflecting differing context. The paper will also summarise some main learning points from the recently concluded third ICT in Education masterplan in Singapore to give further depth to this comparison across the jurisdictions.

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Introduction

When ICT gained popularity in the early 1990s, countries worldwide began to step up the use of technology in their education systems. Many governments created programmes to integrate technology in schools on the belief that technology has the potential to transform education and improve student learning (Hew & Brush, 2007). This resulted in most national ICT policies focusing on the education sector (in Tondeur *et al.*, 2007).

Since the earlier initiatives in the mid- to late-90s, observed trends have shown a direct relationship between the application of ICTs and the changes in the teaching and environments of schools (in Nair & Hindle, 2013). As ICT capabilities advance, and more importantly, as understanding in the use of ICT in education deepens, the focus on ICT use has been extended to increasingly include the development of 21st Century Skills (Gut 2011; Kong *et al.* 2014).

Beijing, Hong Kong, Singapore, and Taiwan – four jurisdictions in Asia that share many parallels in sociocultural and economic terms – are examples that have undertaken extensive efforts in transforming and enhancing education through the use of ICT. This paper will first compare the similarities and distinctiveness of how these four examples have systematically integrated technologies into their teaching and learning practices, by drawing upon an earlier framework used by Kong *et al.* (2014) albeit with some distinctions. In the second segment, several key learning points from the recently concluded third ICT in Education masterplan in Singapore will be provided to give further depth to the comparison across the jurisdictions.

ICT in Education Masterplans: Key Areas

In Kong *et al.*'s (2014) paper, the authors considered five key areas in analysing e-learning policies.

- (1) Infrastructure – the hardware, software, and Internet connectivity for e-Learning,
- (2) Curriculum integration – the re-interpretation of school curriculum and development of pedagogical practices for e-Learning,
- (3) Students learning – students' development of domain knowledge and 21st century skills through e-Learning,
- (4) Teacher professional development – teachers' pedagogical competency and training activities of e-Learning, and
- (5) Leadership and capacity building – school leadership, research support, and community involvement for e-Learning.

In the current paper, similar key areas will be adopted to aid in comparing and contrasting the approaches used by Beijing, Hong Kong, Singapore and Taiwan in developing ICT in education. This paper will attempt to broaden the understanding of these five dimensions by analysing the conceptual ideas underpinning the education masterplans of these four territories. As an example, while the original definition for infrastructure was specific to the hardware, software, and Internet

connectivity for e-Learning, the current paper also considers other augmenting supporting structures which may be non-physical. For example, in Singapore, while Kong *et al.* (2014) noted that ICT infrastructure development focused primarily on access and network, the current paper also highlights the rationale for putting in place those arrangements (pedagogy-directed).

Brief Overview of ICT in Education in Beijing, Hong Kong, Singapore, and Taiwan

The education sectors in Beijing, Hong Kong, Singapore and Taiwan have been through extensive reforms over the past two decades (Wong, 2007; So & Swatman, 2006).

In mainland China, the government wanted to modernise education through ICT and had been aggressively facilitating ICT applications in education using a series of specific policies and measures (Zhang *et al.*, 2010). According to Huang and Lin (2010), developments of ICT in education took place in four stages:

- (1) 1980s – Teaching computer programming
- (2) 1990s – Computer Aided instruction
- (3) 1998 onwards – ICT infrastructure construction
- (4) 2005 onwards – Building competences for ICT in education

In line with this, Beijing promoted the integration of ICT into learning and teaching in K-12 schools (Kong *et al.*, 2014) since the late 1990s. Three “five-year” plans (the 10th, 11th, and 12th five-year Beijing municipal plan of educational reform and development) were put in place to build up e-Learning environments in the city, with large investments poured in since 2001 for such developments.

