Education in the Asia-Pacific Region:
Issues, Concerns and Prospects 61

David Hung
Longkai Wu
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Diversifying Schools

Systemic Catalysts for Educational Innovations in Singapore

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Education in the Asia-Pacific Region: Issues, Concerns and Prospects

Volume 61

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Series Editors' Introduction

This important and ground-breaking book, edited by David Hung, Longkai Wu and Dennis Kwek, on *Diversifying Schools: Systemic Catalysts for Educational Innovation in Singapore*, is the latest book to be published in the long-standing Springer Book Series "Education in the Asia Pacific Region: Issues, Concerns and Prospects". The first volume in this Springer series was published in 2002, this book by Hung, Wu and Kwek being the 61st volume to be published to date.

Diversifying Schools: Systemic Catalysts for Educational Innovation in Singapore examines the complex and important matter of school reform through education innovation. It explores ways in which the Singapore education system had adapted over time to meet the diverse needs of students, with educational innovation being one important way to enable substantial, sustainable educational change to occur over time.

The book documents the change journey of diversifying school practices. As the editors put it, "the book examines how Singapore enables diversified practices, within a structured environment, through innovations in mainstream, specialized and future schools".

The volume consists of nineteen chapters, organized into five parts, which contain chapters that explore (and provide case studies) of various ways of constructively transforming education and schooling in Singapore.

The book is designed to explore how innovations can (and have) transformed education and schooling at a system-wide level, in Singapore. It will be of interest to researchers, policymakers and practitioners with a keen interest in exploring, and better understanding, the main ways in which education innovation, for the development of education and training, is possible. The book is not just of interest to those in Singapore, but will no doubt have an Asia-Pacific and worldwide audience.

In terms of Springer Book Series in which this volume is published, the various topics dealt with in the series are wide ranging and varied in coverage, with an emphasis on cutting edge developments, best practices and education innovations for development. Topics examined in the series include environmental education and education for sustainable development; the interaction between technology

and education; the reform of primary, secondary and teacher education; innovative approaches to education assessment; alternative education; most effective ways to achieve quality and highly relevant education for all; active ageing through active learning; case studies of education and schooling systems in various countries in the region; cross-country and cross-cultural studies of education and schooling; and the sociology of teachers as an occupational group, to mention just a few. More information about the book series is available at https://link.springer.com/bookseries/5888.

All volumes in this series aim to meet the interests and priorities of a diverse education audience including researchers, policymakers and practitioners; tertiary students; teachers at all levels within education systems; and members of the public who are interested in better understanding cutting-edge developments in education and schooling in Asia-Pacific.

The main reason why this series has been devoted exclusively to examining various aspects of education and schooling in the Asia-pacific region is that this is a particularly challenging region. It is renowned for its size, diversity and complexity, whether it be geographical, socio-economic, cultural, political or developmental. Education and schooling in countries throughout the region impact on every aspect of people's lives, including employment, labour force considerations, education and training, cultural orientation and attitudes and values. Asia and the Pacific is home to some 63% of the world's population of 7 billion. Countries with the largest populations (China, 1.4 billion; India, 1.3 billion) and the most rapidly growing mega-cities are to be found in the region, as are countries with relatively small populations (Bhutan, 755,000; the Island of Niue, 1600).

Levels of economic and socio-political development vary widely, with some of the richest countries (such as Japan) and some of the poorest countries on earth (such as Bangladesh). Asia contains the largest number of poor of any region in the world, the incidence of those living below the poverty line remaining as high as 40% in some countries in Asia. At the same time, many countries in Asia are experiencing a period of great economic growth and social development. However, inclusive growth remains elusive, as does growth that is sustainable and does not destroy the quality of the environment. The growing prominence of Asian economies and corporations, together with globalization and technological innovation, are leading to long-term changes in trade, business and labour markets, to the sociology of populations within (and between) countries. There is a rebalancing of power, centred on Asia and the Pacific region, with the Asian Development Bank in Manila declaring that the twenty-first century will be "the Century of Asia-Pacific".

We know from feedback received from numerous education researchers, policymakers and practitioners, worldwide, that this book series makes a useful contribution to knowledge sharing about cutting-edge developments concerning education and schooling in Asia-Pacific.

Any readers of this or other volumes in the series who have an idea for writing or co-writing their own book (or editing/co-editing a book) on any aspect of education and/or schooling, that is relevant to the region, are enthusiastically encouraged to approach the series editors either direct, or through Springer, to publish their own volume in the series, since we are always willing to assist perspective authors shape their manuscripts in ways that make them suitable for publication.

July 2021

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Preface

At the systemic level, the Singapore Education System provides multiple and complementary pathways that recognize diverse students and encourage change towards twenty-first century learning orientations (Mahoney, Mitchell, VanVoorhis & Lasley, 2012). The experimentations of Future Schools and the implementation of Specialized Schools have provided opportunities for innovations and learning that can benefit other schools across the system. Future Schools are provided with resources and funds to harness technology and push the frontiers of teaching and learning practices at a school-wide level (Info-communications Development Authority of Singapore (IDA), 2010). The collaboration between IDA and Ministry of Education (MOE) aims to create meaningful and engaging experiences for students through technology, pedagogy and innovative school design. Specialized schools have focused on specific areas, such as sports, technology and arts, and have been created as exemplar innovation sites with resources and funds to create differentiated curriculum for students with different interests and expertise.

