

THF Working Paper

Working Papers Series No.2 /2018

Twenty Years of *Thinking Schools, Learning Nation* (TSLN) Vision: Reflections on Singapore's ICT Masterplans

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Human Capital & Education for Asian Development

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Abstract

In the year 1997, Singapore committed to reforming its education system, to prepare young Singaporeans for changes in the coming decades. The national Information and Communication Technology (ICT) Masterplans were one of a series of reform initiatives that began with a focus towards change in the teaching and learning in Singapore classrooms with technology integration. In this article, we summarize the four ICT masterplans implemented since the "Thinking Schools Learning Nation Initiative" (TSLN). Following the introduction of the first masterplan for ICT in education, the Ministry of Education ensured that schools had infrastructure, leadership and necessary teacher training to successfully implement the initiatives. The descriptions of the implementations and a case study from a Future School are valuable lessons for other national systems in the region and beyond, seeking to integrate ICT in their education systems. We conclude by raising some questions on where we are, what could be the next level in the technology reform journey and what we think has been achieved.

Introduction

In 1997, the then Prime Minister of Singapore, Mr Goh Chok Tong, articulated Singapore's vision for 21st century teaching and learning in his famous speech entitled "Thinking Schools, Learning Nation" (TSLN, Goh, 1997) thus,

A nation's wealth in the 21st Century will depend on the capacity of its people to learn. Their imagination, their ability to seek out new technologies and ideas, and to apply them in everything they do will be the key source of economic growth. Their collective capacity to learn will determine the well-being of the nation.

In his speech, the Prime Minister outlined Singapore's vision for the future and how education could play a crucial role in the nation's transformation. He argued that despite Singapore having a strong education system, the existing formula for success at that point was not enough to prepare Singapore's young generation in view of globalization and the new challenges they were likely to face in the forthcoming decades. One of the key responses he suggested was the introduction of information technology which would lay the basis for new teaching and learning practices and innovation. Mr Goh laid the emphasis on the need to transform the education system, with ubiquitous use of ICT in education. Integration of ICT in education was believed to have the potential to enhance the necessary digital skills of the students, transform their learning experiences in schools, and develop them into effective members of the future workforce (MOE, 1997). What followed from then on was a series of initiatives to upgrade the education system to be more responsive to the 21st century challenges. Singapore has implemented four Information and Communication Technologies (ICT) in Education Master Plans over the last 20 years in an effort to help the country forge ahead in a changing world, and prepare its

workforce for a knowledge-based economy in the future, thus helping the country remain competitive.

This paper will begin with a description of Singapore's national ICT Masterplans since 1997, summarizing their aims and achievements. Subsequently, we will examine in greater detail its impact on the education, economic and social dimensions of life in the Singapore society. We will share relevant examples and what lessons could be learned from Singapore's technology in education journey. This might be relevant to other countries in the region and beyond, seeking to effectively integrate ICT in their education systems. For example, simply having ICT infrastructure in place and training teachers to use both hardware and software is insufficient. To be able to impart skills and develop dispositions that will be relevant to the future economy, teachers need to continue to improve upon their instructional design capacities. We will examine how teachers are able to adapt the technologies as they emerge and evolve.

Acknowledging the paradigmatic effect of the then-nascent Internet and its transformative potential in teaching and learning, information and communication technologies (ICTs) were formally introduced in 1997 with the launch of the first Masterplan for ICT in education (National Archives, Singapore <http://www.nas.gov.sg/archivesonline/speeches/>). Since then, three follow-on masterplans have been implemented, with the latest being launched in early 2015. While each plan built on the previous ones and prioritised the factors that predominated its 'success', they were also able to adapt strategies to the shifting contexts of the Singaporean education system. This seamless adaptability is a crucial

factor in the strength of the implementation of education masterplans in Singapore's local schools.