In the late 1990s, the Hong Kong government wanted to make Hong Kong a leader in the digital age (Fung & Pun, 2001). In one of their key documents “Information Technology for Learning in a New Era: Five-year Strategy 1998/99 to 2002/03”, plans for physical and human infrastructure development in Hong Kong’s primary and secondary schools in four key areas were presented, including access and connectivity, teacher enablement, curriculum and resource support, and community-wide culture (Fung & Pun, 2001). This was followed by a second strategic plan “Empowering Learning and Teaching with Information Technology” in 2004, with a focus on actual pedagogical shifts, the promotion of life-long learning and e-learning, the use of wireless technology as an extension of the environment, and the roles of both parents and students in the life-long learning environment (in So, 2006). The third stage of development was implemented via the strategy “Right technology at the right time for the right task” (2008 – 2013) focusing on the human factor (Kong *et al.*, 2014). Huang *et al.* (2014) related a fourth ICT strategy “Realizing IT Potential, Unleashing Learning Power” in Hong Kong from 2014. In this fourth stage, there are five recommended actions including (1) enhancing school’s IT infrastructure and re-engineering the operation mode, (2) enhancing the quality of e-learning resources, (3) renewing curriculum, transforming pedagogical and assessment practices, (4) building professional leadership, capacity and communities

of practice, and (5) involving parents, stakeholders and the community. Large funding have been put into each of these plans.

According to Singapore's Ministry of Education (2008), the underlying philosophy of its strategic plans is that education should continually anticipate the needs of the future and prepare pupils to meet those needs. In essence, Singapore recognised the need for the country to be ICT-literate; to meet this, schools were identified as the key starting point. Three five-year masterplans for ICT in Education were devised, with the first launched in 1997. The latest masterplan recently concluded in 2014.

Taiwan has experienced waves of integration of technology into learning since the 1980s. A full reform was implemented in the late 1990s based on lessons learned from earlier transformations (Usa & Twu, 2002). According to Kong *et al.* (2014), 1997 marked a new chapter in the promotion of e-learning in school, following the announcement of a 10-year programme. There were three stages, namely, (1) the formulation of a national plan of e-learning, with a strategic document on school infrastructure building, (2) development of a national science and technology programme on e-learning research, with a white paper for e-learning, and (3) the formation of a task force on digital literacy and national programmes on mobile learning and school-based e-learning. Some of the key ICT policies are as follows (Kong *et al.*, 2014; Chao, 2010):

- Building Infrastructure of e-learning in schools (1997)
- Master Plan for School e-learning (2001)
- Challenging 2008: National Development Project – Building an e-learning system for all (2002)
- White Paper on ICT in Education (2008)

Early on, the government focussed on the construction of an information-convenient environment. Later, research and development on e-learning (Kong *et al.*, 2014) and the idea of community learning became important goals in the Taiwanese educational technology model (Usa & Twu, 2002).

Observations of Key Developments Across the Five Areas in ICT Masterplans

In discussing the five areas in ICT masterplans, it is useful to first look at it from a systems perspective as it helps provide a scaffolding through which developments in each jurisdiction can be understood. The unfolding of efforts in ICT use can be observed to follow three interacting and overlapping layers, specifically: (1) laying a strong foundation in the early phase(s), (2) building on the foundation to achieve student learning outcomes, and (3) providing structures and resources to ensure long term sustainability, such as continuing to enhance the capacity of teachers.

It is important to emphasise that the development of ICT in education is an iterative process wherein lessons from foundational levels are used to enhance and better address learning/outcomes and sustainability, and a robust feedback loop allows for righting actions and continual improvements that reach back down to foundational

changes. This is illustrated in the Figure 1 below.