There are also school-based excellence initiatives that have been implemented and diffused across schools with the intention of helping every school develop excellence in a particular field, such as the STEM Applied Learning programme, niche programmes and co-curricular activity (CCA) programme. These programmes are initiated by MOE to create "a colourful landscape of distinctive schools to choose from", as then Education Minister Heng Swee Keat had put it. Applied Learning programmes teach students to apply learning in real-world settings and schools can focus on areas such as logical thinking or problem-solving. Niche programmes are meant to instil life skills and socio-emotional competencies and could be in the areas of sports or the performing arts. Through CCAs, students discover their interests and talents while developing values and competencies that will prepare them for a rapidly changing world. With these range of different initiatives, schools can develop innovative practices to accommodate learning opportunities for all students.

This book aims to show how Singapore enables diversified practices within a structured environment through innovations in mainstream, specialized and future schools. It tries to highlight the systemic rationale behind various efforts in Specialized and

Future Schools and the kinds of adaptations schools have made to leverage structures and make adjustments for their contexts. It documents the Singapore journey and process of developing diversity in schooling to inspire other education systems that change is possible with time and careful planning.

Summary of Book

The Singapore Education System adopted various foci throughout the *survival*-, *efficiency*-, *ability*-, and *values*- driven *student-centric* phases of education (Center for Curriculum Redesign, 2012). In the later phases, the system evolved to incorporate greater diversity in the curriculum to address the needs of diverse learners (Ministry of Education, Singapore, 2012). As the system adapts to meet the diverse needs of students, education innovation could be one way to enable substantial and sustainable educational change (Ministry of Education, Singapore, 2012; Mok, 2003).

School reform through education innovation is a complex matter that involves building leadership to nurturing educators' professional learning and to the restructuring of curriculum. Some schools have initiated their own reform approach from within while others have collaborated with other organizations to articulate research-based approaches or school reform models. In Part I, we illustrate how Singapore has adopted diversified approaches of education reforms and education innovations in their schools and examine the possibilities that allow for such innovations to flourish. Then, we described the SCAEL model, which stands for Scaling Community, Conditions, Culture and Carryovers through Apprenticing and Ecological Leadership as the overarching framework for this book. We also discussed another potential framework, the Learning Initiatives for the Future of Education (LIFE), which is a partnership between school and few stakeholders to improve learning experiences and the well-being of the lower progress students in a typical Singapore secondary school.

In initiating a reform in schools, many factors might influence the results, such as school ecology (Coburn & Russell, 2008; Felner et al., 2001), social context of the school (Bryk & Schneider, 2003; Daly & Chrispeels, 2008; Holme & Rangel, 2012), leadership in school reform (Fahey & Glickman, 2012), professional learning (Burke, Marx, & Berry, 2010; Doppenberg, Bakx, & Brok, 2012; Frank, Zhao, Penuel, Ellefson, & Porter, 2011). Section two will continue with the diversified changes from the school view where we will discuss how reforms can be implemented based on the needs of schools in Singapore. We highlight how educational innovations can benefit with appropriate resources and processes and the ways schools can adapt accordingly to enable innovations and sustain change for their needs. To balance, section three will continue with diversified changes from the systems view where we will look into how key tenets and lessons learnt, such as school leadership, structures, teacher capacity building and partnerships will support school-wide change and the creation of new learning cultures.

To provide a contrast to the work on school improvement and educational innovation in Singapore, we present three international perspectives from Japan, USA and England in Part IV. These international perspectives offer a comparison between Singapore's policies and provide an understanding of how the Singapore system align or differ with other international systems. Finally, we conclude with examples of how the system, when coupled with the school's own perspectives, can articulate an assessment of how an education system can innovate and adapt in the twenty-first century milieu in Chap. 5. In the case of Singapore, it provides discussions of the importance of teacher capacity to sustain systemic change. School-wide change and the creation of new learning cultures are concomitantly linked with school leadership, systemic structures, teacher capacity building and partnerships. It also proposes recommendations to cope with future developments, issues concerning scaling and translating innovations at a system-wide scale.

Structure and Outline

Structurally, this book is to: (1) document the change journey of diversifying school practices, including future schools, specialized schools, and school-based excellence programmes in Singapore, with a view to understand the key tenets that enable school-wide change and reform; (2) learn about international perspectives on school-based innovation development; (3) discuss the strategies that the Singapore Education System has embarked to encourage school change and innovations. The intents for change and reform are to anchor the education system to the basic foundations and principles of education and yet enable the system as a whole to be malleable to change and globalization.

The book comprises 19 chapters, structured in five parts,

Part I: Case Studies and Diversified Adoption of Innovation

Part I consists of Chaps. 1–4. Chapters 1 and 2 highlight the case studies of how a future school and specialized schools have adopted education reforms and innovation in their schools. These case studies highlight possibilities that push the extreme boundaries of innovation for students with diverse expertise and interests. Chapter 3 will continue to describes the SCAEL model which is relevant for educational policy formulation and for school leaders to understand the reasons for spreading or scaling of learning and pedagogical innovations. Chapter 4 sought to improve learning experiences and the well-being of the lower progress students in a typical Singapore secondary school, in partnership between NIE, Science Centre Singapore and New Life Community Services, with the Learning Initiatives for the Future of Education (LIFE).