Singapore's three ICT Masterplans

The first ICT Masterplan was launched in 1997 with a budget of SGD 2 billion and the objective was to lay a strong foundation in ICT for all schools in Singapore in terms of technology infrastructure and educator capacity (MOE, 2002). The target was to begin teacher capacity building for technology tools so that teachers were comfortable to begin using the computers. Networked access for entire schools with Internet and an ambitious 5:1 pupil to computer ratio was planned. Towards the end of the first phase in the year 2002, Singapore was ranked second in the world, after Finland, in the then Global Competitiveness Report (2001-2002) for the availability of Internet access in schools. Between 30 and 50 hours of teacher capacity building was planned for every teacher in the system over a one-year period, which was considered remarkable by international comparisons. In fact, a policy was established that entitled each teacher to have 100 hours of sponsored professional development per year. Teachers had to complete a few modules of just ICT training over 30 to 50 training hours in the initial stages of the masterplans.

ICT Masterplan 2 followed in 2003 with a budget of \$600 million, where a key focus was the establishment of structures, such as tiered support for schools at various levels of using ICT for Teaching and Learning, to promote a culture of exploration and innovation in the use of ICT in education. During this phase, a set of baseline ICT standards that every student in the system had to attain at certain milestones of their education (eg. by Primary 3 or Secondary 3 level) was also implemented. These reflected MOE's commitment to continue a coordinated, national effort to maintain

the country's economic competitiveness in an increasingly competitive world.

Schools competed amongst one another to showcase the innovative usage of ICT in education within their everyday curricula. New alternative pedagogies such as inquiry-based learning and problem-based learning emerged. ICT related products from the students included blogs, e-portfolios, animations and videos where they demonstrated what they learned in class. It is important to note that all of these were happening concurrently with the rise of socio-technological innovations such as Wikipedia, YouTube and the immersive world of Second Life.

The third Masterplan began in the year 2009. The emphasis this time was to enhance ICT integration within the curriculum, pedagogy and assessment in order to keep pace with 21st century competencies (MOE, 2008) . Use of ICT was encouraged not only for building technology literate citizens but also to instil higher order thinking, communication and collaboration skills. A push towards varied ways of learning using ICT was encouraged - self-regulated learning, individualised instruction, anytime anywhere learning, deeper learning, collaborative learning etc. Teacher capacity building continued throughout and a concerted effort to identify and support pockets of teacher innovations were initiated. Teachers were also encouraged to share best practices and learn from their peers.

The Ministry continued to focus concurrently on leadership capacity building for implementing ICT based plans in the schools. The impetus was to identify successful school leaders as peer coaches for other leaders, and teachers as peer mentors for others to support the implementation of successful ICT initiatives, and find innovative practices that could be scaled across schools. By 2014, several initiatives like Fasttrack @ school, Edvantage, and eduLab were implemented and evaluated,

With the implementation of these masterplans, the overall ICT infrastructure in schools has improved to the current state which allows for high speed broadband and 4G access island-wide (Koh & Lee, 2008). As a consequence of these integrated efforts, teachers and school leaders began to grow comfortable using technologies for teaching and learning. The cultural mindset shift is noticeable through the types of questions and requests for support raised; where these once reflected apprehensions about the technologies, it is broadly now about how best to use them effectively for education. At the same time, in 2015, about 93% resident households reported using an Internet-enabled mobile phone and other internet-enabled equipment (e.g. Game console with internet connection, Smart TV, etc) (<https://www.imda.gov.sg/industry-development/facts-and-figures/telecommunications>) In a broader sense, it is important to note that changes in the education system were happening alongside transition in the use of technology beyond the school, at home and within the larger society.

As Singapore continues to progress and remain globally competitive, the country is continually expanding and refining its ICT apparatus that includes infrastructure and capacity building. The MOE clearly believes that the implementation of ICT in Education is a vehicle that can help students develop skills that are relevant to the global economic shifts. To date, four ICT masterplans have been successfully implemented, namely, Masterplan One (1997 – 2002), Masterplan Two (2003 - 2008), Masterplan Three (2009 – 2014), and Masterplan Four (2015 – present).