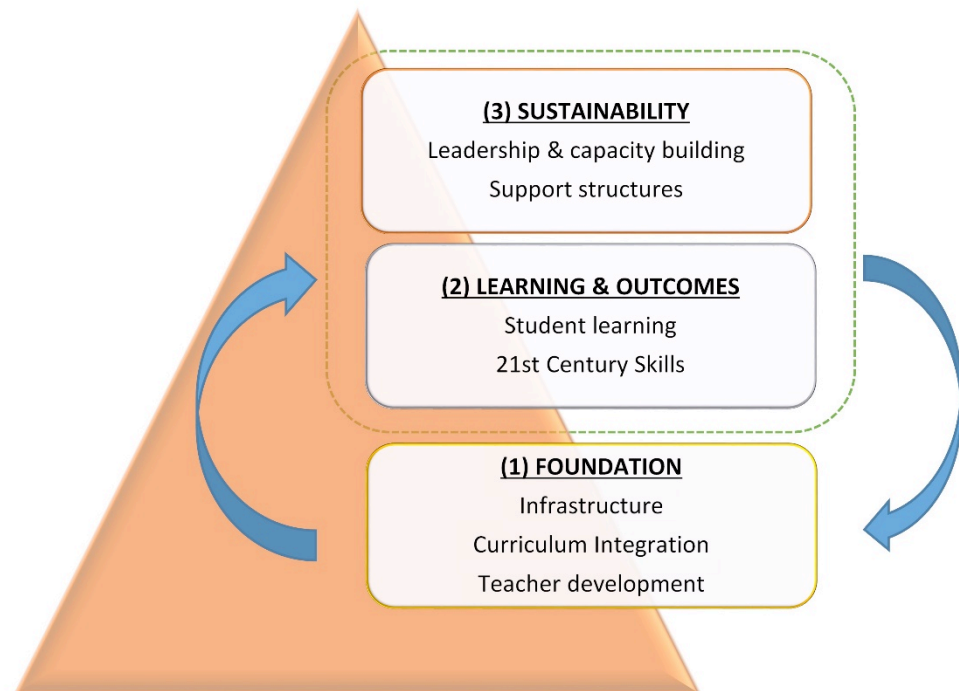


Figure 1. An iterative process in the development of ICT use in education: three interacting and overlapping layers

While the convergence in the approaches taken by the four jurisdictions lie in the overall directions and processes as seen in Figure 1 above, the implementation of the plans and interpretation of what is required within each layer of this model and the five domains of infrastructure, curriculum integration, student learning, teacher development, and leadership are distinct. For instance, the overall balance of the plans' components as well as their actual implementation differ in instructive ways, reflecting differing contexts across the jurisdictions.

Using the model described above (figure 1), the development of each of the five domains will be revisited in the four jurisdictions, supported with observations about particular contextual goals, considerations and constraints.

Layer 1: Building foundations

Table 2a highlights the key developments in infrastructure within each jurisdiction during the implementation of their plans for ICT in education.

Table 2a

Beijing	Hong Kong	Singapore	Taiwan
Basic physical infrastructure development	Physical infrastructure as key consideration	Pedagogy-led ICT infrastructure development in	Physical infrastructure installation and

including internet access & network connectivity in urban and rural areas, and installation of campus facilities and networked computers	with the installation and strengthening of ICT campus facilities, access and connectivity, including the use of wireless technology	schools, including campus facilities, access, connectivity, digital resources for teaching and learning, and ICT support	upgrades in schools including access, connectivity, and campus facilities
Digital resources and platforms for e-learning and teaching	Technical support and IT coordinators in schools	Digital resources and platforms to support e-learning in school	Strong public-private partnership
Education information management systems and platforms	Online repository with curriculum-based resources	Partnership between schools and IT industry	Digital access for rural areas
Data management and capital support platform for integration and storage of education data	E-textbooks		Open-source software
Digital schools	Use of mobile devices		Learning objects management system with platforms for sharing
E-textbooks			E-learning based interactive whiteboards classrooms