Chapter 1 studies the development trajectory of a Singapore ICT-enriched primary school, examining how ICT is used to meet the demands of pedagogical reform for student-centred learning. The qualitative case study carefully maps out the development trajectory of the school's ICT integration path from year 2001 to 2013. The findings distilled four major phases of ICT integration, namely embarkation, entanglements, expositions and elevation. During each of these phases, the school's priorities, philosophy, ICT programme, curriculum structures, instructional practices, assessment strategies, professional development foci and infrastructural design have undergone evolutionary changes to reflect changing emphasis. Four assertions were drawn from the school's experience in integrating ICT for sustainable change.

Chapter 2 explores how students from a specialized school in Singapore designed and built a full-scale model and simulation of the school campus using an open-source platform, OpenSim. The research builds on a curriculum framework known as the Six Learnings to design learning environments that nurture maker dispositions in students. Six Learnings describe the six primary affordances for learning of game-based worlds and immersive environments. Maker culture has garnered the interest of educators and is an example of how learning can take place in authentic contexts outside of the formal spatial and temporal bounds of schooling. Here, the innovation is not only through the medium of learning, but is also highlighted through the integration of the curriculum design framework for the contexts of learning within games and immersive environments.

Chapter 3 describes the Scaling Community, Conditions, Culture and Carryovers through Apprenticing and Ecological Leadership model (SCAEL) a context-sensitive translational and scaling framework developed by the authors that can translate theories to practices in sustained educational changes. In this chapter, the SCAEL model is used to analyse recent Singapore-based education innovations that have attained substantive traction as well as recent reforms in the German education system. The authors also propose a practical and iterative framework for school leaders for operationalizing SCAEL.

Chapter 4 discussed about LIFE which is a four-lives framework that aims to address the challenges teachers faced to teach subject-content necessary to prepare students for life and examinations through facilitating higher order thinking skills. With the collaboration of different communities, LIFE takes a holistic "village" metaphor that works towards a long-term purpose of scaling and sustaining educational innovations, to benefit the wider community of the education sector. This chapter demonstrate how a workable model of LIFE by the agency of policy, socio-technical and teaching and learning mechanisms can develop effective and specific teaching and learning strategies.

Part II: Diversified Changes from the School View

Part II, consisting of Chaps. 5–8, showcases how school-based excellence initiatives enable innovations with appropriate resources and processes. In this section, the authors describe how schools adopt system-level policies that shape change and diversity in schools. These case studies illustrate how schools leverage on systemic structures and adapt accordingly to enable innovations and sustain change for their needs.

Chapter 5 looks at making-centred learning spaces as avenue in formal Singapore school settings to support meaningful learning and for engaging student interest. Making-centred learning spaces could be an entry point for innovative learning in preparation of the knowledge-based economy. Schools are continually evolving to develop new curricular forms, pedagogies and assessment methods to impart deep knowledge that inspires innovation that result in deeper understanding. In this chapter, the authors describe how making-centred learning programmes have been initiated and enacted in three case schools, summarizing contextual factors and underlying principles behind school practices that foster twenty-first century competencies. The implementation and enabling of making-centred learning spaces involves changes at the teacher and school level. Therefore, the school has to ensure a smooth transition between the intended and implemented making-centred programmes.

Chapter 6 describes niche programmes as organized by schools in Singapore and their importance in twenty-first century learning. Niche programmes are supported and funded by the state's Ministry of Education as a means to foster students' interest and agency in learning. Framed within the context of student-centric values-driven education, the chapter will show how the school's niche operationalises within a CCA, providing students with learning opportunities and experiences and preparing them with the skills and dispositions that are increasingly valued for the twenty-first century workforce. The chapter will also look at students' participation in the informal or semi-formal curriculum of CCA that simultaneously also serves as a niche programme.

Chapter 7 delves into cocurricular activities (CCAs), which are an integral part of the Singapore education system that students take part outside of the formal classroom curricular hours and beyond the physical space of the classroom. It explains how CCAs as a potential learning platform for students, in an out-of-classroom structure within the schooling context, facilitate an authentic learning experience for students. The chapter examines why and how the structure-and-agency afforded by both the activities and the agency of the persons involved produced a productive relationship, and hence an authentic learning experience. The authors identify a collective structure that constitute as multiplicity of planes of social structures in a schooling system. The planes accorded systemic designed opportunities at the school level, enabling access to multiple resources for students to participate at ease without having the burden of expectations that comes with high-stake examinations. The multiplicity of planes constitutes differentiated levels of competitions, disciplinary and CCA types.

Chapter 8 looks at how innovative practices and culture can be deepened and sustained through middle managers within a school organization. Teo delves into the role of middle managers in deepening and sustaining a twenty-first century teaching and learning practice and knowledge building within the eco-system of the whole school. The practices of three middle managers are analysed to understand the realities of leading from the middle. Key dimensions, strategies and approaches are identified, as well as the tensions they experienced as "mid-layer leaders" in sustaining knowledge building practice and culture in their school. It outlines the practices taken by the middle managers in much of the navigation, strategies and progression within the organization.

Part III: Diversified Changes from the Systems View

Part III consisting of Chaps. 9–15 attempts to tease out key tenets and lessons learnt—such as school leadership, structures, teacher capacity building and partnerships—that support school-wide change and the creation of new learning cultures. This part also presents recommendations to cope with future developments, issues concerning scaling and translating innovations at a system wide scale and the importance of teacher capacity to sustain systemic change.