Technology in schools 20 years on (2015-Present)

The Fourth Masterplan for ICT in Education (Mp4), which is currently being implemented, is meant to build on the experiences and successes of the preceding three Masterplans for ICT in Education, and extends the emphases beyond self-directed and collaborative learning (SDL and CoL) to the overall curriculum. Mp4's focus is to use ICT productively to develop knowledge through subject mastery, skills through 21st Century Competencies, and attitudes through responsible digital citizenry. The alignment of this fourth masterplan follows MOE's direction towards student-centric and values-driven education. Mp4's vision is to nurture "Future-ready and Responsible Digital Learners". The objective is also to deepen digital learning in the areas of cyber-wellness and responsible and safe media literacy. On the whole, mp4 aims to put "Quality Learning in the Hands of Every Learner - Empowered with Technology" (<https://ictconnection.moe.edu.sg/masterplan-4/vision-and-goals>). The two enablers associated with this objective are: i) Teachers as Designers of Learning Experiences and Environments, and ii) School Leaders as Culture Builders. A set of future-ready, scalable, and reliable infrastructure in every school will form a firm basis for achieving this vision of quality learning with ICT. These will enable the students to have the capacity to learn anytime and anywhere. Four different approaches listed within mp4 seek to explain how the vision will be achieved in their respective areas:

Deeper ICT integration in curriculum, assessment and pedagogy

The focus in this area is on the end-to-end integration of ICT into curriculum, pedagogy, and assessment of subject disciplines and supporting resources. This will ensure that ICT is appropriately embedded at the design and development stages of

curriculum. Specific strategies to bring about deeper integration of ICT are: integrate ICT into the national curriculum, provide quality online learning resources for students, incorporate ICT in assessment, and deepen digital learning in the areas of cyberwellness and new media literacy.

Sustained professional learning

Mp4 takes a more systematic view of the various capacity building efforts for ICT in learning from pre-service to in-service teacher training. It will also provide a more coherent core knowledge-base to better bring about quality teaching and learning with ICT among various members in the school team. The following key strategies aim to bring about sustained professional learning using ICT in the teaching fraternity: build capacity of school teams, develop good ICT practices, and strengthen Networked Learning Communities (iNLCs) for Technology in Learning.

Translational research, Innovation and Scaling

This approach in mp4 seeks to nurture a culture of innovation and reflective practice across schools. To this end, it aims to engage schools and teachers in experimentation and innovation efforts. This will allow teachers to engage each other in professional discourse and in so doing, learn, reflect, and explore issues together, deepen their knowledge of practices and improve their craft. Through translational research, successful evidence-based practices will be identified and scaled up to benefit other schools in the system. The strategies to support, drive and encourage experimentation and innovation in schools are: scan for educational technology-related issues and applications, seed innovations across schools and translate research findings into classroom practices, and spread successful practices for adoption and adaptation across schools.

The FutureSchools@Singapore (FS) initiative, under which ICT solutions are developed in partnership with infocomm industries and implemented to support effective approaches to teaching and learning, has produced many new tools and applications that have transformed the classroom experience for both teachers and students (MOE, 2015). Since 2008, concurrently with the mp4, the establishment of the FutureSchools in Singapore was another initiative where ten selected schools across the island worked closely with the MOE, IDA, and infocomm industry partners, to significantly change student learning to be self-directed and collaborative. A product called the AmBook – an interactive digital textbook which takes an inquiry-based approach to learning was one, among several student innovations that were developed (MOE, 2011; imda.gov.sg). It is crucial to extend the new teaching and learning practices within the education system through effective scaling strategies.