Each jurisdiction invested substantially on the installation and upgrading of ICT facilities in schools, such as broadband internet access, wired and wireless network connectivity, and computing spaces and devices. Hong Kong and Taiwan in particular geared sharply towards laying the foundation for a mobile environment. In the case of Hong Kong, one major focus in their phase 2 masterplan was on technology improvement (Law *et al.*, 2010), where the use of wireless technology as an extension of wired network was implemented, so that by phase 3 (Kong *et al.*, 2014) all computers were already networked and connected to the internet (Chen, 2011). In fact, since 2014, Hong Kong has been working on providing a Wi-Fi campus for all students, and encouraging the use of mobile devices (Education Bureau, 2014). Taiwan also moved towards modernizing infrastructure in their phase 2 development, which included city-wide Wi-Fi coverage as part of the School of the Future Project (Kong *et al.*, 2014). According to Taiwan's Ministry of Education (<http://english.moe.gov.tw>) (2012), the TANet Whois system for management of IPv4/IPv6 protocols was developed in 2011 and the Router of their regional network

centre was updated to Dual stack IPv4/IPv6, while inter-school wireless campus network roaming facilities were made available. Both jurisdictions relied on these infrastructure enhancements to establish the use of mobile devices for teaching and learning, and invested heavily in stockpiling digital resources to be made available for educational consumption.

The development of e-textbooks was also part of Beijing's education plans. However, there was significant emphasis on developing its infrastructure to support online distance education and digital schools (Kong *et al.*, 2014; Zhang *et al.*, 2010; Li *et al.*, 2009). This development objective stands out in the case of Beijing, where the substantial sub-urban and rural needs in this large city likely prompted efforts in establishing digital educational links to circumvent the problem of distance. Taiwan similarly had to develop access and connectivity in order to reach its rural areas. Whereas these two jurisdictions were concerned with building foundations for widespread access and connectivity to support distance or mobile learning, Singapore, perhaps due to her smaller geographical size and urbanisation, tended to be more pedagogy-driven. In all of the ICT masterplans for education, especially from the second ICT masterplan onwards, Singapore has adopted the principle of developing infrastructure based on pedagogical considerations. This meant that instead of building technologies first and try to use them afterwards, teaching and learning (T&L) interactions were evaluated first, particularly interactions that could not be done without the use of technologies, before searching for effective technologies to enact the T&L interactions. Some of these include the use of virtual worlds such as Second Life, blogs, wikis, podcasts, e-portfolios, animations and video productions.

Singapore, however, did share some commonalities with Beijing – the use of teaching platforms and digital resources – and with Taiwan, in terms of school-industry partnerships. For instance, in Beijing, an online teaching platform, interaction platform for teachers, and an educational information management platform were built, while in Singapore, sharing platforms such as WeSHARE and Inter-cluster Sharing of Resources (iSHARE), enabled the expansion of resource base for others to share (Ng, 2008). In Taiwan, projects such as School of the Future saw collaborations from various private and public entities, while in Singapore, examples of such partnerships could be seen in Backpack.net, which was a collaboration involving the Ministry of Education, the Infocommunications Development Authority of Singapore, and Microsoft Singapore.

Another similarity across the jurisdictions is the provision of both physical infrastructures, such as Learning Management Systems (LMS) and e-content. These have greatly facilitated the use of ICT for T&L (Voogt *et al.*, 2013; McLoughlin & Lee, 2007).

Curriculum integration is another pillar in the foundation of ICT in education. Each jurisdiction had to ensure that relevant content could be delivered appropriately in day-to-day teaching and learning. Table 2b highlights some key developments in

curriculum integration.

Table 2b

Beijing	Hong Kong	Singapore	Taiwan
ICT-related curriculum in school (compulsory for some levels)	Set thresholds of ICT-integrated lesson time (25%)	Active integration of ICT into curriculum (e.g. by 2002, 30% of curriculum time to include IT-based teaching & learning), with corresponding content reduction (30%)	Substantial review of K-12 curriculum throughout masterplans
Developed ICT resources in line with curriculum	School-based e-learning pedagogical innovations (e.g. Composite Information Technology Grant for schools to acquire devices, resources, or services related to e-Learning development in school)	ICT skills development in early plans	Established digital literacy and assessment framework within curriculum
Basic education resources available to rural and urban schools	Pilot schemes on the review of existing e-Learning resources and the educational use of new ICT tools.	Development of ICT-based/alternative pedagogies	Digital Education and e-Learning Project to integrate ICT into curriculum
IT innovation activities that cultivate students' problem-solving abilities.	Promote ICT integration into curriculum	21st Century Skills framework (i.e. through ICT integration into curriculum, pedagogy and assessment, develop 21 st century skills such as IT skills, and the ability to communicate persuasively and collaborate effectively.)	Promoted use of mobile technology
New instruction software, platform tools and new style IT products, exploring new models and new ways of applying ICT in instruction, e.g. one to one e-learning, mobile education, miniature learning and digital whiteboard-based interactive learning.	Curriculum-based teaching modules with ICT resources		
	Enhance quality of e-learning resources		
	Renewing curriculum, transforming pedagogical and assessment		