Chapter 9 discusses a policy-to-practice translational implementation issues, including the supply of shared expertise and resources, as schools in Singapore transform towards inquiry-based learning practices for twenty-first century learning. It describes how inquiry-based learning is sustained in schools and classrooms with the hypothesis that school-to-school networks are needed to engender and sustain the change-cultures in schools. The authors have appropriated the Leadership from the Middle (LftM) concept, a key leverage to be situated within the levels of the system with teacher leadership working in tandem with school leaders and applied it to the school-to-school cluster network of schools in operationalizing the MOE's vision and goals of twenty-first century learning and inquiry-based practices for schools and classrooms. This chapter reports on a study on a network of schools and the innovation journey according to the macro-, meso- and micro-layer; it went through over five years.

Chapter 10 seeks to address the skills gap between what Singapore schools develop in students and the high-value workforce skills needed for innovation and enterprise. With its focus on mathematics problem-solving, the authors identify the system's affordances in cultivating its reputation in international assessments and its trade-offs in developing students' skills in dealing with authentic, non-routine and complex real-world problems. Although Singapore students have demonstrated outstanding levels of performance in international mathematics assessments, their stellar results stand in contrast to Singapore's real-world problem-solving capacities. Implications for policy, practice and research are put forth to propose how the Singapore mathematics

education can be enhanced to mould the value–creating talent that Singapore needs to stay competitive.

Salleh addresses the role of school leadership in Chap. 11. He describes findings from a qualitative study of one government primary school in Singapore which had undertaken a school-based and school-wide curriculum innovation involving ICT. The study puts to the fore the indispensable role of leadership across all levels of the organization and encompassing a diverse set of leadership models supporting curriculum development. Salleh argues that schools, as organizations are now engulfed in a sea of change, characterized by increasing rapidity, intensity, fluidity, complexity and uncertainty. School leaders, being the sole authoritative figure, are faced with increasing demands from a range of stakeholders inside and outside schools including policymakers, district authorities, business partners, parents, teachers and students. A main consequence of it lies in the school leaders' responsibility and prerogative to provide diverse curricula that satisfy diverse needs of stakeholders.

Chapter 12 articulates the use of teacher learning communities as a catalytic lever for educational innovation in Singapore schools. The authors contend that scaling of innovative inquiry requires strong teacher beliefs and the resilience for change seeded by the variant degrees of epistemic learning afforded by networked Learning Communities (nLCs) within the system, coupled with appropriate leadership and socio-technological infrastructures. It discusses how scaling agentic inquiry practices, that underpin educational innovations, may be mediated—and catalysed—through networked Learning Communities. In characterizing the variant types of nLCs within the Singapore education system, the research reported in this chapter seeks to (i) unpack how nLCs afford teacher's epistemic learning in the context of innovation scaling and diffusion and (ii) distil tenets of scalable epistemic learning for the teacher innovation change process.

Chapter 13 introduces a school-based teacher professional development (PD) approach taken by a local secondary school in Singapore to support school improvement and educational success in the twenty-first century. The authors discuss the three fundamental dimensions of teacher PD, namely context, enactment and outcome, as well as the contemporary research agenda related to these three dimensions. It provides details into the key features and operational principles of effective teacher PD programmes advocated by educational researchers. The chapter discusses the contemporary research agenda in teacher PD, followed by a case study of an exploratory approach to teacher PD undertaken by a Singapore school. Implications of this school-based PD approach on educational research are then discussed.

Chapter 14 seeks to advance an understanding of how teacher capacity building can be a driver for innovation and change that is nuanced to Singapore's centralized–decentralized education landscape. Central to the discussion is two case studies from schools with successes in technology-mediated pedagogical innovations. It encompasses the implementation tenets for building teacher capacity to drive innovations and change practices towards inquiry in: (1) creating consensus and tailoring innovation for school's context; (2) forming communities and building capacity through

lesson designs; and (3) deepening understandings through in-situ enactment and refinement. In doing so, the authors unpack lessons learnt through capacity building situated within practice, and the implications are discussed to show how tight–loose couplings between and beyond schools involve multiple stakeholders from the education ecology to create leverages for innovation and change.

Chapter 15 explains how the current education paradigm has been evolving to meet the needs of the twenty-first century. It remains necessary for schools to collaborate with agencies such as the Science Centre, museums and other similar organizations that can provide learning experiences without ties to national high-stakes examinations. They can encourage students to engage in activities that can fuel interest and passion. Trust ought to be given to students to pursue purposeful learning and to be motivated to do so. It also discusses the current programmes in schools and deliberates how we can draw lessons from another education system, including leveraging on student agency, teachers as designers of learning, learner dispositions and twenty-first-century learning.

Part IV: The International Perspective

Part IV, consisting of Chaps. 16–18, provides international cases and perspectives on the strategies that these international schools have adopted to promote diversity in their educational landscape. The comparisons will deepen the understanding of how Singapore's policies align or differ with other international systems at different levels related to schools, teachers and students' learning goals.