Teacher capacity development and preservice training

Professional development (PD) of teachers to ensure that teachers have the capacity to weave new practices into their respective teaching and learning contexts have been continuous and concurrent. The PD includes ICT skills trainings and the peer-supported, collaborative and self-directed nature of ICT pedagogical developments. Hence, having been equipped with the appropriate sets of skills, teachers are not only familiar and comfortable with utilising ICT for teaching and learning, but have also developed the mindset of a reflective practitioner in exploring different avenues regarding ICT pedagogical approaches. The National Institute of Education (NIE) has revised its teacher preparation curricula over a few years so the graduating trainees had basic ICT skills and some core pedagogical training to be able to use the ICT

resources. The academic faculty were trained and they had to model the use of ICT for all trainee teachers. On top of these, the strategies adopted for the professional development of school leaders have contributed significantly to a conducive environment for the use of ICT for teaching and learning. For example, a “Technology in Learning — Implications for School Leaders” module was designed to train and emphasise how the role of the leader was crucial in providing the vision, direction and support (Koh, T. S., & Lee, S. K., 2008). Thus, the current education system has the cultural disposition, infrastructure, and expertise to engage in technology-based teaching and learning

Learning with technology in a Singapore classroom: Future School Case Studies

The school in which the intervention described here was implemented is a state-funded school in Singapore. The school enjoyed access to additional funds under the FutureSchool (FS) programme of the Ministry of Education (MOE, 2015). The FS programme operated under a unified structure (known as 'eduLab') that coupled the endeavours of schools, institutions of higher learning (IHL), and industry, to focus on the use of Interactive and Digital Media (IDM) in Education projects. Besides providing support for bottom-up initiatives, the school leaders were also actively involved in leading curriculum innovations and research to promote higher order thinking and collaborative learning among students. The teachers made use of a shared pedagogical discourse and expertise that allowed for active engagement and participation in the development of innovative curriculum. This was enabled through the careful nurturing of professional learning communities among teachers to enable them to meet and collaborate on curriculum improvement and innovation. To effectively support the school-wide embrace of technologies for teaching and

learning, the school campus was equipped with wireless capability with a dedicated data transfer capacity of 20mbps.

To illustrate the collected and concerted approach adopted for developing and scaling pedagogically sound practices in the use of ICT in Education, the following section describes an intervention among Grade Nine students in 2015. The intervention was a technologically-mediated learning environment designed by teachers and a team of researchers from the National Institute of Education in Singapore to nurture values associated with citizenship education. The classroom environment was designed around the metaphor of a Newsroom, in order to encourage students to understand the connections between the formal citizenship education curriculum and their everyday interactions on social media. The environment was web-based and was designed to be deployable over a range of popular handheld platforms which students would already have ready access to. This case study is particularly important and relevant in the current ongoing national debate on the “Deliberate Online Falsehoods - Causes, Consequences and Countermeasures”, which focuses on the consequences that using digital technologies to spread of falsehoods online can have on the Singapore society. Educators and learners today live in a time when potential opportunities for learning present themselves nearly every moment. Smartphones and computers allow us to receive news nearly instantaneously and continually. Mobile devices permit communication where material can be broadcast immediately. Liang et al. (2005) outline some communication affordances afforded by mobiles with educational applications aimed at supporting teacher-directed instruction, small group learning, and individual learning: response collecting (engaging in question and answer

sessions), Posting, Pushing or delivering learning content, Controlling, File-exchanging and Instant-messaging (exchanging ideas with peers in another group).

Tan and So (2015) emphasize the physical environment within which mobile learning takes place and how real world contextualization could generate critical thinking and collaborative knowledge building. With localised apps such as 'Channel NewsAsia' and 'Straits Times', which provides the latest news updates, the youth of today have fewer reasons to access printed newspapers as their source of news. However, with news moving onto online platforms, the line between news and entertainment becomes increasingly blurred as Internet media companies such as BuzzFeed and Daily Mail publish a mix of real news, fake news, 'alternative facts', and entertainment. With no dearth of such sites on the Internet, one would find it harder to discern whether a site is from a genuine news company. Furthermore, given that even the main news media tended to get their newsfeed from the same source, the reporting could generally be fairly homogenous, especially for breakout news. This is a tendency that the demand for speed has traded off against veracity and quality. On the whole, the youth of today encounter and are able to access facts, statements purporting to be facts, quasi-factual statements and fake news to a degree unprecedented in history. Students read about peace conferences, political issues abroad, wars, and countless other things online while having their breakfast or taking the bus to school. The advent of online messaging has made communication faster than ever. The information overload at high speed has resulted in news consumption being done increasingly at the surface level, where scanning headlines become the sum total of our engagement with news. This has added further challenge to proper analysis of news content. The access to news has been mainly