	practices		
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Across all four jurisdictions, it was recognised that specifically integrating ICT within the curriculum represented an important strategic action to ensure that ICT were actually used in day-to-day T&L. Thus, early efforts in the various ICT plans tended to include such integration. In fact, both Hong Kong and Singapore went further by actively carving out spaces within their respective curriculum to cater to the injection of ICT into T&L, taking into account that more time was needed for ICT-based lessons. Note that integration of ICT into curriculum came with specific learning objectives and outcomes. More importantly, such integration also provided the basis and motivation to develop 21st Century skills, as ICT have the potential to support the acquisition of these skills (Voogt *et al.*, 2013) well. As such, the development of such skills through curriculum integration and delivery became important goals particularly for the governments of Singapore, Hong Kong, and Taiwan (Kong *et al.*, 2014).

Teacher quality is a fundamental factor that can determine the success or otherwise of an education system. Recognising this, all four jurisdictions have substantial parts of their plans focused on developing teacher capacity.

Table 2c highlights the key initiatives for the professional development of teachers in the various ICT plans. Of the four, Hong Kong is the only jurisdiction that defines a baseline ICT standards for teachers. (This contrasts with Singapore which developed a similar standard, but only for students.) However, all have in place training programmes, such as the train-the-trainer programme for the 1st masterplan in Singapore, which aimed at ensuring that all teachers have the basic competency to use ICT in T&L.

As the ICT plans evolved, various platforms were built to encourage greater sharing of expertise among educators, taking advantage of social media tools. In Hong Kong's case, a set of self-learning web-based tools were developed for teachers, whereas sharing platforms, such as *professional learning communities*, were also constructed. The use of peer support is common, although various forms of support are being used. For instance, in Taiwan, industrial partners represent an important provider of training, often in partnership with government.

Table 2c

Beijing	Hong Kong	Singapore	Taiwan
Technical and pedagogical training for teachers	Baseline ICT standards for teachers	On-going Professional Development on ICT Skills & Pedagogies	Pedagogical training for teachers (peer-coaching programme)
Interactive platform for teachers to share experiences	Technical and pedagogical training (funds allocated to schools)	Peer-mentorship approach on ground	Enhanced coherence & sustainability of teacher

	Self-learning web-based tools	Professional learning communities	development
		Subject Chapter	

Realising that centrally-provided resources and training were not sufficient, a more ground-up level of support was considered necessary. To answer this need, Singapore put in place an *ICT mentor* structure; four senior teachers per school were selected for training and subsequently posted back to the school to serve as advisors and mentors for other teachers in the use of ICT for T&L. Such grounded support ensures not just timely support for teachers, but more importantly, also allows for adaptation of practices that suit the T&L context of the school (including learning profiles preferences of students).

Overall, there is a clear shift towards student-centred T&L interactions as evidenced in the content of the various professional development programmes and content of the sharing platforms, particularly salient moving into the 3rd masterplan (Ng, 2008). This is an important development, and likely to remain central to future ICT plans.