Chapter 16 reviews the literature and explores the systemic factors that help and/or hinder change and innovation across school systems, with a focus on evidence from England. The chapter draws on five specific examples drawn from three areas of policy and practice—pedagogy, curriculum and school improvement—to illustrate and explore these issues. It also sets out an innovation framework as a means of comparing innovations and analysing the factors that influence them. The chapter draws on the author's experience of working with schools in England on a range of innovation-related projects over a 20-year period as well as a wider review of the literature. Greany proposes a balance of central control (structure) and local agency, so that innovation is encouraged and learning is spread. Neither can succeed without the other because it is not feasible to operate on pure centralisation or pure decentralization. Instead, it requires a sophisticated set of capabilities from those overseeing public education systems.

Chapter 17 highlights the development of career education in Joetsu city, Japan. The chapter focuses on innovative practices in schools and the building of an educational base among stakeholders for a seamless programme of work experience practices and learning. Joetsu city's career education demonstrates an exemplary practice of how one city can revitalize its economy through regional cultural principles and

sustainable educational change. The development of career education in Joetsu city illustrates a system-wide approach towards systemic change in the schools. Career education moves students out of the classroom to real workplace experience learning and practice. Career education is based on collaboration and cooperation among the stakeholders in the city, in education, in business and industry, and among citizens.

To provide a contrast to the work on school improvement and innovation in Singapore, Chap. 18 explores the possibilities and challenges for educational innovation in New York City. In doing so, the chapter draws from research on individual and organizational learning to document the evolution of two organizations that have worked to launch new, alternative schools in New York City since the turn of the twenty-first century. The chapter concentrates on how these organizations have evolved to shift attention away from questions like whether things have "changed" or whether their work is "new" or "innovative". Instead, the chapter strives to shed light on what it takes for organizations like these to anticipate predictable challenges and to take advantage of opportunities to pursue their visions and make meaningful and lasting improvements in students' learning.

Part V: Summary and Conclusion

Concluding the book, Chap. 19 delves into integrating innovations and initiatives mentioned in this book to build a cohesive twenty-first-century learning-orientated community in Singapore. This chapter also examined the current issues faced by Singapore that hindered reforms using the SCAEL model, introduced in Chap. 10, to further discuss how education innovations, system reform and case studies meet the diverse needs of Singapore's ever-changing education system. Implications of studies are made with the intents for change and reform built on substantial and sustainable school innovations, with the view towards more diverse measures of merit that is more adaptable to change and globalization.

This book is designed for the professionals such as educational researchers, policymakers and school leaders, who are interested in how education innovations transform pedagogical practices and teacher professionalism on a system-wide level. The book is also useful for policymakers and aspiring researchers to understand how education innovations can inform practice and policies to transform education systems. Aspiring, pre-service and in-service teachers can benefit from this book by understanding their role in education innovations, such as how their professional knowledge and beliefs get transformed as they participate in research, innovations and dialog with researchers and other teachers about their practices.

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Singapore

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Contents

Part I
Case Studies of Diversified Adoption of Innovation

Chapter 1
Creating Sustainable Levers for ICT Integration: A Development Trajectory of an ICT-Enriched School

Yancy Toh

Abstract The chapter looks into the development trajectory of a Singapore ICT-enriched primary school to understand how the school has harnessed ICT to meet the demands of pedagogical reform for student-centred learning. The qualitative case study maps out the development trajectory of the school's ICT integration path from year 2001 to 2013. Data sources include interviews with actors across different levels of school hierarchy, observations of lessons and fieldtrips as well as document analysis of school's policy papers, presentations, publicity materials and publications. The data was subsequently coded using two layers of coding—open and longitudinal coding. The findings distilled four major phases of ICT integration, namely: embarkation, entanglements, expositions and elevation. During each of these phases, the school's priorities, philosophy, ICT programme, curriculum structures, instructional practices, assessment strategies, professional development foci and infrastructural design have undergone evolutionary changes to reflect changing emphasis. Four assertions were drawn from the school's experience in integrating ICT for sustainable change: *Whilst there can be deeper alignment between the school's use of technology and the principles of student-centred learning, tensions that threatened the fidelity and adaptations of innovations may not abate correspondingly; the continuous perturbations could lead to the crystallisation of strategic direction; to sustain pervasive and meaningful ICT integration requires political will and skilful orchestration of resources across generations of leaders; and schools must build internal capacity and ensure there is capacity transfer from partners to school-level change agents.*

1.1 Introduction

Studies on the use of technology in education have yielded inconclusive results across the globe. Proponents of technology usage contend that ICT can be a catalyst to transform learning practices (Bransford et al., 2000; Owen & Demb, 2004; Selwyn, 2011)

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whilst dissidents are less optimistic and argue that teaching practices have remain largely intransigent over the decades (Cuban, 2008, 2013; Weston & Bain, 2010). In response to these emergent developments, Singapore has cautiously embraced and purposively integrated technology into its national curriculum, as seen from its Masterplan for ICT in Education. From ICT Masterplan One (MP1) to Masterplan Four (MP4), the undergirding philosophy is that the use of technology has to be centred on pedagogy. In recent years, more emphasis is placed on the holistic integration of technology into pedagogy, professional development as well as planning and implementation of curriculum. For MP4, the rhetoric has shifted to leaders as culture builders and teachers as designers of learning experiences and environment (MOE, 2016), suggesting the situated use of technology in the school's ecology with cultural norms and professional capacity being foregrounded.