through digital devices. Data from the 2015 annual survey of infocomm usage in households and by individuals conducted by the then Infocomm Media Development Authority of Singapore revealed that about 85 percent of youths used handheld mobiles to access social networks.

At the beginning of the lesson, each group was assigned a topic with two opposing stands or viewpoints. Different groups within the class may be assigned the same topic or different topics. The two sides within each group are each assigned a specific stand. The lesson consisted of several stages, i.e. source review and selection, presentation of stands, presentation for perspective reversal, presentation of reversed stands, and collaborative creation of final artefacts. Each of these stages had a time limit. During the source selection stage, the students used the *Newsroom* interface to review the sources (text paragraphs, images, audio or video data) which had been made available for their group for their particular stand, and select sources which they would like to present in order to support their stand. Each side within a group had their own separate Newsroom for organizing source material. The process of review and selection was updated in real-time. The outcome of the task was to write a final report presenting a stand on the topic which the group had been debating about - either to choose one of the stands, or to present some synthesis of the two stands. This activity was synchronous within the group. At the end of this activity, the final report was submitted to the teacher. This stage typically lasted between 30 to 60 minutes.

Students in Singapore were well versed in new media, from creating their own content online to reading forum posts, and they were very much engaged with new media. The question is then, how digitally literate were they? One key aspects of

new media literacy is the ability to assess new media content critically, including recognising misinformation. This is significant as social media platforms become inseparable from people's lives, and we want students to be critical of what they read and see, and not take them at face value. The functional aspects of digital literacy are how well they use such new media resources and how responsible they are in participating in such new media activities.

Findings

In the interviews and focus group discussions with the students, it was clear that they showed a high degree of media literacy and also displayed wide knowledge about different news media outlets. They were able to list major news outlets such as "BBC, CNN, The Sun, Fox...etc". They got their news from traditional media such as TV, Cable, Radio, newspapers as well as online media such as Yahoo news, Twitter, Facebook, Reddit...etc. They were able to give examples of how certain news outlets will offer biased interpretation of certain news items, the examples they gave was about a protest against a shooting and the photo the news media used misled readers into believing that the protesters were more numerous than reality.

The second example is a Structured Academic Controversy lesson. The Controversy that the students were introduced to was the naming of two Indonesian corvette warships in 2014, after two Indonesian commandos had been hanged in Singapore in 1965. Singapore had hanged the two Indonesian commandos because they had planted a bomb in Singapore which killed three people and injured at least 33 others during the period of the Indonesia-Malaysia confrontation (known as Konfrontasi) of

1963-1966. The naming of the warships in 2014 after the two saboteurs worsened relations between Singapore and Indonesia at that time.

Newsroom helped students appreciate the biases inherent in journalistic epistemologies (both in terms of traditional broadcast media and the broadsheet press, as well as in terms of more emergent forms of social media). With regard the latter, students also showed an increased awareness of their self-regulatory behaviour. Based on the data collected during the Structured Academic Controversy lessons, some examples of how the students approached new media and engaged with each other on discussions on how news event were portrayed. These include: Students displaying sensitivity to the context of the reporting through the use of emphasis - *"Indonesia's actions of naming its navy ships after the two Indonesians who bomb Macdonald's [sic] house were justified. To the Indonesians the "bombers" were just marines and were not seen as terrorists,"*