Layer 2: Learning and Outcomes

As highlighted earlier, 21st Century Skills development is seen as important, although the engagement in this area is at different stages of development across the four jurisdictions. In Singapore's case, the development of these skills had an early start with its articulation of 'Thinking School, Learning Nation' in 1997 (Chang, 2001). This took the shape of a 21st Century Skills framework and the focus on *self-directed* and *collaborative* learning skills in the 2nd ICT masterplan for education. Quite often, the early stages of engagement tended to focus on ICT literacy skills, such as the ability to use productivity tools. This is illustrated by the various frameworks, such as that in Hong Kong and Singapore – see Table 2d.

Table 2d

Beijing	Hong Kong	Singapore	Taiwan
<i>Integrating e-Learning elements into learning tasks</i>	<i>Integrate e-elements into learning tasks</i>	<i>Baseline ICT standards (Productivity)</i>	<i>Students encouraged to use ICT to share, learn, interact & collaborate</i>
	<i>Foster students' proficient and ethical use of ICT</i>	<i>Explicit focus on e-learning outcomes</i>	<i>Strengthen self-directed learning</i>
	<i>Four dimension IT literacy framework</i>	<i>Self-directed & collaborative learning</i>	
	<i>Explore IT-related career path</i>	<i>Cyber-wellness</i>	

		<i>Initial e-assessment for national exam</i>	
		<i>Education & Career Guidance Portal</i>	

Towards the later stages of ICT plans, the ethical use of ICT gained importance as sources of values, skills and knowledge became directly available to students rather than being predominantly coming from schools and home. This has prompted the adoption of frameworks, such as the cyber-wellness framework in Singapore (MOE Singapore, 2010), as part of the skills set necessary for students to negotiate the cyber environment.

The use of ICT for national assessment has only just begun, with Singapore introducing e-assessment for selected national examinations in 2014. A further development is the use of ICT to support students in making career decisions, such as in Hong Kong, and the development of an education and career guidance portal in Singapore (MOE Singapore, 2013).

Layer 3: Towards Sustainability

It is well-documented that school leaders play an important role in education innovations (Yuen *et al.*, 2003), thus having strong and enlightened school leadership is key to the success of the ICT plans. Table 2e provides the key developments in leadership and capacity building in each jurisdiction. One thing becomes clear from the respective ICT plans for school leadership: there is a need for school leaders to be sufficiently exposed to technological advances. This is so that, while they do not need to know the full details of how each technology can be used for T&L, they can be in a position to envisage such usage and weave ideas emerging from teachers within the overall development of the school. To this end, the jurisdictions introduced programmes for school leaders targeted at pedagogical usage of technologies as well as establishing peer-led learning communities to ensure that school leaders are aware of latest developments in ICT. On top of this, Taiwan also provided support for research into the use of ICT for education, while Hong Kong and Singapore ensured that key stakeholders (e.g. parents and the public) were included as part of the larger community (Fung & Pun, 2012; MOE, 2010) that would keep the ICT in education developments sustainable.

Table 2e

Beijing	Hong Kong	Singapore	Taiwan
School leadership training on e-Learning, decision-making	Support school-based planning of e-Learning	Targeted support for school leaders	Research community support
Established	Enhance partnership with	Leadership programmes on ICT integration	development of policy & practices of e-learning

mechanism for resource allocation	community, industry Community of practice for school leaders Communication with parents and engaging with community (e.g. Hong Kong Education City)	Professional learning communities Engaging and educating parents in programmes e.g. role of parents in nurturing cyber wellness at home	Research on mobile learning across school curricula
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Approaches of the Four Jurisdictions

While the key areas that each jurisdiction focuses on in all their respective ICT plans have been broadly similar, there are discernible differences in the adopted approaches. These tend to be dependent on the context of each jurisdiction, and are highlighted in Table 3.