Whilst some schools are advanced in terms of integrating technology meaningfully, others are struggling with attaining the aspirational vision articulated by the Ministry of Education (MOE). Hogan et al.'s (2013) study on Singapore classrooms reveals that instructional strategies in Singaporean classrooms rarely deviated from "a logic of curriculum coverage, knowledge transmission and reproduction" (p. 58) due to the pressure of high-stake national examinations. Parents' anxieties over their child's academic performance have resulted in teachers "parenting credentialing anxieties" (Hogan et al., 2013, p.58). With performative anxiety and transmissionistic instruction acting as countervailing forces to reform, this chapter looks at how a Singapore ICT-enriched school has, over the years, used technology as a lever for pedagogical change. The data collected maps out the development trajectory of the school's ICT integration path from year 2001 to 2013. Due to the long trajectory, a detailed account is warranted. There is attempt to externalise not only the technological development, but also the socio-historical, structural and cultural developments which technology is embedded in. The focus is thus on the micro-meso interfacing of influences that affect the implementation path of technology.

The chapter is organised into the following sections: review of literature on technology integration for reform at both the national and organisational level; research context including profile of school, data collection and data analysis; findings on the developmental trajectories and the assertions that arose from the findings followed by conclusion on takeaways and limitations.

1.2 Literature Review

The recent OCED report (2015) is a sombre reminder that the use of ICT in education has largely failed to create coruscating impact on student learning across the globe. Notwithstanding the overarching dismal performance, some economies appear to have more success than others in terms of integrating technology for deep learning. According to the UNESCO report (2011), macro-policies that enable schools to move multiple linked components to "unfreeze the system" for long-term change have better propensity for transformation, and it is this understanding of how schools use

such levers of change that is important. However, the literature on ICT integration rarely delves into the dialectical interplay of technology integration at the institutional and individual level. Whilst stories and theories about technology integration at the micro-level of teacher adoption are aplenty (Hall & Hord, 2011; Mishra & Koehler, 2006; Rogers, 1983), there remains a gap in the documentation and theorisation of the long-term trajectory of technology integration at the meso-level of school organisation. This temporal connectivity of development is worth exploring as it can potentially inform us on how policy, structural and cultural affordances can be created over time to seed an environment for the meaningful integration of technology in schools as well as the impediments that may threaten the longevity of meaningful integration.

In broad strokes, the UNESCO report (2011) maps out how education reform can contribute to national development by moving up the knowledge ladder of providing basic education, acquiring knowledge, deepening knowledge and finally creating knowledge. ICT, as the report posits, can be used to support each of these phases, in particular the knowledge creation phase where technology can be used to "support a significant restructuring of the school schedule that is required for extended, real-world, multidisciplinary problems" (p. 32) and provide access to resources that allow students to explore concepts in depth and create social networks to enable ubiquitous learning. Buettner et al. (2004) identified four broad approaches through which educational systems and schools can proceed along the continuum of ICT integration efforts. They are namely: *emerging*, *applying*, *integrating* and *transformation* in areas of vision mapping, learning pedagogy, development plans and policies, as well as facilities and resources.

Tong and Trinidad (2005) as well as Mooij and Smeets (2001) allude to the fact that a school needs to go through several phases of ICT implementation before it approaches maturity. Tong and Trinidad's model for "innovative pedagogical practices using technology" (IPPUT) aims to help school leaders identify which phase of development the school is at by looking at the conditions and constraints in school. They contend that a school will go through the following ICT integration phases: "pre-adoption", "initial adoption", "institutionalisation" and "sustainable development". The phase a school is at can be determined by looking at whether the school has "necessary", "sufficient" or "sustainable" conditions and whether the school is experiencing "critical", "inhibitory" or "tolerable" constraints. The study is premised on the assumption that ICT can be utilised to enhance a pedagogically sound environment for constructivist learning and that it is possible to integrate the innovation into the curriculum and sustain its development. According to the authors, all the necessary, sufficient and sustainable conditions will be satisfied, and all critical, inhibitory and tolerable constraints of ICT implementation will be eliminated by the school at the final phase of the development. Such conceptualisation, as the authors espouse, aims to help school leaders gauge the readiness level of school. However, more often than not, conditions and constraints are not static and linear in nature. The dynamic and iterative nature of conditions may render the status differentiation arbitrary, subjective and indeterminable. What is perceived as "tolerable" constraint can become "critical", depending on the changing circumstances.

Mooij and Smeets (2001) on the other hand devise a five-stage model for ICT implementation after analysing ten secondary schools in Holland. The successive stages are: (1) Incidental and isolated use of ICT by one of the teachers; (2) awareness of the relevance of ICT for the school and subject-related departments; (3) ICT coordination and the hardware facilities in the entire school; (4) didactic innovation and ICT education support; and (5) integrated ICT support of learning processes (p.279–280). As articulated by the authors, these stages represent a gradual transformation of learning processes mediated by ICT. The authors also map out possible intervention actions which could be adopted by school leaders for each of the phases. However, as Law et al. (2011) have critiqued, the model may not be appropriate for such purposes as it focuses more on the "technical history of ICT use in schools rather than the implementation and development history in schools" (p.115). Moreover, as with Tong and Trinidad, the developmental pathways are also linear in nature, which may not be the case in actual implementation.