Students being critical in an affirmative manner, looking for flaws in explanations - *Though the bombers were just marines, they were associated greatly with the major chaos that struck Singapore upon the bombing of the MacDonald House. Whether they were seen as terrorists or not, there was not a positive relation to their names as they were the bombers who attacked Singapore".*

Students showing empathy and trying to provide a balanced point of view: *When Indonesia pleaded for reschedule of the execution, Singapore yet chose to ignore and proceeded on with the execution. In a way, Indonesia sees this as the two marines sacrificing their lives for their country. Therefore, the two marines are heroes and Indonesia honours them"*

A student presenting his case clearly with evidence to support his logic *"It is not justified as one may question the narrative Indonesia intend to bring when naming its naval ships after the two bombers. This is evident in source A where (Singaporeans would ask what message Indonesia is trying to send by naming its warship in this manner). After the matter has been closed in May 1973, Singapore and Indonesia are in good terms. However, when Indonesia decided to name the ships after the bombers, Indonesia is, whether intentionally or unintentionally, bringing up the dreadful past between both countries"*

Students being reflective and looking at the issue from a macro perspective; analysing the bigger picture - *"The action of renaming the naval ships after the two bombers is not justified as the action may bring misunderstandings and it is also a sensitive issue to Singaporeans, who were deeply affected by the bombing incident back in the past. In the source, it states that 'Singaporeans would ask what message Indonesia is trying to send by naming its warship in this manner.' This proves that even after decades, Singaporeans are never able to forget about the bombing incident. As it might have been a terrifying experience to them, renaming the naval ships after the two bombers will cause disputes and the friendship between Singapore and Indonesia will be at risk. Hence, the renaming of the naval ships is not a justified action to be taken."*

In Singapore's context, a digital and media literate person is one who is able to critically evaluate and interpret information on media platforms, both online and offline, make informed choices and be aware of the choices of information an individual creates, posts and shares online, and finally, be accountable and demonstrate sound judgement for the actions in their online interactions.

Media literate students and learners and the concept of digital citizenship assumes that students are better able to understand the complex messages we receive from social media, television, Internet, newspapers, magazines, books, and all other forms of media. Media literacy skills are increasingly been included in the educational goals of our schools. Many educators have discovered that media literacy is an effective and engaging way to apply critical thinking skills to a wide range of issues. The mobile based Newsroom platform lends itself readily to support and foster such development and effort to educate and communicate with our students on media literacy.

Taking Stock and Looking Forward

Singapore continues to outperform all other countries in the recent 2015 Trends in International Mathematics and Science Study (TIMSS) indicating that Singapore primary school students are highly competent in Mathematics and Science. There exists a criticism that Singaporean students lack creativity and problem-solving skills. However, the 2015 results from both TIMSS and PISA have suggested otherwise. PISA 2015 assessed students on an important 21st century skill - collaborative problem-solving. This was part of OECD's updated assessments whereby the tests measure other skills that are becoming increasingly crucial to thrive in the workplace. In this area, Singapore students came top at problem-solving as a team. This indicated that strong performance in academic areas did not necessarily imply weak social skills (MOE, 2013).

This paper has attempted to examine how Singapore prepared her students for the knowledge economy by implementing three ICT Masterplans spanning from 1997 to 2014 with the fourth ICT Masterplan currently ongoing since 2015. The

implementation of the four ICT Masterplans have seen the progression from improvement of frequency (quantity) of ICT use by teachers and students towards the quality of its use; and in the transformation from principally a teacher-centred, direct instruction pedagogy to a more learner-centred, constructivist pedagogy with the integration of ICT. Over the two decades of ICT Masterplans in Education, the use of ICT in teaching and learning has evolved from a strong focus on “Foundation building” towards the “strengthening and scaling” of pedagogically sound practices. As ICT is increasingly woven into teaching and learning interactions, the work of ICT Masterplans would necessarily be more complex and diverse. However, the key elements of successful use of ICT in education remains broadly the same. They are -

- (i) strong ICT infrastructure that can support their use in education;
- (ii) teacher capacity in adapting pedagogically sound ICT-based teaching and learning practices;
- (iii) strong school leaders who can provide the enabling environment for teachers to work within; and
- (iv) a continual engagement in exploring and experimenting with innovative practices.