Table 3: Approaches to ICT plans implementation

Beijing	Hong Kong	Singapore	Taiwan
Grand scale infrastructure build-up Highly centralized implementation Greater recent focus on curriculum development	Central planning sketches out parameters with supporting resources Strong grounds-based practices and adaptation Focused on resources and infrastructure	Plans are holistic with differing balance & aligned to other policies Centrally conceptualized, 2 nd plan coincided with greater autonomy for schools – moved to ground-up with central support Aligned to professional capacity building	Strong technology development and product focus Strong government-industry partnership – tendency to promote adoption of technologies developed to schools

		and pushing at cutting-edge R&D focus plus scaling and dissemination structures	Shift towards pedagogies in more recent years
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The development of physical infrastructure in Beijing tended to be on a strong and grand scale with a fast build-up. In general, the drawing up and implementation of ICT plans were highly centralised and coordinated, resulting in a fairly uniform rate of development within the jurisdiction, which could allow the schools to interact at a similar level. As the infrastructure build-up gathered pace, the focus of the ICT plans increasingly turned towards curricula matters.

Hong Kong and Singapore have been similarly centralised in the construction of their respective ICT plans. However, while Hong Kong generally focused on spelling out the intents of the plans as well as the associated parameters within which the plans were to be implemented, a large part of the actualisation of the plans were decentralised and left to the schools. This resulted in a strong diversity of responses to the ICT plans. Singapore, on the other hand, provided centralised support as well as putting in place structures to encourage grounds-up actualisation of the ICT plans. Importantly, Singapore's ICT plans were usually developed with a strong alignment to other key national policies, such as economic and manpower policies.

Among the four jurisdictions, Taiwan seemed to have the strongest involvement of the private sector in pushing for the use of ICT for T&L. Not only do the companies help to develop the technologies for education, they also play important training and promotional roles in encouraging schools to adopt the developed tools. This, perhaps, is a contributing factor to the Taiwan ICT plans being generally more technology-focused than the others. Similar to Beijing, the Taiwan plans have also seen a definite shift towards pedagogies and curricula needs.

On the allocation of resources for R&D in ICT for education, Singapore perhaps has a more sustained and longer period of engagements. The R&D component to push for exploration of innovative and cutting edge use of ICT in T&L started from the first ICT masterplan. This sustained focus has led Singapore to participate meaningfully in early exploration of cutting edge areas, such as the automated scoring of 21st century skills.

Key Learning Points from Singapore's ICT in Education Masterplans

Apart from identifying the main focal areas of ICT masterplans, almost two decades of ICT masterplan development and implementation in Singapore have highlighted the importance of adapting strategies that are suitable for the context within which the plans are intended. Singapore's apparent strength in the use of ICT in education stems from its ability to anticipate and respond effectively to the changing landscape; and to realise early on that the set of so-called 'success factors' are intimately

intertwined. How these factors interact and push the plans forward are hard to predict. As such, while each key area and what to do within it needs to be carefully articulated, there should be sufficient flexibility and space for refinements as the plans unfold. This broadly translates into (a) developing ground capability, i.e. teachers and school leaders, so that deeper and more effective use of ICT for T&L can be developed; and (b) ensuring sufficient structures for 'bottom-up' initiatives with 'top-down' support exist or are constructed (Tan *et al.*, 2013; MOE, 2008).

The five identified success factors overlapped with the 5 areas of focus in this paper, but contain elements expanded from the latter set. These five, after re-categorisation, are (i) 'human' infrastructure, (ii) ideas generation, (iii) ideas interactions and translation, (iv) support structures, and (v) physical infrastructure.

'Human' infrastructure refers largely to the capability-building of teachers and school leaders, which have been covered above. What is perhaps a 'new' perspective is to examine how such capacity-building evolved over the three ICT in Education masterplans, which serves to illustrate the adaptive nature of the success factors.

During the 1st ICT in education masterplan (mp1), the ICT skills level among teachers was rather uneven, and computing networks were not as pervasive in the schools. On top of this, a large proportion of teachers were fearful of the 'new' technologies and most were unused to interacting in cyberspace. The development of ICT skills needed to be systematic and comprehensive. As such, a centrally organised train-the-trainer approach was used. At the same time, 100 hours of paid professional development per year for each teacher was introduced (Koh & Lee, 2008; Lee, 2008), signalling both the importance of capacity-building as well as empathetic support from policy makers.