It is hoped that this article will fill the literature gap by mapping out a school's decade-long implementation and development history of integrating ICT for pedagogical transformation, thus distilling the multifaceted considerations that accompany technology-mediated school change. The research question that the chapter attempts to address is: ***What was the development trajectory of a Singapore ICT-enriched primary school that harnessed technology to meet the demands of pedagogical reform for student-centred learning?***

1.3 Research Context

1.3.1 Use of ICT in Singapore's Educational Landscape

Technology has been perceived as one of the key enablers in transforming pedagogy in Singapore's educational landscape. Elaborate, coherent and longitudinal frameworks were drawn up to guide educators in integrating technology into the school curriculum. First introduced in year 1997, the ICT Masterplan for Education has since gone through four evolutionary phases. The first phase of Masterplan, known as MP1 in short, spanned from 1997 to 2002. It emphasised the foundational building blocks for schools to be equipped with the skills to harness ICT proficiently, as well as providing the basic infrastructure and building capacity. MP2 which spanned from year 2003 to 2008 focused on seeding innovations to forge alignment with the overarching educational goal of "Teach Less, Learn More" where schools were encouraged to use the freed up space to develop their customised pedagogical innovations. MP3 was demarcated by the period spanning from 2009 to 2014 which foregrounded the strengthening and scaling of promising innovations to promote critical twenty-first-century dispositions, in particular self-directed and collaborative learning. MP4 spans from 2015 to 2019. It underscores the importance of deepening learning and sharpening practices to promote student-centric, values-driven education.

The data covered in this chapter encapsulated the years of 2003–2013, which coincided with the phases of MP1, MP2 and MP3. Under MP2, ICT-enriched schools were recognised as LEAD schools or FutureSchools. The inception of LEAD ICT@Schools (Leading Experimentation and Development in ICT) in 2006 and FutureSchools@Singapore (FS@SG) programmes in 2007 provided these forward-looking schools with an incubator environment and funding to continue their tinkering with technology. About 15–20% of Singapore schools were LEAD schools. These schools were either ready to achieve a higher level of IT use via action research efforts or had used ICT effectively for at least one subject across one level. On the other hand, only about 5% of Singapore schools were FutureSchools. These were exemplars that had demonstrated readiness to use ICT across all subjects and levels at a school-wide level. Other criteria for consideration of award included how well ICT had been integrated into the school's curriculum, pedagogy and assessment, the readiness level of school leadership, staff and culture as well as the innovativeness and effectiveness of the physical learning environment to support learning endeavours.

Serving as peaks of excellence, the espoused mandate for FutureSchools was to spread their innovations to propagate informed practices on the use of ICT to enhance engaged learning. Supported by the National Research Foundation, these schools worked closely with MOE, Infocomm Development Authority, industry partners and Institutes of Higher Learning to bring their concepts of transforming teachers and students' learning experiences to fruition. Fortitude Primary School (FPS), the case school featured in this chapter, was a LEAD school and subsequently became a FutureSchool.

1.3.2 The School

The school, Fortitude Primary School (FPS), is an ICT-enriched primary school that has started experimenting with the use of technology for improving teaching and learning since 2001. A mainstream primary school with affiliation to a Chinese Clan Association, it has consistently performed well in national exams in recent years and has become a popular school that is well known for its cutting-edge use of technology as well as its emphasis on Chinese values. Over the years, the school has won several local and international accolades for its meaningful integration of technology for student-centred learning at a whole-school level. Working closely with NIE researchers, the exemplary school has employed evidence-informed approach towards pedagogical innovations. Due to its sustained effort in using technology in an integrated manner that fundamentally changes pedagogy, the school attained FutureSchool status in year 2011. Due to its unique trajectory and recognition as an exemplary case of using ICT for effecting pedagogical changes, FPS can be considered as an intrinsic case study that can potentially provide rich insights.

1.4 Data Collection

To understand how FPS had been using technology for student-centred learning, data sources which comprised interviews conducted with 17 personnel of FPS were collected. The interviewees were selected based on the maximum variation sampling strategy. They can be re-grouped into four broad categories: senior management (principal, HODs), middle management (level heads, subject heads), teaching staff and support staff. Altogether, five senior management (SM), seven middle management (ML), four teaching staff (TS) and one support staff (SS) had been interviewed. To observe annoymnity, pseudonyms were used. Criteria used for the selection of participants include teaching subjects, their years of teaching experience and school's internal profiling status which comprised a four-tier dual track assessment of teachers' competency in action research and knowledge in integrating ICT into lessons.

Unstructured lesson and fieldtrip observations were also conducted to glean how technology was used by technology-using teachers to advance student-centred learning. These observations were followed by short interviews of about 20 min to clarify matters related to pedagogical strategies. The researcher was also present during professional learning sessions and meetings to understand the pedagogical issues faced by teachers. These observation notes served as a form of data triangulation in addition to interview data. More importantly, such contextualised discussions tend to bring out multiple perspectives of key leaders in a more natural setting as compared to individual or focus group interviews.

Document analysis was also employed to map out the school's ICT integration journey. Document analysis allows readers to "locate, interpret, analyse and draw conclusions about the evidence presented" (Fitzgerald, 2007, p.279). It is also a conduit for connecting the "past and present on the one hand, and between public and private on the other" (McCulloch, 2004, p.28).

1.4.1 Data Analysis

Inductive analysis was employed for data analysis, starting off with open coding. The first round of open coding yielded seven categories of how ICT had been used to advance student-centred learning: champions, philosophy of using technology, ICT programmes and curriculum structure, instructional practices, assessment strategies, professional development system and infrastructure.