The success of the first two masterplans can be attributed to the rigorous efforts and resolve of MOE in providing the necessary resources and building the structures, as well as establishing the ground support from teachers and school leaders in realising their vision and goals. Research studies on the third masterplan indicated that mp3 has largely succeeded in moving schools to use ICT towards 21st century learning, particularly in the areas of self-directed and collaborative learning (Tan et al., 2011). The latest data from PISA assessments in

2015 demonstrates that the top performers in Singapore are adequately skilled in and knowledgeable about science to creatively and autonomously apply their knowledge and skills to a wide variety of situations, including unfamiliar ones.

Following that, it is also important to note that one in four students in Singapore are able to handle tasks that require the ability to formulate complex situations mathematically, using symbolic representations.

The culture of sharing amongst educators has been carefully nurtured through the Masterplans, and this needs to continue so that best practices can be effectively spread within the system. In a vibrant teaching and learning community, teachers can learn innovative teaching and learning approaches that work, and interact with experts and educators from Universities and even other teacher colleagues from outside the country. Mp4 has envisioned the strategy of “Strengthen Networked Learning Communities (iNLCs) for Technology in Learning” to sustain professional learning among the pre- and in-service communities. The plan is also to seed innovative practices across schools and spread the successes for wider adoption. It is critical that teachers and school leaders model in their day-to-day activities, the attributes of a 21st century learner with the use of ICT. Students, on the other hand, no longer need to turn to their teachers and schools for all the answers to their learning needs. In the new culture of learning, the divide between formal and informal learning becomes blurred. Much can be learned from interaction with peers, everyday activities and the social media. Schools should recognise this and perhaps alternative assessment methods can be considered to incorporate student learning in their informal activities.

Continuing research needs to be done to better understand the factors that help or hinder the whole-school implementation of ICT. This will ensure that learning points and usable pedagogical innovations cascade to the schools and the educational system as a whole. A longitudinal study of successes and challenges faced over the course of the four masterplans will aid in assessing where the classrooms and teachers are today, since the implementation of the first masterplan; and to identify areas where further strengthening is needed. With mp4 now advancing into its middle phase, there is great potential for Singapore to share her learnings and collaborate with the greater international community, so that genuine transformation of teaching and learning practices using ICT can take firm roots in various regional education systems.

The work of the first three ICT Masterplans in Singapore between 1997 and 2014 was manifold - to establish the physical ICT infrastructure in the schools, to provide digital teaching and learning resources for teachers to design ICT-based lessons, and most importantly, investment in teacher capacity building to equip teachers with the knowledge and skills of the various ICT tools and pedagogical training for designing and implementing the ICT lessons. Other nations in the Southeast Asian region that are reforming their education systems with ICT as part of the reform agenda, have some valuable lessons to learn from Singapore in this regard.

Subsequently, there was a slow shift towards building the schools' capacity to innovate using ICT in teaching and learning by selecting and identifying "Lead ICT" schools. This approach stimulated a strong culture of ICT use in particular schools which became anchor points for scaling innovative practices across the rest of the system. The following are some questions that now arise:

1. What could be the 'next tier' of ICT Masterplans within the Singapore education system?
2. What changes in thinking and learning behaviours evolve when students are increasingly exposed to different inquiry-oriented, problem-solving and self-directed learning approaches across their school years and subjects?
3. What processes and capacity building are needed to help schools effect strong, sustainable and impactful technological pedagogical innovations?
4. How can valuable innovations be sustained and scaled that are important and valuable to our students?
5. Where are students in the journey towards fully being digital citizens in the Singapore Smart Nation?