The 2nd ICT in education masterplan (mp2) coincided with the gradual devolving of autonomy to the schools for a wide variety of local decisions. Thus, rather than continuing with a train-the-trainer approach for teacher capacity-building, each school drew up its own ICT plan, with help from the Ministry of Education, and decided on the needs of its own teachers. Where feasible, such needs could be addressed centrally, such as when there were similar demands from a large number of schools, or the schools could choose to engage its own expertise, say, from the local university, to develop the required skills.

By the 3rd masterplan (mp3), the level of ICT use among the teachers had matured to a good extent, and there was sufficient diversity in both practice and experience that a large part of the system's expertise in ICT use for T&L actually resided within the teacher community. Recognising this, the approach to capacity-building further evolved to tap into the collective expertise of the teachers. Structures such as subject chapters, sharing platforms and professional learning communities were set up to support the interactions amongst the teachers. Centrally organised programmes were still available, but these and what the schools did strived to complement each other.

The trajectories for the other four factors tell a similar story. 'Ideas generation' refers to the system's ability to generate ideas and practices that are pedagogically-sound. These evolved from centrally-produced resources that had embedded pedagogies in mp1 to the teacher generated practices in mp3. The challenge here was how to capture the ground practices, as well as centrally-developed practices, to scale to the rest of the system. In this aspect, effective partnerships among teachers, ministry headquarters, researchers and industry partners are important.

Quite often, ideas generated in a specific context need further work to translate and broaden their applicability within the system. Thus, 'ideas interaction and translation' represents an important conduit through which a system can capture and spread its good practices. The structures for these were put in place with an increasing emphasis on direct teacher participation by the time mp3 was formulated. Similarly, 'support structures', referring largely to making tools and learnings available to schools, such as the school self-evaluation tool By(i)tes 2.0 (MOE, 2011) and the ICT mentor programme mentioned earlier. Both the nature and provision of these have changed from mp1 to mp3.

As for 'physical infrastructure', it has also changed from early central provisioning to a balance between central and school-determined provisioning. Most important, however, is the strengthening of pedagogy-led infrastructure development in the later plans.

Conclusion

Despite developing fairly independently, the ICT plans of the four jurisdictions converged on five key areas, i.e. infrastructure, curriculum, student learning outcomes, teacher professional development and school leadership. While there are considerable similarities on the broad strategies in each area, important differences indicate that details and context still matter. Given that web 3.0 tools have already emerged (Kurilovas *et al.*, 2014), i.e. tools that not only facilitate interactions among users, but also learn about the user such that tailored information and resources can be pushed to the user, future ICT plans are likely to need to operate at a different level of complexity. In such circumstances, it becomes even more important for each jurisdiction to be clear about their central philosophy with regard to the use of ICT for T&L.

This not only serves to guide the formulation of ICT plans, but also the direction of educational development as a whole. As an illustration, there is an increasing push for the use of automated delivery systems, which can be pedagogically-sound in its design, to compensate for weak teachers (Cheah & Lee, 2015). Should such centrally-designed systems be adopted, the skills demand on the teacher could potentially be reduced, and might lead to a general de-skilling over time. This is not inevitable, but the possibility exists. On the other hand, focusing on providing ICT tools to teachers broadly means the need to increase their T&L capability, i.e. make them even more skilful to use these tools for T&L. This could potentially result in unevenness of

capability within the education system, with some teachers considerably better at using ICT for T&L than others (which is probably the case for most system at present). Either way, or even with a mixture of both approaches, the philosophy adopted will affect future ICT plans, and careful considerations need to be exercised.

The use of ICT for teaching and learning is here to stay. Being able to learn from each other, particularly in today's complex and connected knowledge environment, is crucial for designing ICT plans that are coherent and which meet the needs of the education system. The main ideas presented here from the four jurisdictions serve to provide a first level attempt at understanding the key factors for success within the ICT plans.

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Cheah Horn Mun

Contact Email: hmcheah@unisim.edu.sg

Laura Lynn Lee

Contact Email: lauralynn.lee@gmail.com