In addition, four phases of development were demarcated according to FPS' key milestones and critical events, as gathered through interviews. From the synthesis of the corpus of data, FPS' process of using technology for student-centred learning can be viewed as evolutionary which include the four phases of: embarkation, entanglement, exposition and elevation (See Appendix 1). The first principal identified the year 2001 as the year where the school embarked on innovation ("embarkation|") and

2005 as the "tipping point" in terms of quantitative and qualitative growth of champions as well as record number of failed demonstrations ("entanglements"). The ex IT HOD identified year 2008 as the year where more pedagogical frameworks were introduced under the stewardship of new principal ("exposition"). Year 2011 was the year where FPS received the FutureSchool award, thereby shifting its priorities to innovation scaling ("elevation"). These four nonlinear phases demarcated different milestones and foci of FPS' ICT implementation at an organisational level. However, they were not exclusive and could coexist.

To attribute "selected change processes to qualitative data collected and compared across time" (Saldana, 2009, p173), a second round of coding known as "longitudinal coding" was conducted to map out the key developments of FPS' ICT usage along the seven dimensions (what has increased/emerged; what is the turning point; what is cumulative; what has decreased; what is constant; which parts are idiosyncratic and what are missing). The matrix was favoured as it was loosely structured to allow the study of emergent and dynamic Interactions to be traced without any disposition towards predefined codes. The trajectory of FPS' ICT development was then carefully mapped out by studying each of the seven dimensions across the seven columns of change processes that appeared within a data pool set. Together, both rounds of coding led to the distillation of conceptual themes. Assertions were drawn up by examining the interrelationship of themes.

1.4.2 Findings

Embarkation Phase (2001–2004) The embarkation phase refers to the infancy years of technology usage which spanned from years 2001–2004. FPS' attempt to explore technologies began as early as 2001. Initial success was palpable as the school won accolades for using equipment such as digital microscopes and data-loggers appropriately, resulting in the invitation from MOE to showcase its innovative projects in a nation-wide conference that marked the completion of the milestone of MP1 in 2002. The embarkation phase also saw an important turning event as Carl, the first principal of FPS decided to explore the use of handheld organiser as a teaching and learning tool after witnessing a demonstration in a workshop conducted by a renowned educational expert. When first introduced in 2003 in FPS, the handhelds were used to enhance self-paced learning. In terms of the philosophy of using technology, the school's focus was on the affective aspects of learning. Carl was student-centred in his approach to ICT integration, foregrounding students' affective emotions of enjoyment and engagement during the process. The use of technology, to him, was about the qualitative transformation as a person, especially on whether students had become a more "exciting and curious" person during the being and becoming process. Said Carl, "We want to teach the children to learn, rather than teach them what we know".

Carl also reiterated the importance of thinking critically about the use of technology in FPS:

> ……[B]efore anybody can challenge us, we must always be very critical of what we are doing. The question was, and the question always will be, can it be done without? ……(W)e know that we are our worst critic.

The embarkation phase involved critical reflection of why technology was being used. Carl's intention rested on his belief that technology can enhance participatory learning through networked technology as it could give students access to esoteric knowledge and experts that could otherwise be inaccessible. He felt that the online discussion mode favoured the social construction rather than transmission of knowledge. Learning independently and coconstructing knowledge collaboratively were affordances which Carl highly valued. At the heart of his epistemic belief was that ICT could play an important role in disintegrating the power divide between teachers and students in a profound way by democratising access to education and fundamentally challenging the traditional perspective of relying on the teacher to impart knowledge. Carl also noted how using technology in classrooms, computer laboratories or during fieldtrips that involved the use of mobile technologies can effect changes in pedagogy:

> One thing that I see, when we use ICT, my teachers tend to teach differently. They tend not to, just teach in one direction, that means I talk they listen. Somehow ICT lessons don't allow you to do that……In itself, the way it is structured, [ICT] forces the teacher to rethink the way the lesson is conducted.

Carl attributed the reasons of non-didactic instruction to the inherent affordance of mobile technology and the socio-cultural factors in educational settings. Shelia, one of FPS' ICT champions, subscribed to the same belief. She elaborated that the ICT-mediated activity allowed students to interpret and apply what they had learnt through their own lens. In this sense, technology gave students more voice and can be seen as playing a catalytic role in restructuring teacher–student discourse.

During this phase, the number of ICT champions started from a modest number of 3 teachers in 2003 to about 15 teachers in 2004. Carl emphasised that the teachers invested the time to explore emergent technologies on their own accord, after being inspired by what the pioneering colleagues had done:

> It was not something that I had instituted, something that I wanted to structure, something that I said I want to do. It was amongst the teachers themselves. As they were talking about it, they wanted to be part of this.

Admitting that he was not a technology person, he was glad that the teachers were spontaneous in this aspect. A retrospective examination of the synopsis of IT projects undertaken during this period indicated that the notions of active, mobile and cross-disciplinary learning were incorporated for key projects, which was a very forward-looking stance. Most of the Singapore schools then were still ingrained in traditional teaching practices (Hogan et al., 2013). However, these successes were relatively insular phenomena revolving around key projects. The predominant use of technology during this phase was to disseminate electronic worksheets through the school's Learning Management System. The IT department also worked at creating learning packages and placed them in the repository so that teachers could download