Smart Nation is Singapore's vision today to be a competitive global city. It is a movement with an entire nation focussed on harnessing digital technologies to build a future-ready Singapore. The ICT Masterplans in schools following the TSLN vision was one integral element to help citizens achieve their aspirations through good jobs and opportunities. The last 20 years has seen a revolutionary shift in classrooms where teaching has become learner centric, and the use of ICT increasingly more pervasive. In 2018, teachers in Singapore appear much more comfortable with technology in classrooms, using it for both teaching, administration, as well as their own learning. The shift requires transforming an entire system. The process has involved and continues to involve overcoming several barriers at many levels in order for the change to be sustained. Beginning with a vision, a leadership to implement the vision, enabling infrastructure, followed by curricular changes. Further, encouraging teachers to move away from a direct-instruction pedagogy to a

technology-integrated inquiry-oriented pedagogy was a huge challenge but now shown that was not impossible. Influencing a change in teacher beliefs and perceptions along with building a professional community of practice to support it is happening, and efforts to sustain it is continuous. Teacher professional development for technology infused teaching and learning happened in several phases. A cascading model of teacher capacity building in phases, with the help of skilful classroom practitioners has proved to be as a highly effective way of scaling the training.

While Singapore's educational system has been successful and efficient in producing skilled workers, the government recognises that for Singapore to continue to thrive in the knowledge-based global economy, a more sustainable innovations-driven, ecosystem is critical. Singapore does have her strengths in being able to attract and develop a talent pool in the STEM (Science, Technology, and Engineering & Mathematics) disciplines, enabling its workforce to better meet the greater demand for infocomm-technology professionals and engineers. The Smart Nation initiative when completed, will have created new opportunities in a digital age, and transforming the way people live, work and play, so that Singapore remains an outstanding global city (<https://www.smartnation.sg/happenings/press-releases/strategic-national-projects-to-build-a-smart-nation>). Within such an environment, it is important that workers are able to work collaboratively in teams, think critically and innovatively, add value to existing knowledge and cultural artefacts, and be competent in the use of information technology and telecommunications. This calls for the nurturing of knowledge workers, first within the formal education system, and later within the continuing education landscape.

Such demands have led many developed and developing countries to embark on reforming their respective education systems (Day & Sachs, 2004).

It is often assumed that high-stakes tests in Singapore inflict pressure on teachers' pedagogic styles to "teach to the test", resulting in rote learning. This contrasts with pedagogical practices, such as inquiry-oriented and self-directed pedagogies, that aim to strengthen the learners' 21st century skills. However, examples from various future school interventions have demonstrated that different types of assessments at classroom level have helped children to acquire the content knowledge, inquiry and creativity skills, and 21st century competencies needed for the 2030 workforce (Norris et al). Other case studies have been reported on how innovative curricular designs in Science classrooms that incorporate elements that help in bridging formal and informal student learning spaces using seamless mobile technologies have been successful (C.K. Looi et al, 2016). The introduction of the recent online platform, Student Learning Space (SLS) for various primary and secondary schools is another initiative that empowers students towards self-directed learning.

To conclude, the Singapore education system is one of the best public education systems in the world today twenty years hence. The "Thinking Schools Learning Nation (TSLN) initiative and the accompanying ICT Masterplans were system-wide endeavours that attempted to transform the Singapore education system. The plans demonstrated the importance of addressing important factors like infrastructure, resources and capacity building – a holistic ecosystem to support learning with ICT. A clear vision supported by able leadership that worked hand in hand with an alignment of purpose was critical to the successful implementation of the initiative. The foundation laid during the early years provided a great platform for subsequent

progressive changes over the next 20 years. It is important to mention that OECD's 2015 report shows that there has been no appreciable improvement in student achievement in international assessments in reading, mathematics or science, on average, in countries that have invested heavily in ICT for education. But the argument here is that Singapore has successfully implemented ICT in a wide-ranging scale in schools so that technology can help build an inclusive and accessible society. The Masterplans have addressed digital and information divides through a sustained agenda of ICT education in schools, where there are opportunities and avenues for "ALL" citizens to engage and participate in the digital economy.

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